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Earthen Heritage
New Technology, Management
7th International Conference

5-7 September 2019
Köyceğiz, Muğla, Turkey

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I

Proceedings for the
Seventh International Conference
Kerpiç'19
Earthen Heritage, New Technology, Management

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Hasan Kalyoncu University & Kerpiç Network

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Themes of The Conference:

Proposed Main Theme Earthen Architecture: Lessons from Past to Future Proposed topics: All studies on movable and immovable cultural assets and tangible and intangible earthen heritage as:

- Historical, Architectural and Archaeological researches
- Studies on Information and documentation Systems
- Traditional construction techniques
- Evaluation of experimental methods and tests
- Structural behavior - static, dynamic and numerical analysis methods
- Researches on principles and methods of conservation
- Protection against environmental effects and disasters, evaluation of risk
- Preservative conservation in museum
- Intervention, restoration and prevention techniques
- Heritage site planning and management
- Case studies
- Cultural heritage education, skill development and communication by innovative systems
- Sustainability in building materials
- Sustainable architecture

DEAR COLLEAGUES;

7. International Conference www.kerpic.org/2019 will take place at Köyceğiz, Muğla/ Turkey, will follow the www.kerpic.org/2005 "Living in Earthen cities" at Istanbul Technical University; www.kerpic.org/2008 "Learning from earthen architecture in climate change" at Cyprus International University, TRNC; www.kerpic.org/2013 "New Generation Earthen Architecture: Learning from Heritage" Istanbul Aydin University, www.kerpic.org/2015 "Built Environment on Silk road" Istanbul Aydin University, Istanbul; www.kerpic.org/2016 "Cultural landscape, rebuilding after decay", Istanbul Aydin University, Istanbul; www.kerpic.org/2018 "Back to earthen architecture: industrialized, injected, rammed, stabilized", Hasan Kalyoncu University, Gaziantep.

Over thirty years, Kerpiç–network is carrying researches on durability, seismic response and production techniques on earthen construction material. Durability researches are based on gypsum & lime stabilization of earth, called "alker"; seismic response researches are based on horizontal energy dissipating surfaces in the load bearing walls and production techniques are based on shotcrete and compacting production of earthen walls. www.kerpic.org, info@kerpic.org We are pleased to announce the Call for the 7. international conference on kerpiç'19 "Earthen Heritage, New Technology, Management" and the workshop on production: 5,6,7 September 2019 Organized by Kerpic Akademi and Kerpic Network.

The conference scope will focus on using earth for housing, "Earthen Heritage, New Technology, Management", The study will range from the graduate programs, together with the academics and professionals to exchange results and experience. It will be an opportunity to understand the strategy and the advances how to use the contemporary construction technology, using earth-based material.

Prof. Dr. Bilge IŞIK

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Common-Action Walls: Integrating Digital Fabrication Techniques with Rammed-Earth Production in Search of Ecological Architecture

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ABSTRACT

This paper deals with Common-Action Walls, a rammed-earth wall supporting urban agriculture, constructed by POTplus Design Research Group, for the IV. International Architecture Biennial of Antalya in 2017. This wall is still being used in Karaalioğlu Park as a sustainable vertical garden that exposes the possibilities of integrating architecture with ecology and technology. It is designed and produced within an interdisciplinary process in order to relate local construction techniques with advanced design and fabrication systems and also with permaculture design principles. The double-sided wall system is composed of modular rammed-earth blocks that are assembled to create continuous surfaces and voids. The holes in these blocks perform as pots for growing edible plants and are integrated with a drip irrigation system for sustainability issues. The mold, designed and produced with digital design techniques is based on the Gyroid geometry, a mathematical model that is used to create minimal surfaces and is fabricated in a facade company factory. In order to deal with construction issues, Alker material system is developed with other ingredients within the guidance of our consultant. The rammed-earth blocks are supported with steel rods in order to deal with stability issues which need to be further studied from the point of sustainability. This paper covers the design and fabrication process of this wall under the titles of concept development, geometric exploration, material research, fabrication process, and on-site application. This design-fabrication process is the trigger for further research on integrating rammed-earth construction techniques with digital design and robotic fabrication through an ecological approach. This initial prototype of Common-Action Walls series is followed by a summer school Robotic Earth Crafts in 2018, a master thesis integrating biomaterials with Alker system and is planned to be developed as an interdisciplinary design research project which will be explained the conclusion part in detail.

Keywords: rammed-earth, ecologic design, digital design, digital fabrication, gyroid

1 CONCEPT DEVELOPMENT: COMMON-ACTION WALLS

Common-action Walls is the prototype wall, constructed within a series of Common-action Works by POTplus Design Research Group [1], which is established to explore digital design and fabrication strategies in order to integrate ecological principles with design and architecture 'Figs 1and 2'. Urban parks are the common ground for our 1:1 scale applications for communicating our intentions with the public and test the various performance of these prototypes through stability, durability, user-interaction, sustainability, environmental parameters, and landscape issues.

Common-action Walls is designed and fabricated for the International Architecture Biennial of Antalya, IV. IABA in 2017 within the experimental works category and on-site application is realized in Karaalioğlu Park [2]. The theme of the biennial was *continuity*, proposed in order criticize the mainstream approaches of current sustainable architecture approaches guided w limited technical parameters; get beyond these approaches by rethinking the context of architectu in its relations with climate, tradition, topography and regional belonging.

Figure 1. Common-action Walls, designed and fabricated for the International Architectu Biennial of Antalya, IV. IABA, in 2017.

Common-action Walls is an innovative proposal through a sustainable, economic and ecolo architecture in the way that it uses earth, a material that is obtained from architectural excavatio integrates rammed-earth, a local building technique with advanced fabrication process; crea spaces for plants and animals in its holes and becomes an interface in-between people and natu tradition and technology and break down into the earth at the end of its use.

Figure 2. Common-action Walls, a sustainable rammed-earth wall that performs as a verti garden wall

From the point of architecture, the main idea is building a wall composed of blocks and hol Holes should perform to optimise the environmental parameters of sunlight, shading, wind a water flows and also serve as an appropriate environment for plants and animals. Blocks shou cover these holes, have pot-holes for planting-soil and have constructional stability. All of the intentions required to develop a design, fabrication, and demolishing strategy and mater exploration guided by sustainability issues. This strategy is managed through integrating ramme earth building techniques with computational design, digital fabrication processes and permacultu design principles[3] which will be explained in the following parts.

2 GEOMETRIC EXPLORATION: INTERPRETATION OF A MATHEMATIC MODEL FOR CORRELATING SOLIDS WITH CONTINIOUS VOIDS

The geometric exploration of this wall started with three challenges: A porous geometrical patte that collaborates with natural parameters such as water flow or sun-light; continuous voids maximizing the space entailed for plant growth; solids covering these voids that can be tesselat as modular blocks.

We worked on *Gyroid*, a mathematical model based on minimal surfaces, and is the model for various elements in nature such as corals. Scientists and mathematicians have long studied minimal surfaces by analyzing the formation of soap films and bubbles in their relation with the forces of surface tension and the pressure of air on both sides. Soap film takes the shape it does, in part, because the surface tension and the pressure of air on both sides of the film cause the film to take the minimum amount of surface area necessary to span a region of space. A *minimal surface* is a mathematical model of a soap film, a simplified version that ignores the effects of gravity and some other physical phenomena [4].

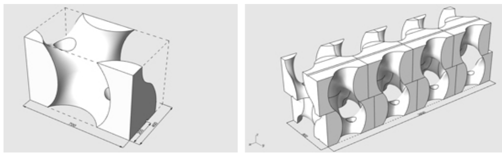

Figure 3. The single block form and assembly method of the blocks

Gyroid model which enables continuous surfaces and voids in x, y, and z axis is interpreted via solid model boolean operations in order to find out the unique form of the blocks. After various explorations, we ended up with a single block module form, that could be reproduced and arranged in a continuous order via rotation operations 'Fig 3'. This geometric exploration opened up the way for the fabrication strategy that bases on molding techniques and furthered the process through material research.

3 MATERIAL RESEARCH: LEARNING FROM ALKER

After concept development phase and geometric explorations, we worked with a consultant to learn about the earthen building methods. Öztürk [5] as an architect who had experienced rammed-earth building techniques in her interior design projects and who is an educator in *İ.T.Ü. Foundation Earthen Buildings Working Group* [6], shared her knowledge about rammed-earth building techniques. She introduced us with the *Alker* building material, developped by *Ruhi Kafesçioğlu*, the founder of that group, which is based on his long-term research projects since 1970 and various building applications as *Experiment Houses* [7]. *Alker* is the building material which is composed of clayey earth, plaster, lime and water and _if needed_ retarder agent. This mixture is dired with sun-light and hardens in 20 minutes and has appropritae physical and mechanical properties as a stable earthen based building material. This material can be applied via compaction methods in a molding, and can be used as a building construction system through on-site applications or via block production.

The properties of *Alker*, as a material that prevents energy consumption through it's manufacturing process, and its potantials for re-cycling of excavation soil and waste control was appropriate for our design research through sustainability issues. The construction process based on block formation and molding challenged the use of our digital design and fabrication strategies through block-mold form explorations to improve the performances through ecologic design.

We worked with a concrete facade company as our fabrication consultant [8] that uses advanced technologies for computational design and fabrication and had a factory in Düzce which have become a research-center beyond a fabrication area via supporting various research-development projects. They sponsored our project via fabricating our molds, opened up the factory for block production, helped us through workmanship, and organised all of the logistics required for carrying the fabricated blocks to Karaalioğlu Park, Antalya, and also on-site application process.

That support for the fabrication process was the determinative factor about all of the decisions taken for design development and application phases. Fabricating the mold, required the analysis of our building block geometry based on *Gyroid* model, and various mold types are explored in order to correlate with rammed-earth building techniques. Through various attempts, the mold is fabricated as a two-layered system made up of plasters and rubber; elevated via steel profiles for ramming operations; divided into three basic parts for the appropriate dismantling of the mold 'Fig 4'.

Figure 4. Explorations with the mold, at Fibrobeton Facade Company Factory at Düzce.

Figure 5. Material explorations at Fibrobeton Facade Company Factory at Düzce.

We explored the appropriate material mixture to be used in our wall blocks which has curved parts and large openings, and ended up with a mixture based on *Alker* which is improved by additives such as fiber glass, perlite and acrylic as a retarder agent, 'Fig 5'. After initial trials at our departemnts' fabrication laboratory, it became obvious that we needed to continue the fabrication process at the factory which has cranes, more space for hardening process and workmanship support.

4 FABRICATION PROCESS: A SINGLE MOLD, VARIOUS SPACES

After the fabrication of the mold, and finding out the appropriate material mixture, we started with time-planning for the production and application of Common-Action Walls project. In the application project ,we proposed a double-sided wall, composed of 12 blocks, thus 24 blocks shoud be produced . The wall is 280 cm long, two walls taking up 80 cm in width, and 150 cm in height, 'Fig 6'.

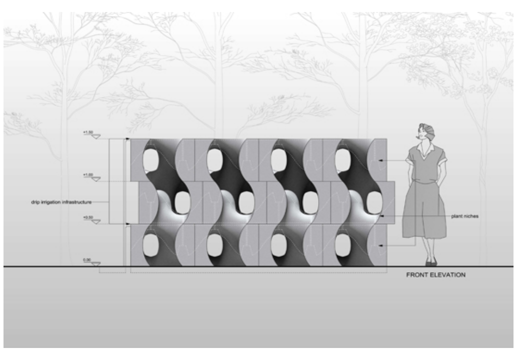

Figure 6. Elevation of Common-action Walls by POTplus Design Research Group

After various trials, the fabrication consultants convinced us to integrate the rammed-earth blocks with a thin steel rod frame in order to increase the blocks stability and durability while using the same rods for the crane lifting operations. The fabrication process started by composing the material mixture; adjusting smaller granules via earth sieve, adding the ingredients according to their decided ratios; ramming the mixture within the fabricated mold in phases; adding the steel frame; filling all of the mold in at least five phases; adjusting the upper face of the block with an additive mold to open space for the drip irrigation canals; leaving the mold for hardening; dismantling the mold; aligning the block to the reserved place in the factory 'Fig 7'.

Figure 7. Fabrication of the blocks at Fibrobeton Facade Company Factory at Düzce.

Figure 8. Assembly of the blocks at Fibrobeton Facade Company Factory at Düzce.

The optimised dimensions for each wall block was 70 cm. length, 40 cm. width, and 50 cm. height. The standard mold is dublicated for fast and parallel production. After reaching a required number, we tested the assembly of the hollow rammed-earth masonary via rotation operations 'Fig 8'. We also tested the integration of drip irregation system [9] and planting of the edibles and therapeutic herbs. After one-month fabrication process, 24 blocks had been produced and prepared for transportation via wooden frame modules.

5 ON-SITE APPLICATION: A VERTICAL GARDEN WALL

We had two days for the applications on-site according to Biennials' programme. The blocks carried to its place by a truck, and landed on its place, the green refuge of the main pedestrian road in the Karaalioğlu Park by a forklift 'Fig 9'. The green park ground is prepared for the integration of our drip irregation system with the park irregation system, and also for levelling by our materail mixture. It took one day to assemble the blocks of the double-sided wall in its place 'Fig 11'. During the masonary operations, the drip irregation system is applicated. The drip irregation project involved one vertical main pipe attached nearby the wall, 3 branching horizantal pipe axis passing through our rammed-earth blocks, and thinner pipes reaching to each pot, passing through holes reserved in each block.

Figure 9. On-site application of the blocks at Karalioğlu Park, Antalya,for IABA 2017.

The other day was used for planting issues. Common-action Walls perform as a vertical gardening wall involving 48 pots within the building blocks, some of which are plants enabling upside-down growing 'Fig 10'. Our landscape and permaculture consultant shared her knowledge about chosing the edible plants, integrating the irregation system and various issues about urban farming; based on permaculture principles of biodiversity and cyclic design [10]. From the point of growing plants, if you compare the lay out area of this wall, you can grow an amount of plants which is 5 times more than the capacity of this area by using this vertical gardening wall. This drip irregation system exposes the use of sustainable infrastructures by reducing the water used. It also exposes that rammed-earth walls are appropriate for any kind of infrastructure integration now that you can reserve any holes in the blocks via molding techniques.

Figure 10. On-site application of the plantings and drip irregation at Karalioğlu Park, Antalya,for IABA 2017.

Figure 11. On-site application of Common-action Walls at Karalioğlu Park, Antalya,for IABA 2017.

6 CONCLUSION

Common-action Walls are the prototypes in a design research process that inquire about the potentials of architectural components to generate solutions in between inter-sections of the city and nature, interior and exterior spaces.These walls are also the experiments to integrate local and traditional building materials and construction techniques with advanced digital design-production technologies[11]. This first prototype wall is an innovative proposal through a sustainable, economic and ecological architecture which is selected in the annual of best architectural practices, *Arkitera Mimarlık Yıllığı 2017* and also awarded by Honourable Mention Prize in *S.ARCH 2018* the Sustainable Architecture Conference Awards in Venice [12]. This design and fabrication strategy of Common-action Works reveals the interdisciplinary process entailed for ecological architecture and the support of computational methods for reaching that goal.

This experince is furthered by a summer school in Bilgi-Graduate Programmes studio, *Robotic Earth Crafts* in 2018 'Fig 12'. In that studio we fabricated the molds via robotic foam cut at our departments' fabrication laboratory and used the same material mixtures for creating permaculture structures with groups of students[13]. With my thesis student, we worked on biomaterials to further the structural perfromances of rammed-earth walls[14], and will begin an interdisciplinary research project in October 2019, which will involve another Common-action Wall to be used as part of a public space for a city council.

Figure 12. Robotic Earth Crafts summer school graduate studio at Bilgi University by POTplus.

Previous Common-action Works and our recent work Common-action Walls had been analysed as "Ecological catalysts in public space" [15] which we hope to reach as a a goal.

7 ACKNOWLEDGMENTS

As the founders of POTplus Design Research Group, Tuğrul Yazar and Fulya Özsel Akipek, we would like to thank to Bilgi University Department of Architecture, for encouraging us through all of our design reserach projects and opening the departments' fabrication laboratary facilities through all of our research projects, espacially to our Head of the Department of Architecture, Şebnem Yalınay Çinici.

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Tradational wooden houses as a container of life patterns: A detailed study of Architectural spaces and elements of houses of Neelum Valley, Azad Kashmir, Pakistan

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ABSTRACT

Neelum valley, located in the eastern part of Azad Jammu and Kashmir. Traditional wooden / wood log houses are successful examples of buildings for extreme cold climate. These buildings are successful in such severe climate because the design and style is derived from old traditions and use of local available building material and being practiced in the valley and adjutant valleys of similar climate from centuries. The regionally developed architecture is more climate responsive.

This study is about architectural elements and properties of traditional houses of Neelum valley, layout, plan, traditional architectural features and uses of various spaces in the house, and effect of these traditional elements, spaces and materials on the daily life activities or pattern of the local community.

Today in the era of development and world as global village, technological advancement, techniques and materials new buildings are being built, but the climate design factor is not being considered. As a result these buildings are not supporting traditional practices and patterns, resulting in discomfort, discomfort in sense of spaces and thermal as well. The change in design and layout resulted in change of traditional pattern and practices, which is not being accepted by the local community.

The aim of the study is to emphasize the use of traditional architectural elements and layout as being practiced for centuries in the valley and make them more energy efficient resulting in more appropriate buildings for the climate and environment and not adopting an alien design with foreign materials in such harsh climate.

Keywords: Tradational Architecture, Wood Log Architecture, Pattern Language

1 INTRODUCTION

Over last 20 years significant transformation has taken place in the country in general and specifically in the research area, Neelum Valley. These transformation are stimulated both by the economic development of the people of the region along with introduction of new techniques and materials due to the globalization factor. Another important factor behind this development is the cease fire agreement held between Pakistan and India over the line of control back in 2003. (Akhtar 2017) Tourism also flourished in the area after the cease fire agreement.

Neelum Valley falls in Muzafarabad division and was part of Muzaffarabad district until 2008. Valley is located in the thick forests of greater Himalayas and accumulates snow in winters from Kel to Hilmat / Taobutt regions. The area has greater potential for nature tourism as the valley contains thick forests, beautiful lakes, natural sceneries and remarkable wood log architecture. (Akhtar 2017)

1.1 The Earlier History

How people started their settlement here is such harsh cold climate is still a question mark for the researchers but some social scientists are of view that while crossing passes from the north one of off-shoots of Aryans lost their way to India and settled here around 3000BC (Kaul)
Later with the spread of Buddhist religion in the Kashmir especially in the rule of Ashoka (The great Buddhist ruler) Shiva Temple was built in Sharda for the local community who were worshipers of Lord Shiva (Bazaz 1954). As this region became famous among locals and religious pilgrims local traders, Pandits and Kashmiri families started there settlement around the temple now called as Sharda (ur Rehman, Gardazi et al. 2017)

2 TRADİTİONAL WOODEN HOUSES OF NEELUM VALLEY

The traditional wooden houses of Neelum valley are utmost attraction to the tourists visiting the valley along with the traditional living pattern of the people. This is a fact that spaces you are living in effects the life pattern of the resident. Analysis of traditional architecture with reference to its temperature, humidity, environment and sound gives useful outcomes for consideration, where spaces are usually created to use the warmth of the sun or the shades to create cooling effect as desired. It is obvious that climate design can be well learned through the analysis of traditional indigenous architecture (Sözen and Gedík 2007).

With the advancement of technology in building materials and heating and cooling systems the traditional building techniques were no more used even climate design was ignored which resulted in the discomfort in the buildings or high use of energy resources.

The old houses of Neelum valley, Kashmir are the best examples for the buildings adopted for the cold climates. The basic climate characteristics are explained followed by general architectural elements of traditional houses of the Neelum valley with references to practices of the local community.

2.1 Climatic data:

Neelum valley is located north east of Muzaffarabad, capital of Azad Jammu and Kashmir (AJK) and has an altitude of 900m – 6325m above sea level. (Mahmood, Qureshi et al. 2011) neelum valley is the largest district of Azad Kashmir having total area of 3737 km2. The climate is very cold in winters (average: 0 to -6 ºC) and moderate summers (average temperature 20-30 ºC). Average annual rainfall is 165cm. majority of the area is covered with thick forests and plants. (Dar 2003)

3. THE GENERAL ARCHİTECTURAL ELEMENTS OF THE OLD WOODEN HOUSES

Figure 1: Taobat village

3.1 Description of Middle Class Family House: A case Study

3.1.1 Plan of the house

Middle Class family house is usually found two floor along with an Attic space in the roof. As a traditional development all the spaces in the houses are found similar in the traditional wood log houses, with minor changes in the interior division of the spaces. Even though all the spaces developed are meant for a purpose. All these architectural features explained below are result of a traditional / vernacular development as per the need of the local community in both winters and summers, considering the climatic conditions of the region.

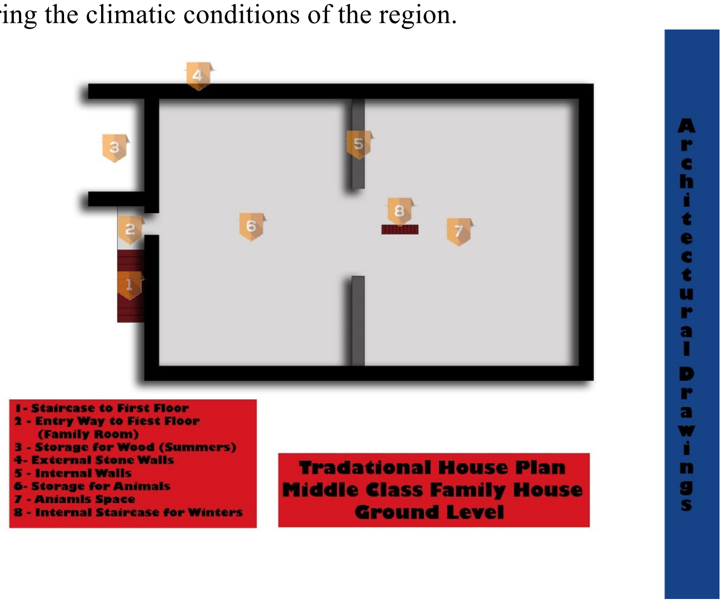

Figure 2: Ground Level Plan of the Single Family House in Taobat (Neelum valley)

3.1.2 Snow accumulation in winters around the house

As winters are very difficult in the region due to heavy snow accumulation around the buildings and in the streets, see figure 3, therefore to protect the building ground floor is constructed of free standing stone walls or stone masonry along with wood framing. This protects the house from damage from water and snow in cold winters.

Figure 3: Image of Taobat Village in December 2018

3.1.3 Animals in the Ground level in winters

As there is now way out of the house in winters due to snow outside therefore animals are kept inside the house ground level. This also transfers the warmth of the animals to the upper level through wooden floor in the house.

Figure 4: Entry to Animal Area at Ground Level

3.1.4 Collection of woods in summer for burning in winters

Space is designed outside the house for storage of wood for the summers as wood is only available fuel to keep the houses warm

Figure 5: Collection of wood outside house to be used in winters

3.1.5 Elevated entry for the First floor

Due to snow accumulation outside the building the stairway / entry of the house is kept high (At least 6 Feet from ground level – Depends upon the level of snow in the area)

Figure 6: Picture describing elevated entry to the house (Upper Taobat Village)

3.1.6 Storage for animal's fodder

Animals fodder is stored in the Ground level along with the animals so that in winters they can easily feed their animals.

Figure 7: Inside of a house (Animal Area)

3.1.7 Access to Ground level in the winters from inside the house

As exterior access is not accessible in winters due to snow an internal ladder entry is placed inside the house to access the Ground Level in the winter season to feed their animals

Figure 8: Inside access to the lower level (Animal level) wooden ladder

3.1.8 Hard flooring in ground level for animals
As for the animals and melting water in the ground level as hard surface is required in the ground level therefore stone flooring is used in the area.

3.1.9 Spaces in First Floor (family living area)
Family Spaces like living room, kitchen, bedrooms, bathroom and other spaces realated to family living are all arranged on the first floor, and vary according to the family size.

Figure 9: First Floor Level Plan of the Single Family House in Taobat (Neelum valley)

3.1.10 Need access to the first floor (family house) in winters
As there is snow outside the house in winters therefore entry to the house is kept raised at least 6feet above the ground level, so that snow accumulation cannot block the entry to the house

Figure 10: Access to the living area from Outside (Elevated entry)

3.1.11 Space required for male visitors
If the male visitors form the neighborhood visit any house they usually cannot enter into the family room therefore a space is planned at entry for the sitting.

Figure 11: Front Elevation of the House (Showing Various Spaces)

3.1.12 Warm room for sitting in winters

Activities are usually clogged in winters due to snow, therefore a single room is kept warm for the whole family. Wood stored in the summers is utilized here. Same room is used as kitchen and family sitting and as sleeping room in winters. As described in figures below (See Figure 12 and Figure 13)

Figure 12: Central Hearth / Storage

Figure 13: Sitting place inside the Kitchen

3.1.13 Separate rooms

As per family size separate family rooms are designed inside the house around a corridor, house size w.r.t. rooms varies. Same as the depth of the house increases.

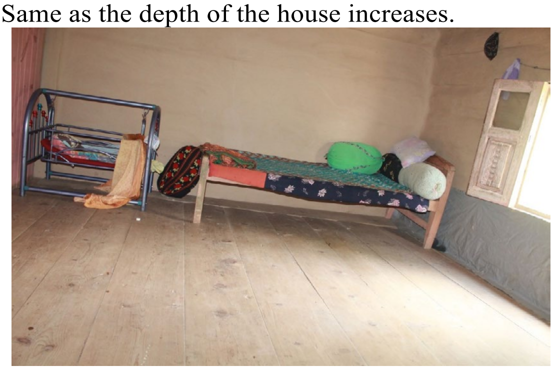

Figure 14: Bedroom (Separate for Married Couple)

3.1.14 Family activity area in summers

Separate family terrace is left at the back of the house, this usually carries a ladder entry to the Attic as well.

Figure 15: Family Terrace at the Back of the House

3.1.15 Internal access to the basement in winters

Internal access to the basement is required therefore it is placed in the center of corridor to the rooms almost at the mid of the house.

3.1.16 Thinner walls at interior

Walls inside the house are kept little thinner as they are not exposed to the harsh weather as the exterior walls. Therefore wood planks are used instead of wood logs. This is also because they need lighter interior walls for structural stability.

3.1.17 Insulated walls for winters

Heating room is the utmost important thing in winters, therefore exterior walls are kept thicker to insulate the interior from the cold outside and cladded with Mud plaster. The plaster needs to be fresh every year before winters.

Figure 16: Outer Mud Insulated Walls

3.1.18 Small windows for less air flow in the rooms

Small windows are placed in the rooms for less air flow to maintain interior temperature and light inside the room.

Figure 17: Small Windows as visible from outside

3.1.19 Access to Attic

An access to attic is required to store / dry grass for animals in summers and store wood in winters. Internal circulation / Access is required for movement in winters.

Figure 18: Wooden ladder access to attic level

3.1.20 Washroom outside the house

Washrooms are always left outside the house, usually right at the front in the covered veranda space. Attached from outside.

Figure 19: Washrooms are parasitic structures

3.1.21 Insulation from the roof / pitched roofs for snow / Wooden Roofs

Roofs are made of wood for better insulation from the snow and low temperature outside in the winters. These roofs needs repair and maintenance every year but traditionally a suitable developed way to protect inner heat loss.

Figure 20: Wooden roofs for better Insulation

4 CONCLUSİONS:

Form all the above-mentioned architectural features it was concluded that in traditional architecture, specifically old wooden houses of Neelum valley, each of the space in associated with some sort of developmental factor and hence needs to be retained for the upcoming generations as an example

It is also concluded that in general circumstances tourists are more attracted by the traditional architecture and their living pattern, therefore existence of the traditional pattern is more essential in tourist's perspective

The current traditional houses meet the social and climatic needs of the residents, therefore it needs to be preserved as cultural asset and in future development the similar pattern may be replicated.

4.1 Future Recommendations:

To enhance the Socio – Economic conditions and preserve the cultural assets of the region and develop sustainable tourism following measures are recommended:

- Paying Guests facility and Traditional food restaurants
- Cultural Museum along with Art and Craft display center and tour guides
- Protection of local ecology and land use
- Planning guidelines regarding use of new building materials in sustainable way but keeping the traditional elements and comfort

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Adobe Houses User Satisfaction and Preferences: The Case of Kırşehir

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ABSTRACT

Architectural practices, built with traditional construction techniques using local and natural materials, have provided environmentally conscious and sustainable solutions for centuries. One of the oldest traditional building materials used in Anatolia is adobe. Adobe is a contemporary material that is respectful, sustainable and improving material for nature. This material reflects the living culture and climate of its surroundings with architectural forms and construction techniques. Few contemporary approaches tend to use the new structure of the material in Turkey, though still remain in the traditional rural architecture material attributes. Most of the samples are destroyed and the buildings where unhealthy materials are used are being constructed. The most important condition for the protection and sustainability of mud brick buildings as a cultural heritage is to provide the original function of the house and to ensure its conformity with the modern conditions of use. It must meet the basic requirements for livability or minimum use. In order to determine these criteria, it is essential to evaluate the usage process and define the satisfaction of the user. The ways of preserving and maintaining the physical and spatial characteristics of adobe houses are defined according to the needs and expectations that differ according to the user, their ease of use and difficulties. From this point of view, the level of availability and user satisfaction of these houses is defined in Kırşehir province. Traditional residences which still exist in Kırşehir province, Ahi Evran District, Sıtmasuyu, 611, 645, 647, 657 streets and Kuyubaşı Street were evaluated face to face in terms of their structural characteristics, space organization and user behaviors, living habits and evaluated with survey method. As a result of the study, usage satisfaction and problems were determined and solutions were proposed about the problems.

Keywords: Adobe house, traditional house, user satisfaction, Kırşehir.

1 INTRODUCTION

The adobe soil architecture, which is one of the oldest forms of architectural construction in the world, also varies in the construction technique in the proportion of the geographies applied. This technical diversity can be a signal of the diversity of solutions in the context of sustainability and improving structures, which are the most important debates of the architectural agenda in recent years.

The assortment of earthen structures ranges from basic structures to tremendous, fantastic destinations of high multifaceted nature. In reality, earthen locales make 10 percent out of the World Heritage List of UNESCO. Yet, numerous critical locales are compromised; 16 of the 100 places on the World Monuments Watch 2000 List of 100 Most Endangered Sites—just as 57 percent of the destinations of the World Heritage List in Danger—are of earthen development [1].

The adventure of mudbrick, which has lasted for thousands of years, has created an architectural culture and has been the source of the earth, which is the source of life. Adobe remains a dominant building material in many parts of Africa, Asia and Central and South America. According to the United Nations, an estimated 30 percent of the world's population lives in houses made of clay [1]. In Anatolia, adobe has become an important construction material. It is seen that adobe material is used together with stone or wood material depending on the climatic characteristics and economic conditions of the region. As it is a material and technique used in Anatolia for centuries, adobe is well known to the public and therefore the buildings can be built by the people themselves without the need for technical support. Especially in Central and Eastern Anatolia which has difficult climatic conditions, sun dried bricks (mudbrick) can be produced with almost no energy. In this sense, it has become an ideal building material in terms of ecology, energy criteria used in the production of materials [2].

An agricultural country, Turkey has an important rural heritage society. With the extension of urbanization to rural living areas, these buildings remained neglected and few of the examples were destroyed. As a cultural heritage, it is important that mudbrick architecture is preserved and transferred to the future in order to contain the traces of a life style. The most basic condition of protecting this heritage is the fact that these structures become living structures together with the detection and registration stages. When the facilities are created to provide the comfort of life required by the users, the buildings will become more attractive for living. In this context, it is important that users evaluate their environment. Satisfaction assessments, which vary according to person, time, social measures and expectations, contain answers to improve the environment of the people. As a result of the interaction of the evaluations of the users about the house and their close environment with the evaluations related to their expectations and satisfaction levels; results in satisfaction, preference, adaptation or changing the environment will guide the needs and interventions to improve unsatisfied conditions in these areas.

In this context, face-to-face interviews were conducted with the users of mudbrick houses in a part of Kırşehir Ahi Evran Neighborhood, which reflects the characteristics of mudbrick construction technique in Central Anatolia Region, and questions were asked to measure their satisfaction. In the light of the data obtained, the satisfaction levels of the users, the reasons for choosing this region and their desires to change were revealed.

2 ARCHITECTURAL FEATURES OF ADOBE HOUSES IN KIRSEHIR SITMASUYU NEIGHBORHOOD

Located in the Central Anatolia Region, Kırşehir is a settlement where the forest areas are generally weak and steppe vegetation is dominant [3]. However, the area selected as the study area is close to Kılıcozu Creek, which causes the area to be wetland. In addition, the active use of the case area contributes to the green and well-maintained appearance of the settlement.

The residences in the study area reflect the examples of the traditional architecture of Kırşehir built in mudbrick masonry system. The central district of Ahi Evran is a settlement developed next to Sitmasuyu, 611, 645, 647, 657 streets and Kılıcozu Creek which includes a part of Kuyubasi Street. The building stock of the settlement consists of mosques, residences, primary schools, factories and public buildings. Therefore, the region is a rural settlement within the city.

Other service units (barn, bread, wc etc.) are added to the single or two storey residential buildings in the garden. Again, in this garden, the users of the housing, planting and livestock works to meet their needs. The garden is an important place where daily works and social life take place and production continues.

In this study, traditional rural architectural structures detected are mudbrick masonry. The foundation of the buildings and the part up to the basement level were built as stone masonry.

Wooden beams are used at the height of the floors and the eaves. The ground floor pavement of the houses was left ungrounded. Wood is used in the upper floor flooring carrier and coating. In the houses where window and door lintels are applied as wood, ceilings (wooden beams + wicker cover on the top) are applied on the ceilings. The facades of the houses are covered with mud plaster and lime whitewash as the building material is adobe. Thus, the structures were tried to be kept as far away from negative external influences as possible [4].

The residences, which constitute the study area, have a plan scheme that can be accessed from rooms with a middle hall and rooms [Fig. 1]. All of the units constituting the residence or the unit which is used as a living space is located in the garden in a way to give way to the road. The buildings are accessed through the garden. In single-storey houses, one of the spaces opened to the sofas is used as kitchen, the sofa and other spaces are used as living rooms and bedrooms. The sofa, which generally functions as a living space, is a place where the stove is burned in winter and can be used as a bedroom due to the hard winter months. Some houses have niches with heights and wooden covers. Stables and bakery spaces are generally located adjacent to the building in the garden. In two-storey houses, the kitchen and the room are accessed from the lower floor, and the spaces accessed from the sofa are used as bedrooms or living spaces. The stairs leading up to the upper floors of the houses are located outside the structure [4].

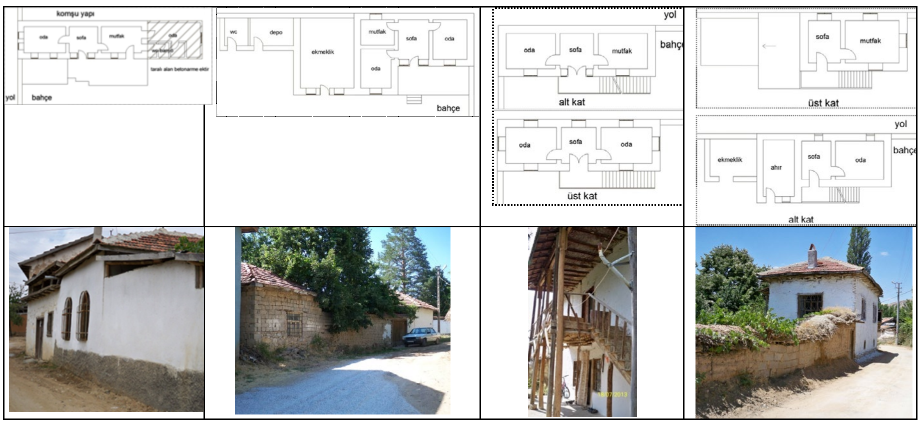

Figure 1. Examples of single and double storey housing from the case area [4,5]

In area, which is a modest settlement, the facades of the housing are undecorated and quite plain. Only one of the houses had wooden decoration details on window sills. All the windows and doors of the spaces are wooden and without details. Almost every house has windows on both sides of the lower and upper floor entrance doors. Windows can be double and single-sashed, as well as species with fixed sections on both sides of the sash. These windows are carried in the interior with the help of wooden pillars to create a different detail.

However, it is seen that the unused or periodically used houses have melting on the wall surfaces due to neglect. According to the information obtained from the archives of Kırsehir Municipality, Sıtmasuyu Residences which are the subject of the study area are unregistered. For this reason, it has been documented that in some houses there are interventions that can be taken into the simple repair class.

3 MATERIALS AND METHODS

In this study, 18 adobe houses with unregistered historical traditional characteristics located in the central district of Kırsehir province, Ahi Evran Neighborhood, Sıtmasuyu, 611, 645, 647, 657 Sstreets and some part of Kuyubaşı Street were evaluated. In addition to assessment, observations and determinations, a questionnaire was applied to determine the qualifications of users and to measure the level of satisfaction of users. The participants were asked about their demographic information (gender, age, educational status, occupation), housing usage periods and property status. In order to measure the usage of the house, the number of floors, number of inhabitants and number of rooms were asked. In order to measure the satisfaction of the users on the environmental and residential scale, they were asked to choose by asking alternative questions. Finally, a 5-point likert scale was used to measure the user's physical satisfaction with the housing and its immediate surroundings.

4 FINDINGS AND EVALUATION

In the questionnaires, the number of users in the houses, the education level of the user, the occupational classification of the user, the periods of housing use and the status of ownership and the satisfaction analysis were evaluated.

The survey was conducted with 18 people, of which 10 were women and 8 were men. The average age of the people living in the houses is high as shown in the table below, which gives the age ranges of these people that we can qualify as the head of the house. 10 of the subjects were older than 65 years, 3 were between the ages of 55-65 and 4 were between the ages of 45-54 (Fig. 2). There are 4 people living in 2 of them, 3 people living in 2, 2 people living in 8, and 1 person living in 6.

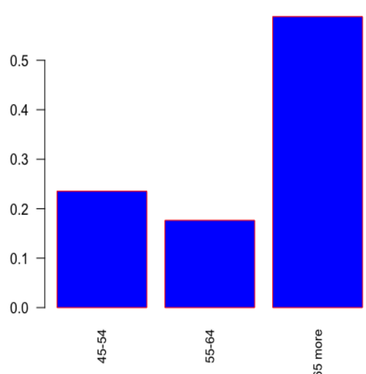

Figure 2. Age ranges of users

When the educational status of the families using the structures was evaluated, it was seen that the heads of the families were mostly primary or high school graduates (Fig.3).

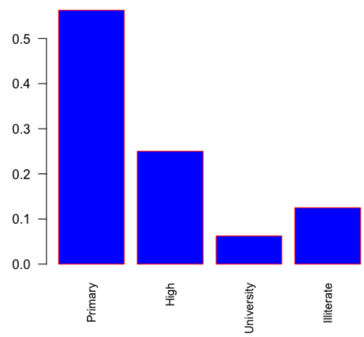

Figure 3. Education status

When the job status of the participants is examined, it is seen that they are mainly retired. Of the 18 people interviewed, 12 were retired, 2 were doing livestock, and 2 were not working.

Looking at the usage period of users of adobe houses, 61% stated that they lived in these houses for more than 40 years. These periods also affected housing ownership. The rental method is preferred for short-term use, while the long-term use is mostly realized by the landlords. As a result of the evaluations, it was determined that 71% of the users were homeowners and 29% were tenants [Fig. 4]. Some of the users of the buildings, which constitute the original architecture of the settlement, have second residences in the city center, but they use the residences in the study area during the summer months due to the difficulty of preparing winter food in the residences in the center. In the settlement, some users are living in their new houses, which they built as reinforced concrete by demolishing the adobe houses, while some users use the new concrete house they built in the same garden next to the adobe house which they consider as a warehouse. These users are permanently residing in their homes.

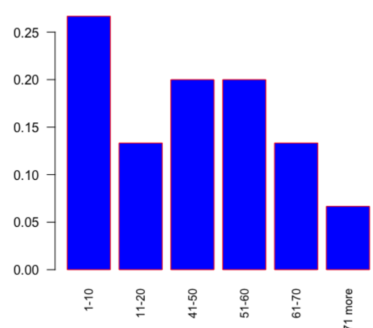

Figure 4. Residential use year

The users were asked the question in *'Why do you prefer to live here?'* 'The answers were as follows: s; (7), It is our own house '(7), It is warm in winter, cool in summer' (2), It is close to relatives '(1) [Fig. 5].

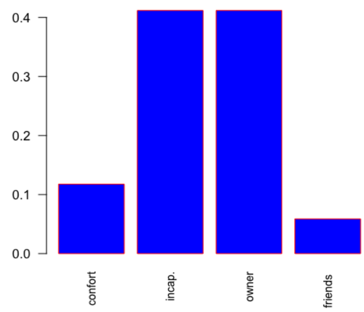

Figure 5. Why do you prefer to live here?

The users were asked the question in '*What are you like the characteristics of the house you live in?*' The answers were as follows: 'Clean air and green environment' (8), 'Social life / neighborhood (2), 'I love everything' (4), 'Our experiences' (1). In addition, there were those who said that they were not satisfied with the environment they lived in (2) [Fig. 6].

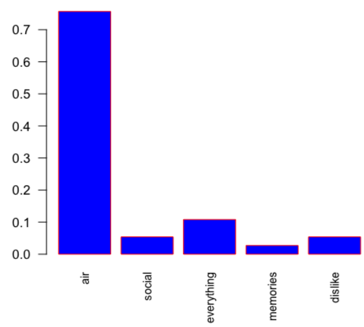

Figure 6. What are you like the characteristics of the house you live in?

The users were asked the question '*Which features of the house and the environment you are not satisfied with*? '. The answers received were 'Nothing (14)', 'Outdoor alcohol consumption (2)', Inadequate built environment (2) [Figure 7].

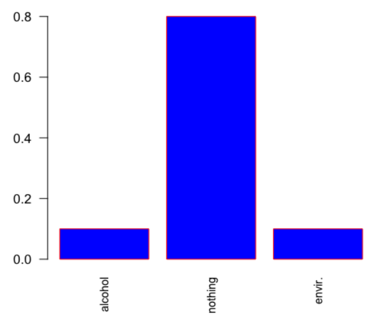

Figure 7. Which features of the house and the environment you are not satisfied with?

In order to measure the usage satisfaction of the users for the building, the questions aimed to measure the user satisfaction in the *use of interior, facade, roof, garden or courtyard, security, thermal comfort, size and daylight* were asked. The answers were measured using a 5-point Likert scale. Satisfaction scores obtained from numerical values of all answers were evaluated over 100 points. According to this evaluation, 11% gave 0-25 points, 11% gave 25-50 points, 47% gave 50-75 points, 29% gave 75-100 points. Based on this data, it can be said that the users are satisfied with the use of their houses [Fig. 8].

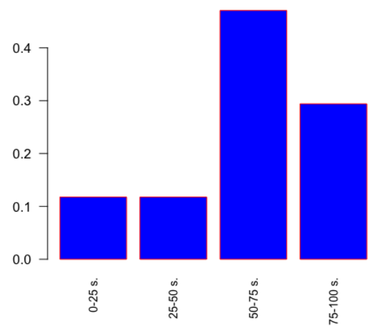

Figure 8. Usage satisfaction

5 RESULT

Regularly saw as just a vernacular type of design, new earthen development—abetted by the natural development—has seen expanding institutionalization and industrialization in ongoing decades. In any case, the protection of earthen engineering has been slower in its advancement. Advancement in protection and in new earthen development is from numerous points of view between dependent; the coherence of the custom of structure with earth educates preservation practice, while conservation of this significant engineering inheritance moves its future use. However protection of earthen design is as yet making its mark as an order [1].

As with all architectural buildings, the main reason for the deterioration in adobe buildings is the use or neglect of the building. In order to prevent the effects of adobe structures from environmental conditions, maintenance should be done continuously and the plaster should be renewed frequently. Therefore, an unused adobe structure is about to disappear. In the area where the study was carried out, most of the dwellings continue to live. The most basic factor in its existence as a continuous tissue is that its life continues.

The users of the houses examined in the study area have owned these houses for a long time and some of them have been inherited from the family. As a result of the evaluations described above, families who have lived in these dwellings for many years and have no financial problems have high satisfaction levels. Although these families have houses in another part of the city, they continue to use these houses, albeit periodically. Satisfaction of the users living in these houses due to financial inadequacy is very low and they want to move to a new house. However, all users agree that mud brick houses are difficult to maintain. In some residences, the presence of many additions arising from the need disrupts the originality of the buildings. Structures should be purified from these unqualified attachments. Due to the water impermeability of the adobe material, periodic maintenance and repair should be performed and contemporary materials and solutions should be utilized. In this region where the average age is high and the education average is low, users should be informed and technical support should be provided in order to transfer the heritage to the future.

With the national and international studies, effective policies and strategies should be established in the context of cultural heritage for the development and dissemination of the traditional adobe architectural heritage existing in our country and for the development and dissemination of the cultural heritage, and the traditional construction knowledge and production of the adobe heritage should be supported with holistic protection and sustainability [6].

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Architectural Approach and Design of The Restoration Project of the Seyh Süleyman Masjid

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ABSTRACT

As an international restorastion training project, "The Şeyh Süleyman Masjid", which is located on, Sinanağa Quarter in Fatih is in the area of 1st Grade Conservation Region according to the Conservation Map of Fatih. The restoration works of the building were started with the collaboration of the Directorate General of Foundations (VGM), Assorestauro, ICE and Emiglio Romagna depending on the protocol in between those institutions where technological potentials of the two countries were shared. The project was involved in the MED ART 1 organization as well and was completed on November 7th, 2016 while the construction started on September 25th, 2013. The building, whic has features of several different eras, is one of the important buildings in 'Zeyrek World Heritage Site".

1 INTRODUCTION

Restoration project consists of three parts as education analysis and application. The Italian experts were assigned, and other experts were later joined to the group in order to organize the material analyses and structural researches. The following steps were taken by the mentioned experts: Preparation of previous projects in terms of photogrammetry which had some measurement mistakes. Figure 1.2

2 THE ANALYSES OF THE BUILDING AND PROJECTS

Determination of structural anomalies of different periods in the building and surroundings in order to define the possible layers of the building belongings to different periods. Figure 2.

All the layers of the building (frescoes, plaster, wall ect.) were observed typologically and chronologically by taking samples. The mentioned examinations were carried out in the laboratories in Italy. Figure 3a-3b

Figure 1.2. Photogrammetric drawings of the building, The georadar implementation to define the gaps on the walls and plastered surfaces

Figure 3a-3b. Site works before the laboratory examinations.

Interpretation of the cracks, gaps and materials to define the structural problems. Figure 4

Figure 4. Examination of the micro cracks with camera.

During all the mentioned works, trainings have been organized both for the VGM stuff and experts from other institutions of İstanbul at the Fatih Sultan Mehmet Vakıf University. The examinations, which had been carried out by Italian experts, were presented to the attendants Figure 5.

Figure 5. During the trainings at site for the VGM stuff and other attendants.

Italian teams which worked at site and gave lectures of the trainings: Laser scanning works, 3D GPR-Radar Works, 3D ERT- Electrical Tomography Implementation Measurement of environment vibration to make dynamic analysis, Analyses of material and deterioration, Researches on frescoes Analyses of structural system, analyses of humidity problems, Energy saving systems. Using the laser scanning technology, a 3D model of the building was created in which every detail of the building either interior or exterior could be seen (Figure 6). Sections of several axises could be examined. Depending on the information got from those data, analytical survey drawings were detailed (Figure 7). Having benefits of this sort of method, documenting of historical buildings were revised and detailing of 2D documents in relation with 3D drawings were discussed. It is stated that current projection systems and tender documentation need to be improved accordingly.

Figure 6. 7. 3D modellings of the building, analytical survey of the building.

During the radar implementations, an archeological area of 4 m x 7,5 m was discovered in the courtyard of the masjid (Figure 8). The location of the well, of whose existance was known but could not be detected because of the floor coverings was also revealed. It was understood thta the crack on the east wall was ot a structural crack but was occured because of the junction of two different wall textures. Figure 9

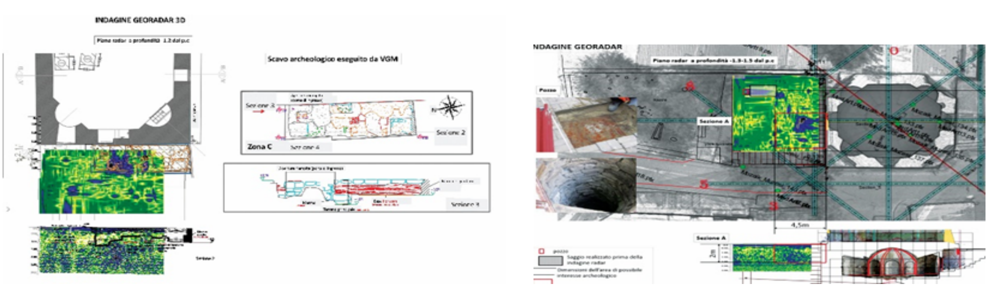

Figure 8.9. The geo-radar implementations in the courtyard, the geo-radar implementation which defines the hidden gaps on wall behind the plasters.

The electrical tomography implementation (ERT) showed that the foundations of the building are positioned 4 m below the ground level (Figure 10). It was understood that the water storage under the crypt was carved into the rock. Also the existance of the archeological area in the courtyard was determined by ERT. The data of ERT and radar confirmed each other on this issue.

Figure 10. ERT implementation surrounding the building.

Many studies on different issues about the building were carried out such as projection of material and deterioration, survey of the structural system, modelling, projection of reinforcement suggestions, climatization, water drainage and humidity balance of the building. Figure 11-12

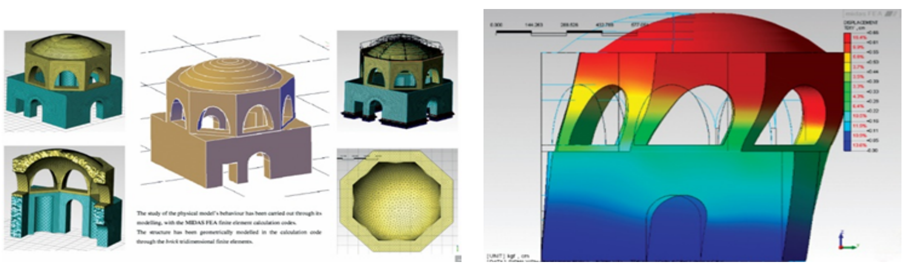

Figure 11-12. Structural modelling of the building.

The revised projects, which were prepared in Italian were presented to the VGM both in 2D and 3D. The translations to Turkish were done and the projects were sent to the Directorate of İstanbul Regional on August 1st, 2014.

The projects were modified as 'for construction' projects and were presented for the approval of the Conservation Committee with the translated reports. First, the reinforcement project was presented to the Conservation Committee and approved by the Scientific Committee. The building has an octagonal plan scheme with four main arches and four lateral niches.

The original entrance of the building on one of the lateral niches had been changed with one of the other niches opposite the altar probably to create space for the pulpit. During the restoration period, the material analyses showed that the original entrance was changed in the Ottoman Period. Depending on this data, the restitution projects were revised according to the latest era modification depending on the approval of Consultancy and Scientific Committees. Figure 13

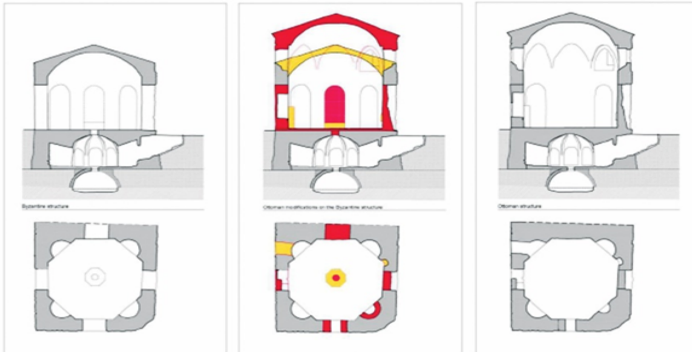

Figure 13. Steps on the evolution of the building: Original Byzantine Era, repairs, Ottoman Era.

3 RESTORATION WORKS

Since it was understood that the previously mentioned annexes belong to the Ottoman Era depending on the historical researches and material analyses, the restoration project in which the annexes are protected (the existing entrances and windows) were revised. Figure 14. After removing the concrete floor covering in the masjid, the surviving original Byzantine flooring, which did not seem in good condition was revealed. It was reported by archeologist Zanini that, this original and octagonal planned flooring had been designed as a central hall in order to reach the water necessary for the baptism. The area was cleaned and protected originally. The relation of this octagonal scheme with the crypta could not be explained. The crypta (grave), which had stayed closed before the restoration, was designed to be visited by protecting the original interior features after the restoration. The architectural construction of the Şeyh Süleyman Masjid has similarities with many other baptisteries in terms of Byzantine Era flooring design and four niches formation reminding of four entrances. In other buildings, there exists a constructive arch in order to carry the tambour. Some examples are seen on the photographs below to compare with: The Baptistery of Ravenna Hagia Sofia, the Ravenna Neonian Orthodox Baptistery and the Albenga Baptistery in Italy (SV) Figure 15-16-17

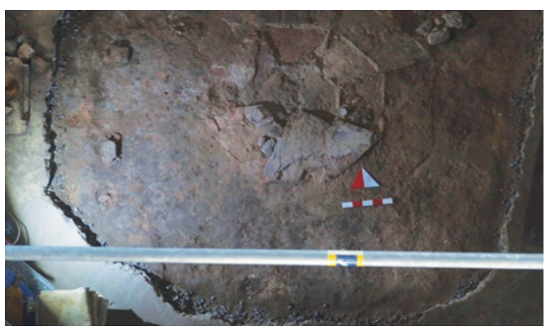

Figure 14. Exterior view of the niche which the original entrance is positioned, Original flooring plan of the central hall.

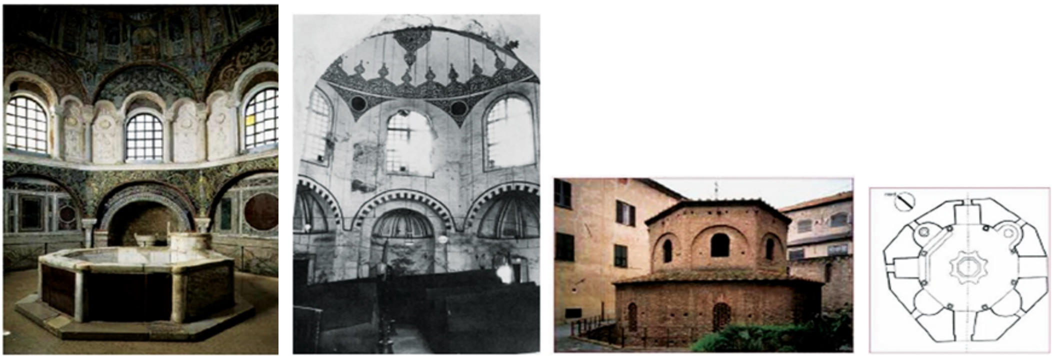

Figure 15-16-17. Similar baptistery examples: the Ravenna Neonian (interior view), the Hagia Sofia (interior view), Albenga (plan and exterior view).

In the Ottoman Era, the dome was filled and arised thus the building had a new elevation. The building had modifications in accordance with a tekke firstly and then with a masjid in terms of altar, niches and frescoes depending on the Islamic rules. The frescoes and the lettering at lower levels were cancelled by painting over and renewed partially untill the arch level. All the mentioned layers were revealed during the restoration and protected. A new ablution place was built as a later addition. Furthermore, the windows were placed with concrete frames. During the restoration period, the mentioned wall was rebuilt in original style. Figure 18, 19. 20, 21,22, 23, 24. The Şeyh Süleyman Masjid is a building which has its own features and the traces of the past as well. It has been an opportunity that the interventions carried out till present did not demolish the traces of past. Each touch of restoration has been carried out depending on the detailed projects which were prepared after comprehensive analyses and researches.

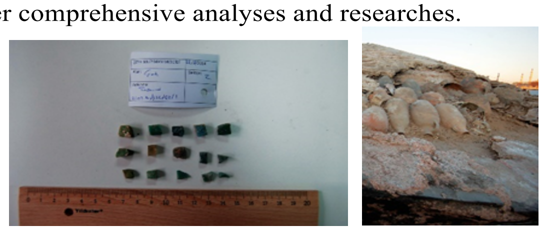

Figure 18. 19. The tessera pieces of the dome filling, the raised dome with the amphoras.

Figure 20-21. View of the walls before restoration and after scapering.

Figure 22-23-24. The condition of wall; in original, during the 20th century and after the restoration.

All the steps starting from the historical background to the chemical formation of different era mortars were carefully taken on site. In other words, all the implementations were carried out according to the diagnosis defined depending on the 'clinical history' of a patient. The original view of the building after restoration is a conclusion of this special work and period. The best way of implementation of a restoration project is reflecting all the results of the analyses to drawings and charts in different scales and in detail with great care. Computerized axial tomography of the roof, walls and flooring of the building is reflected on the drawings. This sort of qualified project is a very good example for the following restoration projects and implementations.

4 CONCLUSSION

As a conclusion, detailed and deep examination of the building helped understanding and documenting the history of thousands of years. All steps of the research are necessary as it is for all successful projects. Having information on the building is the first step and is very important; usage of every material needs to be known. It is not acceptable to complete the project in the office. Knowing the building is only possible by studying on site, understanding the building and the continuity of the building just from the building itself. In order to understand the need of the building and to define the construction steps, the surfaces should be observed very well. The saying *'To know is to conservate* 'could be a slogan which summarizes this period. The restoration project should not compete with the importance of the building, it should be more modest than the building. The designer of this sort of project could accept staying background and should achieve being a 'conservator' who takes part in carrying the building from past to present. The incompatible interventions of recent years were considered as important period documentation. The restoration has not been one which defines an unknown period (Byzantine or Ottoman) or a hybrid character which has ever been existed. During the entire period, having the benefits of all skills has been the goal in order to remove the incompatible annexes and to make the building survive at the end of the period. The article shows a few photos the long working period. This restoration work interpreted on every probable intervention during the projecting period in order to prevent any changes of implementations. A multi-diciplined project is an ideal one on which historical, structural, electro-mechanical, lighting and archeological data could be seen together rather than just architectural data. Restoration project should usually be directed in a way to give and check information on other disciplines and to form relation in between. For instance; the projects on archeology, history of art, laboratory data, lighting and electricity should be designed in accordance with architectural project and with same importance. As mentioned in this essay and understood from the projects and charts of the essay, there is a collaboration of all experts and support of Med Art behind the great success of the project. Each information on the project has been reached by the experts and as seen from the graphics, a sort of x-ray view of the building has been created. The texture of rubble wall was not indicated by the AutoCAD hatch commands, instead they totally indicate the real texture composition of the building. They have been formed depending on the physical observation and survey methods. The project has been an example in terms of reflecting the changes during the implementations and designing accordingly after the whole period which lasted approximately three years. As a conclusion a real and conservative restorastion project has been realized within respect to both the building and the history of the building as well.

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Understanding the Relation Between Qanats' Branches and The Body's Development of Yazd City in The Different Historic Period

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ABSTRACT

The water supplying was one of the most important concern of the people that they live in the specific location especially in hot and arid region. The Kariz Civilizations which they could supply the water with underground channel was shaped almost three thousand years ago. Yazd City is located in the central desert of Iran and its body development has been occurred with some necessary infrastructures that the Qanat digging is one the most important. This paper aims to study and illustrate understanding the qanats branches on the arrangement of Yazd body's development in the different historic periods with the historical-analytical method. For reaching this goal, the data is gathered by the field and library study and survey the exist documents, thereafter the different maps of Yazd city in the different periods compare with the Qanats' map. The results show that the branches of zarch and waqf-abad qanats had the most relation with the development of yazd's body over the history.

Keywords: Qanat, Arrangement, Body's development, Historic periods, and Yazd

1. INTRODUCTION

The course of civilization is closed strongly to water [1] and the underground water id the main reason of human living in the central part of Iran [2]. The Qanat digging is the way of water utilization. Qanat is the underground channel which it has slow slope with some welds to provide the water. Actually, the Qanat is the underground drainage which it brings the underground water [3].

The relation between the Qanat network and city's body can analyze in the different levels. Michele Bonine (1987) researched about the Iranian cities which they are located in the desert and referred to the water supply by the Qanat is the factor for villages and cities locating, the manner of production and living establishment, and it has shaped the built environment of cities in the massive scope. Bonine believed that the Yazd city is the one of main City of Iran's dry and central plateau and it was established in the Sassanian period [4]. Yazd city is located in the east of Isfahan and it is besieged by the Loot and central deserts [5]. As far as the body of Yazd city has beed shaped in the different historic periods such as: Al Kakoyeh, Atabek, Al Mozaffar, Timurian, Safavieh, and Qajar. This research aims to analyze the relation between the Qanat's branches and the development of Yazd city's body in the different periods. So the research questions are discussed in the follow form:

1. Why does the relation between qanats' routes and Yazd city's body's development in the different historic periods inquire?
2. Which one of the Qanat branches had a relation with city's development in the different periods?

It seems that whatever has a flow underground shape the city's body on ground. Of course, it should be considered that some of channels only were crossed under a city to reach the objective city [6].This research can do with the historical analyzing method. So, first of all, the theoretical foundation about the Qanat and development of Yazd city's body in different period is surveyed, thereafter the analysis between both of them is done.

2. THE THEORETICAL FOUNDATION AND FRAMEWORK OF RESEARCH

2.1. The overall history of Yazd in the different historic periods

2.1.1 The Al Kakoyeh's period (almost 400-536 AH)

After the Seljukian army attacked to Isfahan, Abu Mansur Alaodoleh Kalanjar (The ruler of Isfahan) came to Yazd with his family and folk. He formed a local coherent government which it had a relative political independence. The significant change of Yazd belonged to Al Kakoyeh period which it developed Yazd from town to city that had bulwark and gates [5]. In this period, the trench, bulwarks, fence, and four iron gates were made in Yazd around [7]. The name of those gates are Kushkeno, Qatrian, Mahrijard, and Kia's gate which its location does not specified [8].

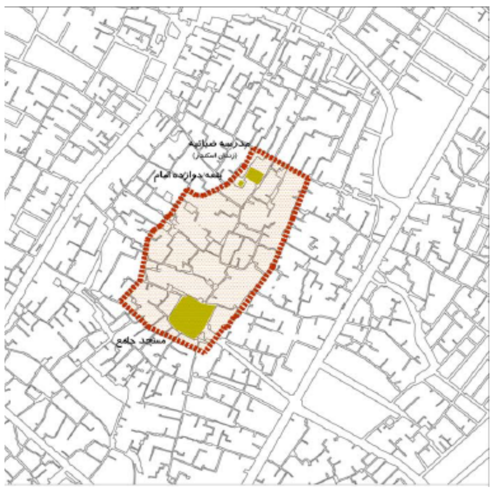

Figure 1. The territory of Yazd in Al Kakoyeh's period [5]

2.1.2. The Atabek's peiod (536-718 AH)

In 536, the last ruler of Al Kakoyeh's family died, after that the girls of him were the ruler of Yazd. A person who name was Roknedin Sam was determined for minister by Seljukian dynasty to guide them, so it caused the Atabek period to start. In this period, the city was developed to the North and Northeast direction [5]. Sam built the school which it was located in the near of Mahrijerd's gate and another school (Vardan-Ruz School) in the Delalan's Bazar. Mahmud who was another king of Atabek developed Yazd and built some neighborhood in the out of city range and made a vast field. His mother built the Maryam Abad village [7].

2.1.3. *The Al Mozaffar's Period (718-785 AH)*

In 698 AH, Mohammad son of Mozaffar fought with Atabek and won. The peak of Yazd's cultural flourishing belonged to this period. A lot of schools were built and Yazd city became famous to the city of science [9]. The different sciences were taught in Mosques, schools and convents [7]. This flourishing caused to change the body of city. In this period, the new wall of city was made and Yazd had 7 gates (Mahrijard, Qatrian, Ilchi Khan, Kushkeno, Malamir, Saadat, and Now) [9]. The new neighborhoods in the inside and outside of the city and new fence were built and a new trench was dug in the around of Yazd.

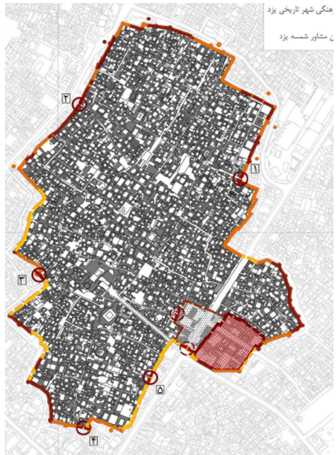

Figure 2. The territory of Yazd in Al Mozaffar's period [5]

2.1.4. Timurian (795-913 AH)

In 795 AH, the great Timur conquered Yazd [7]. The last of eighth and all of the ninth AH century was the worst time of Yazd, because of wars, blockades, and floods. Although the situation was inappropriate for developing, the new buildings were built in Yazd especially when the ruler of Yazd Was Amir Chakhmaq. The Mir Chakhmaq urban complex and new central mosque were built in this period in the outside of fence. Some new Bazar were constructed in the outside of Mahrijard's gate and it caused to shape the Yazd's bazar which it is seen nowadays [5].

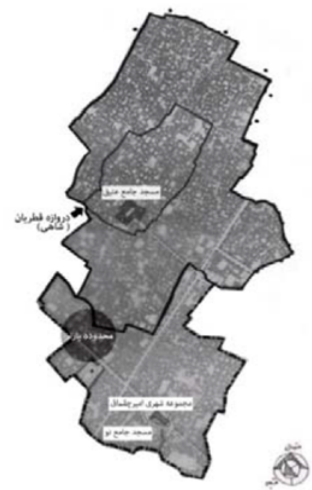

Figure 3. the territory of Yazd in Timurian's period [10]

2.1.5. The Safavian's period (907-1135 AH)

At that time, Yazd had a specific importance in trade, because this city had the high quality textiles and silk and another factor Yazd is located in the business path of caravan [7]. The commercial development did not match with the development of Bazar's structures and bodies. Unlike the last period, the schools making had not flourishing. Yazd did not experience the fundamental development in this period in compared with Al Mozaffar's period. The most important Safavieh's monument in Yazd was the Shah Tahmasb Square [5].

Figure 4. The territory of Yazd in Safavian's period [10]

2.1.6. The Qajarian's period (1208-1300 AH)

The period of power transition from Zandieh to Qajar dynasty was occurred peacefully. At that time, Yazd Bazar had a little activity, because Yazd had the commercial relations with Europe. The three bazars were added to Yazd Bazar. One was Moshir bazar which it was located in the south part of Yazd's bazar and in the near of Jafar's holy shrine, and others were Sadri and Afshar bazars.

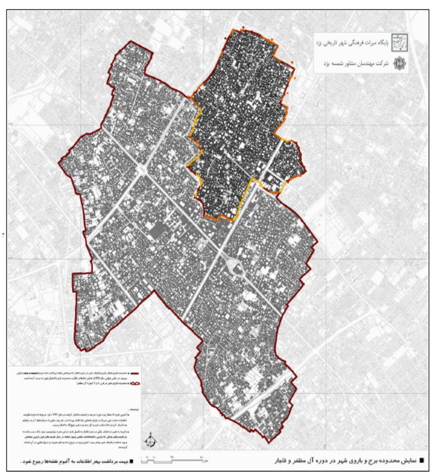

Figure 5. The territory of Yazd in Qajar's period **[5]**

2.2. The course of change, growth direction and physical development of Yazd in the different historic periods

Like any city, Yazd has experienced a lot of change over the history. The development of Yazd city has a close relation to its infrastructure. Yazd has had different buildings which they should be connected and worked with qanat. So the analysis these building can be shown the way of research.

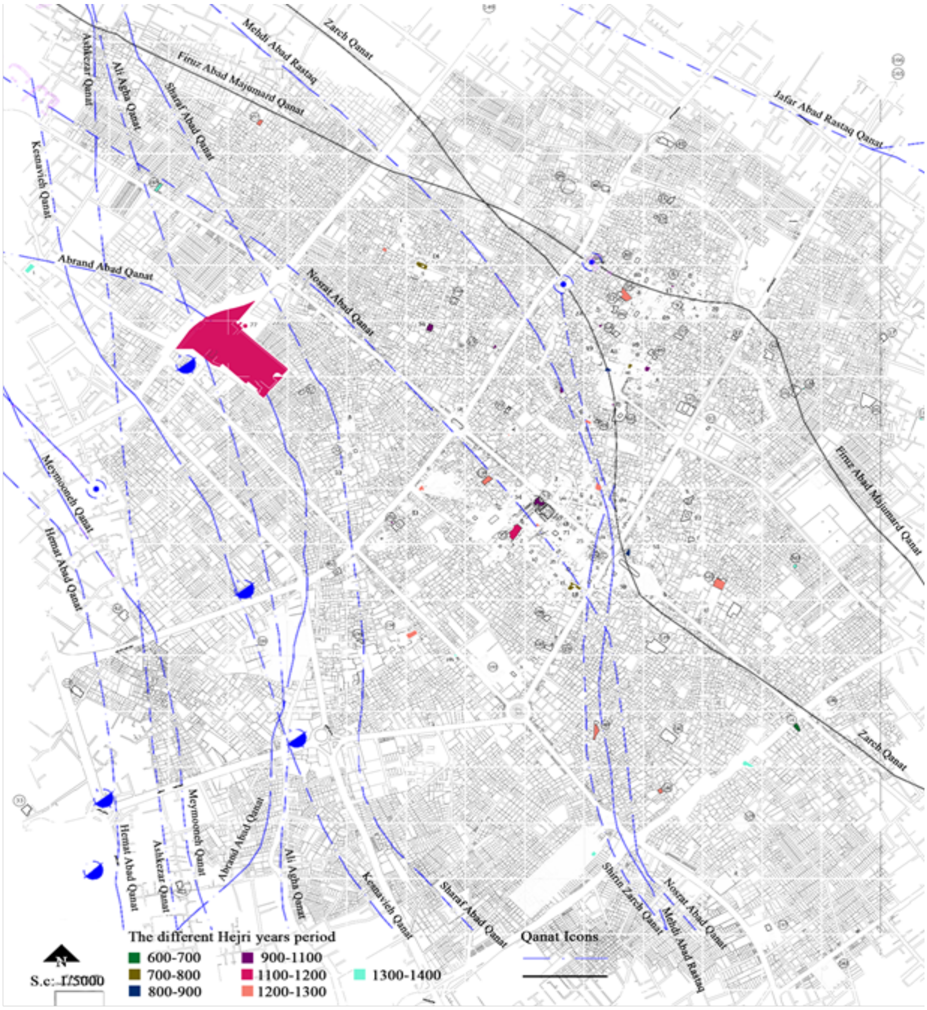

Figure 6. The yazd historic building which they have a relation with qanats in the differnet periods and qanats' routes [author]

2.2.1. The bodies development between "600-700" AH

No building which it had a functional connection with Qanat and went back to before 600 AH is not being except the cellar of Yazd's central mosque. The Zarch Qanat goes back to 3000 years ago and it crosses under the central Mosque. Between 600 and 700 AH years (it coincides with Atabek Period), there is no building which it is located in the new added part to city (North and North-East) and has a functional relation with Qanat. It may be caused by two reasons: at that time, none of buildings which they were built did not connect two Qanat or some buildings were built, but they were destroyed until we do not have information about them. The 4-Kuche water reservoir is only building goes back to this period [5], but it was located in the outside of the city and its location and distance with city in compared with Mahrijerd gate might illustrate that was located on the way of caravan. This reservoir is near to the route of Zarch Qanat, and it is connected to it probably by digging sub branch

2.2.2. The bodies development between "700-800" AH:

The city was developed to the south and south-east direction. The three buildings which they go back to this period had a relation with Qanat (Soltan Sheykhdad complex, Sahl-ebn-ali complex, and Vazir water reservoir). The Vazir water reservoir is located in the near of central mosque and Zarch Qanat route and it seems that has a relation with sub branch to Zarch Qanat. The Sahl-ebn-ali complex was located in the south, outside of the fence and along the Mahrijerd's gate. The map illustrates, this complex is near to Shirin-Zarch and Nosrat-Abad Qanats, but at that time the former one has not been dug [11], so this complex relates to Shirin-Zarch Qanat. The Soltan Sheykhdad complex was located in the west, outside of city, and along the Kushke-No gate. The three Qanats are crossed along this complex (Zarch, Firuz-Abad Majumard, and Mehdi-Abad Rastaq). It is not specified which channel has a relation with this complex, but the Mehdi-Abad Rastaq did not have a relation with it [11]. One of the important happening at that period was the devotion of Waqf-Abad Qanat by Seyed Rokn-edin [12]. The water of it came to city from Mahrijerd gate and it flowed on earth in the creek, after that it came into Sahebieh hospice, subsequently it crossed along the bazar and reached to new and old central mosque [13]. Everybody could use from this Qanat, because he devoted it. [14] believes that Qanat was reached on earth in the south-east of city and after that it flowed on earth and it used for the general using and irrigation of public green spaces. Finally, it reached and connected to Mazvir-Abad qanat. So it seems that the Waqf-Abad qanat may be the main factor for the city's developing to south at that time.

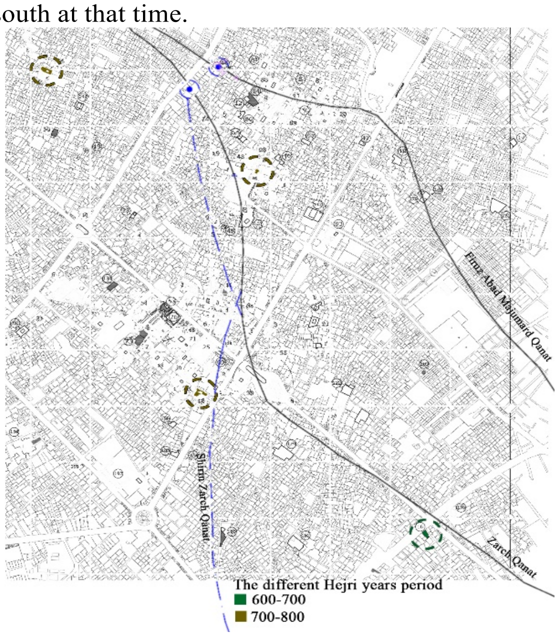

Figure 7. The location of Yazd historic buildings which they belonged to 600-800 AH and Qanats routes [author]

2.2.3. The bodies development between "800-900" AH

This period coincides with the Timuri dynasty. The map of Yazd at this time shows the direction of development to south. The two buildings which they are being now had a relation with Qanat (Jonk and Mir-Chakhmaq water reservoirs). The location of these is completely different with each other. The Jonk was located in the most ancient core of city and near to the central mosque while The Mir-Chakhmaq was located in the newest added part of city. Both of them are located on the Zarch Qanat route, so they are connected to it. But, some historical books refereed to others elements which they were joined to qanat. The following table shows those spaces' names and locations.

Table1. The refereed elements which they belonged to 800-900 AH [author]

Elements	location	Reference
Cellar	Sar-Rig Neighborhood	[9]
Masnaeh Water Reservoir	-	[8] & [11]
The Bagh is the outside of the fence	-	[11]
Do-Bagh	Gowdal-Mosalla Neighborhood	[11]

It seems that a Cellar was located in the Sar-Rig neighborhood. The location of this neighborhood is around the Nosrat-Abad qanat, but this was not dug at that time [11]. The referred Do-Bagh was located in the outside south part of city. According to map, the four qanats (Sharaf-Abad, Nosrat-Abad, Mehdi-Abad Rastaq, and Zarxh) cross from near the Gowdal-Mosalla neighborhood, but both of them were not made at that time. By the next period, a water reservoir would have been constructed in the Gowdal-Mosalla, and it would be near to Sharaf-Abad channel, so it seems that the Do-Bagh had a relation with Sharaf-Abad qanat.

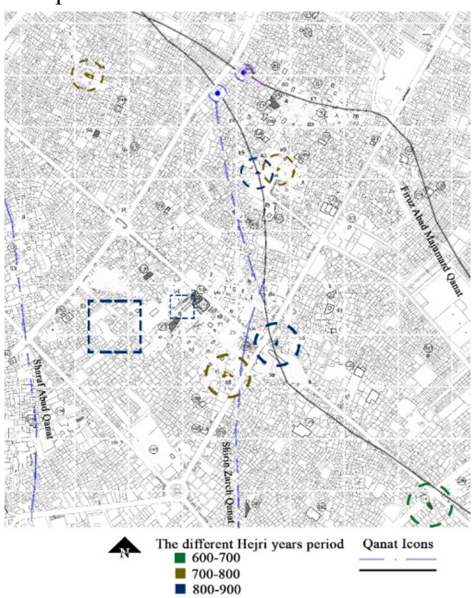

Figure 8. The location of Yazd historic buildings which they belonged to 600-900 AH and Qanats routes [author]

2.2.4. The bodies development between "900-1100" AH

Ten water reservoir were built in this period, but the location of them were different. The four of them are located in the most ancient part of city. According to their location, it seems the three water reservoirs connect to Zarch qanat by digging sub-branch and the other connects to Firuz-abad Majumerd probably. The other six water reservoirs have different locations. Both of them which it seems they have a relation with Mehdi-Abad Rastaq channel, but it would be made at 1280 AH [11], so they connect to Zarch qanat were located in the part of city which it was developed between 700 and 900 AH. The others were fitted with the new city developing. As far as refereed, one of them is the water reservoir which it is located in the Gowdal-Mosalla neighborhood and connects to Sharaf-Abad channel probably. Another is located in the Khan square and it is near to Zarch qanat. The two others water reservoir were located in the west part of city and they were related to zarch channel by digging some sub-branches.

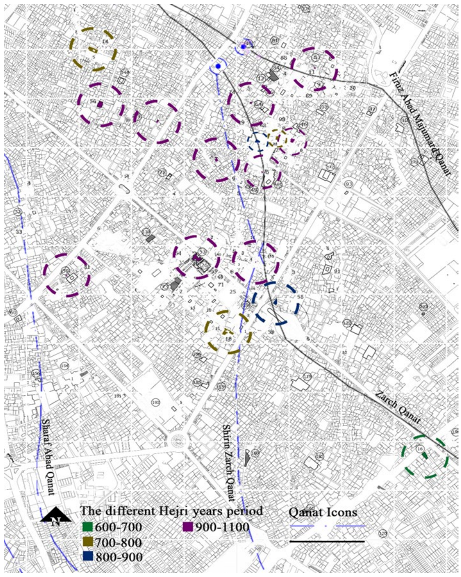

Figure 9. the location of Yazd historic buildings which they belonged to 600-1100 AH and Qanats routes [author]

2.2.5. The bodies development between "1100-1200" AH

A map offers the Yazd developing in the three next periods (from 1100 to 1400). The first period coincides with the Afsharieh and Zandieh reigns. According to the buildings which they were constructed in this period, Khan Bath was connected to zarch qanat. The histrorical document reveals that Mohammad Taghi Khan Bafghi who built the Dowlat-Abad garden, increased the water flow of Dowlat Abad channel [15], and paid the share of water of Abshahi zone [16], made a qanat from Abshahi to Khoramshah zones [8], and finally flowed the water on the watercourse from Khoramshah zone to Dowlat-Abad garden (this watercourse is seen in the south of Dowlat-Abad garden). So the Dowlat-Abad complex (water reservoir and garden) was filled and irrigated.

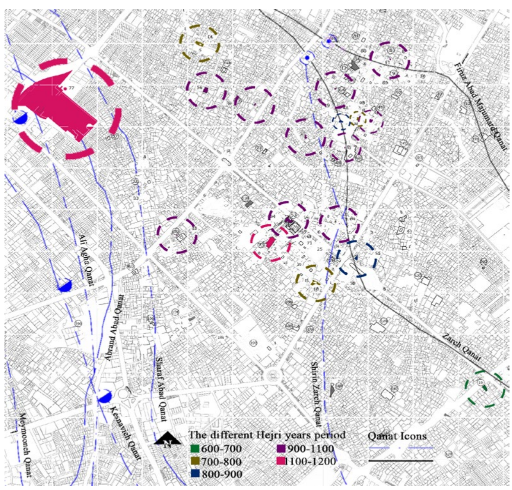

Figure 10. The location of Yazd historic buildings which they belonged to 600-1200 AH and Qanats routes [author]

2.2.6. The bodies development between "1200-1300" AH

In this period, seven Bath, five water reservoir, and three garden were built. The two new Qanat were digged (Nosrat-Abad and Mehdi-Abad rastaq). According to the map, Yazd was developed in the south and west direction. The three bath were located in the older part of city and they were connected to Zarch, Firuz-Abad majumerd, and Mehdi-Abad rastaq probably. The others bath were located in the new part of city and their relation with qanats were that both of them with the new drilled Nosrat-Abad channel, one of them with the Sharaf-Abad, and the other with Zarch.

One of the water reservoir was located in the part of city which it developed in the before period and it was connected to Nosrat-Abad channel. Another water reservoir was located on the Nasr-Abad zone on the commercial route and it was related to Firuz-Abad Majumard qanat. The three others were located in the new part of city. One of them was located in the near of Emam Zadeh Jafar holy shrine. It probably was connected to Nosrat-Abad qanat or Sharaf-Abad with a water reservoir was built in the last periods and located in the south-west of it. Another was located in the west part of city. It was near to Nosrat-Abad and Mehdi-Abad rastaq qanats, it could be connected to Firuz-Abad Majumard qanat by digging a sub-branch and connecting to Sheykhdad complex. The other was located in the near of three qanat (Shirin Zarch, Mehdi-Abad Rastaq, and Nosrat-Abad). The three refereed gardens were not located in the territory of Yazd city, so they do not survey.

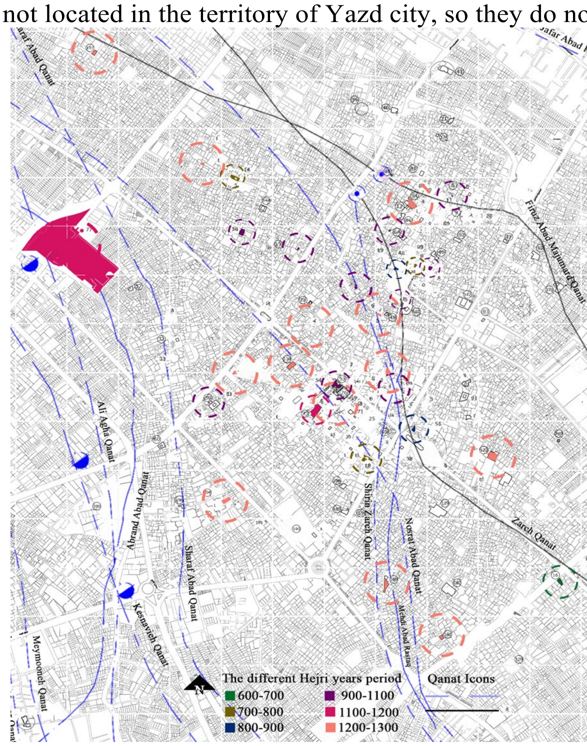

Figure 11. The location of Yazd historic buildings which they belonged to 600-1300 AH and Qanats routes [author]

2.2.7. The bodies development between "1300-1400" AH

This period coincides with the last years of Qajar dynasty and Pahlavi. The six water reservoir was built and the Ali-Agha qanat was dug [5]. Both of the water reservoirs were located in central part of new developing area and the others in the border part of new developing in Qajar dynasty. One of them is located in the Gazorgah neighborhood and it seem is related to the bath which it was built in the previous period in the south-west of it. Another one seems that is connected to Sharaf-Abad qanat by digging sub-branch and connecting with an element which it was located in the west. Another water reservoir is the Rostam-Giv and it is connected to Zarch qanat probably by digging sub-branch.

The three others water reservoir were related to the qanats (Shirin Zarch, Abrand-Abad, and Ali Agha) which they cross near of each one of them.

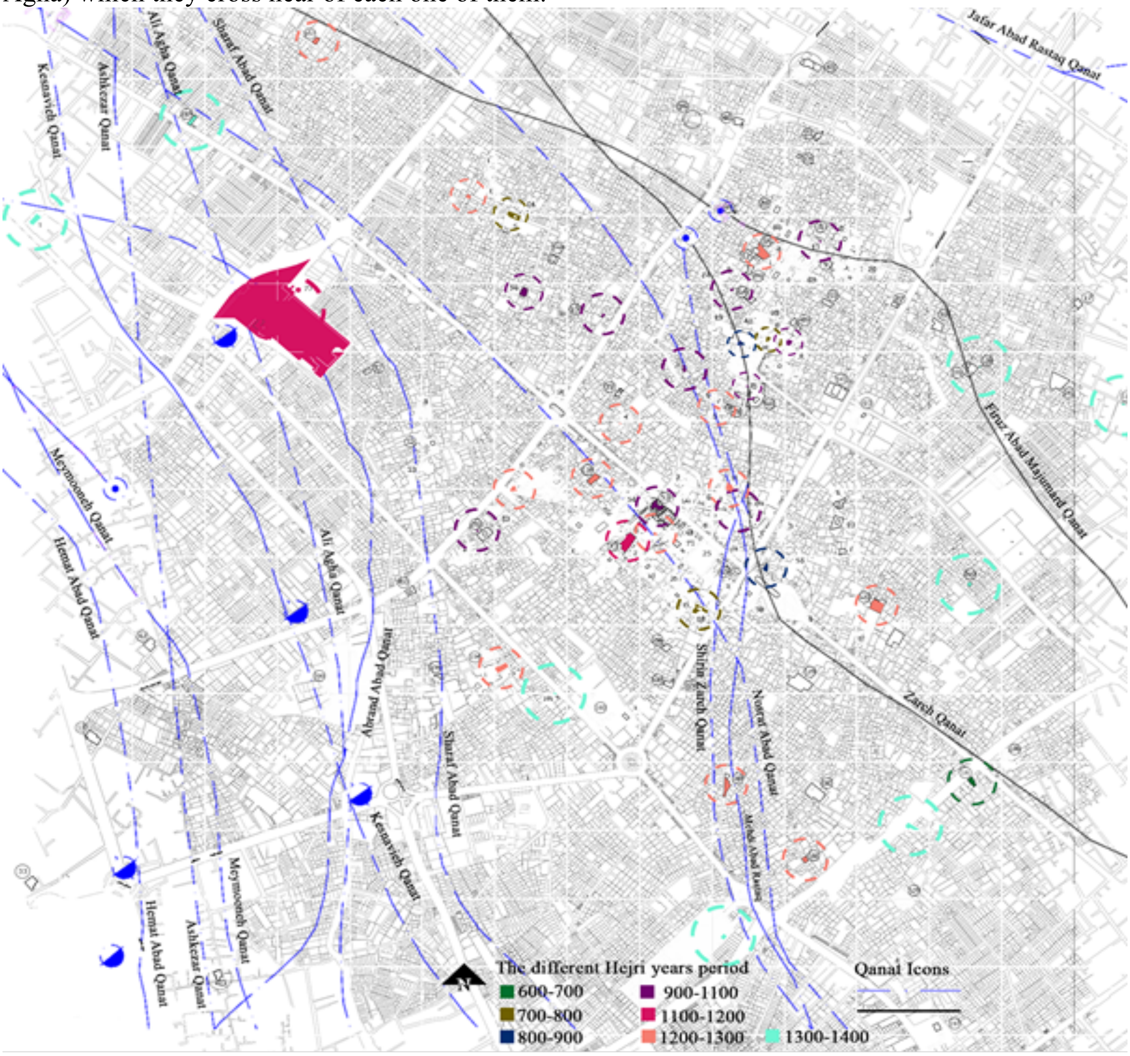

Figure 12. The location of Yazd historic buildings which they belonged to 600-1400 AH and Qanats routes [author]

3. CONCLUSION

The qanat was one of the old ways for extracting and using. The most of them are located in the desert and dry areas to prepare the condition for living. Yazd city has concerned about the water, because it is located in the central dry plateau of Iran. So the underground channel digging in the different historic period provides the city's body development. This paper which it is done with the historical-analysis method analyzes the relation between qanats branches and the development of body of Yazd in the different historic periods as the hypothesis that it is confirmed and the following conclusion is extracted:

1. Al Kakouyeh and Atabekan (400-718 AH): The development of city in the Atabek period was the north direction. In this period only a water reservoir which it was located in the outside of the city on the Mehriz route is remained. While the central mosque which the Zarch qanat is prepared its needed water is built before this period, any building which it

goes back to this period in the city cannot be found. So it seems the buildings which they had a relation with qanat did not build or all of them were destroyed over the time.

2. Al Mozaffar (715-785 Ah): The development of city was the south direction. A water reservoir was built in the inside of city while the two others buildings were built in the outside of the city. The Zarch and Firuz-Abad Majumerd were still the source for the water supplying. The endowments of Waqf-Abad qanat which it was flowed on earth in the inside of city might the main reason for city's development to the south direction.
3. The Timurian (795-913 AH): The development of city was occurred in the south direction. The two water reservoir were built in this period which both of them were connected to Zarch qanat. The historic documents were revealed some other buildings which they connected to Sharaf-Abad channel probabley.
4. The Safavian (907-1135 AH): the development of city was occurred in the west and south-west direction. Ten water reservoir were built in this period. The three of them were located in the part of city which it was belonged to the former periods and the others were fitted with new development. The Zarch, Firuz-Abad Majumerd, and Sharaf-Abad were the main source for the water supplement by digging some sub branches.
5. The Afsharieh and Zandieh (1148-1208): in this period the Khan bath was built and it was related to Zarch qanat probably. The volume of Dowlat-Abad qanat's water was risen and it flowed on earth from the east to west of southern outside part of city.
6. The Qajar (1208-1300 AH): in this period 7 bath, 5 water reservoirs. And three gardens were built and also two new qanat (Mehdi-Abad Rastaq and Nosrat-Abad) were dug. The city's development was occurred in the west and south directions. The location of new buildings belonged to the former parts and fitted with new development. This extension were supplied by the Zarch, Firuz-Abad Majumerd- Sharaf Abad, Mehdi-Abad Rastaq, Nosrat-Abad, and Abrand-Abad qanats.
7. The last years of Qajar dynasty with Pahlavi (1208-1398 AH): The 7 water reservoirs were built at this time and Ali-Agha qanat was dug in this period.

The different buildings were built over the periods. In each periods, the most of new buildings were located in the new part although the former parts were considered. These building were connected to different qanats by digging sub-branches. The type of connection could be direct or indirect with intermediate buildings.

For the expansion of this paper, it suggests that the relation between the qanats and traditional houses which they have a cellar is surveyed. Also this paper can be followed in others cities which their water were supplied by qanat.

4. ACKNOWLEDGMENTS

The art and architecture school of Yazd gives the opportunities for researchers, students, and masters to investigate Yazd historic texture.

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The Benefits of Adobe for Human Health in Terms of Building Biology

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ABSTRACT

Before talking about material specifics, we need to look holistically to the subject in order to have a real understanding of the Building Biology approach. The basis of the approach is that buildings constitute the Essentials of life like food and water. Everything in the earth exists in a system of micro and macro cosmos. In this context, buildings are also organisms, so they can be in harmony or inconsistency with humans. Similar to the way sickness of an organ affects the human body, buildings incompetence affects people's health. So buildings are like our third skin.

Besides, cities and buildings become distant from nature for a while. In the old times, except specific regions in the World, buildings were constituted %30-40 of organic materials (like wood, straw, reed) and %60-70 of inorganic ones (like adobe, tiles, natural stone, lime). Nowadays, buildings defined as 'modern', consist of building materials which are %90-100 composed of chemicals, they are foreign to nature and human metabolism. Parallel to this change, physiological and psychological diseases and communal problems increase and inevitable moral collapse lead estrangement to the perception of a house as 'nest-home'.

The recent standards of building materials, leave health compliance behind, focus mostly on functionality. However healthy building materials take over vital functions. Several diseases can be prevented by healthy buildings (use of earthen materials can be an important enabler). To enable the dissemination of healthy buildings, a suitable political ground is needed, so the use of natural building materials and construction technics can be encouraged in a wider scale.

INTRODUCTION

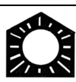
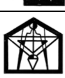
When we ask ourselves "can we explain Building Biology through only one building material?" The answer will be concentrated on 'Earthen materials'.

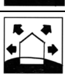
This article aims at demonstrating the benefits of one specific building material; 'adobe' for the community, economy, ecology, individual and human health. The benefits will be evaluated in relation to International Building Biology and Ecology principles. Building biology and ecology emphasizes buildings importance for the life of living beings and humans, like food and water. Everything in the earth exists in a system of micro and macro cosmos. In this context, buildings are also organisms, so they can be in harmony or inconsistency with humans. Similar to the way sickness of an organ affects the human body, buildings incompetence affects people's health. So buildings are like our third skin.

There are 25 principles set by building biology and ecology field of work, some correspond to the environmental effects of a building and the others to the human health effects. The principles are also grouped under 5 different titles: Healty Indoor Air, Thermal and Acoustic Comfort, Human-Based Design, Sustainable Environmental Performance, Social Connected and Ecologically Sound Communities.

HEALTHY INDOOR AIR	
	Supply sufficient fresh air and reduce air pollutants and irritants
	Avoid exposure to toxic molds, yeasts, and bacteria as well as dust and allergens
	Use materials with a pleasant or neutral smell
	Minimize exposure to electromagnetic fields and wireless radiation
	Use natural, nontoxic materials with the least amount of radioactivity

THERMAL AND ACOUSTIC COMFORT	
	Strive for a well-balanced ratio between thermal insulation and heat retention as well as indoor surface and air temperatures
	Use humidity-buffering materials
	Keep the moisture content of new construction as low as possible
	Prefer radiant heat for heating
	Optimize room acoustics and control noise, including infrasound

HUMAN-BASED DESIGN	
	Take harmonic proportion and form into consideration
	Nurture the sensory perceptions of sight, hearing, smell, and touch
	Maximize daylighting and choose flicker-free lighting sources and color schemes that closely match natural light
	Base interior and furniture design on physiological and ergonomic findings
	Promote regional building traditions and craftsmanship

SUSTAINABLE ENVIRONMENTAL PERFORMANCE	
	Minimize energy consumption and use renewable energy
	Avoid causing environmental harm when building new or renovating

	Conserve natural resources and protect plants and animals
	Choose materials and life cycles with the best environmental performance, favoring regional building materials
	Provide the best possible quality of drinking water

SOCIALLY CONNECTED AND ECOLOGICALLY SOUND COMMUNITIES	
	Design the infrastructure for well-balanced mixed use: short distances to work, shopping, schools, public transit, essential services, and recreation
	Create a living environment that meets human needs and protects the environment
	Provide sufficient green space in rural and urban residential areas
	Strengthen regional and local supply networks as well as self-sufficiency
	Select building sites that are located away from sources of contamination, radiation, pollutants, and noise

The outside air in the natural environments regenerate and clean itself. The rule of life is material change, so every metabolism evolution is bounded to this change. The bacterial flora of the clean air is appropriate to our physiology, its ions are in optimal extent, it doesn't include any harmful gases and smells nice.

On the other hand, the indoor air can carry the toxic micro particles or radioactivity released from different materials. In addition, while circulating, and being inhaled many times, the oxygen level in the air drops down. In consequence of this vicious circle, human and other living beings that shares the indoor space can be poisoned, their cell regeneration can slow down and the probability of allergies increases.

The indoor air quality approximate significantly to the one in the natural environments if the building is made by natural building materials. Adobe, being known as the oldest building material in the earth, has the capability to filter and neutralize harmless substances and gases in the air. Plus adobe slows down electromagnetic waves so decrease electro smog impact.

"Adobe"; a building material that prevents allergic diseases
Poor indoor air quality is a significant trigger of allergies. If the indoor space is hot, humid and dark, these conditions favors mold fungus formation and small particles of mold named spores can easily mix with the inhaled indoor air.

There are also plentiful of molds in the nature, in the soil, straw, seed, trees etc. but their contact with human is minimum. So mold has negative effects to our health when the indoor areas have favorable conditions to its formation. Mold exists in buildings, having craftsmanship errors, wrong material choice and insufficiently resolved details. Adobe is one of the best material to prevent mold formation since it has the highest horoscopy and diffusion characteristic.
The natural control of indoor humidity rate by means of Adobe

Nature shows us the ideal living conditions and the building materials that provides them. In nature, the relative air humidity is %40-70. In modern buildings, especially in the winter months, when the indoors are heated, it is seen that air humidity drops to %15-30. In the field of Physiology and Medicine, it is known for years that the air humidity most suitable to human health is %50. The range of %40-60 of humidity in the air is still in human comfort zone. Low humid air holds more dust and microbes inside, increase electrostatic load, lower negatice oxygen ions in the air, ionize dust and microbes to become more aggressive.

In this case, the ciliated epithelia in our respiratory system stay out of function, mucous membrane dries up, becomes stimulated and as a result infections occur. When the indoor air holds low humidity, it prevents the human body to regenerate itself and lead to infectious diseases, neural tension, headache, fatigue, potential fall and eye infections. The natural balance of the indoor air humidity can stay in the limits of human comfort if hygroscopic building materials are used, diffusion, ventilation and radiation temperature are ensured. "Adobe" is again the only material that meets these conditions per se.

Radioactivity

Buildings can be involved to radioactivity only because of building materials used. For example in the buildings made with cinder concrete, it is measured that radioactivity is 3 times more than the natural values of the external environment. Similar results were reached in the buildings where chemical plasterboards were used. On the contrary the radioactivity levels of the buildings made with wood, adobe, stay below natural values of the external environment. An indoor that is insufficiently ventilated, has much higher levels of the radioactivity and toxidity than an indoor open to diffusion.

Social sustainability is not directly related to our subject title however it is very important that "Adobe" production is made by small family business scale. Since in our days, preventing immigration to cities from rural is mainly possible by increasing employment in the rural. So the decentralized production of building materials will support rural development, social sustainability and belonging to the place.

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Traditional Gaziantep Houses, Door and Door Accessories

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ABSTRACT

Traditional Gaziantep houses reflect the culture of the period with their high exterior walls, exterior doors and door accessories which emphasize privacy in terms of architecture and architectural features. The motifs used in the doors and door accessories made of wood, stone and metal reflect the economic and sociological status of the family. Traditional Gaziantep houses are a historical heritage. Necessary investigations of these structures and materials should be recorded before they are ruined. It is very important that the cultural heritage of the doors and the door accessories to be transferred to the future generations. Creating and raising awareness on the topic of protection is as important as protecting them.

KEY WORDS:

Gaziantep, Traditional Gaziantep Houses, Doors, Door Accessories, Protection Awareness

1.INTRODUCTION

Gaziantep, which has been the cradle for history, has inherited its characteristics in many civilizations.

The climate conditions of Gaziantep plays an important role in the formation of the structures. The houses, which are located in the adjacent streets, have high outer walls, courtyards, flat roofs, deaf lower floors and iwans. The wood workmanship in the doors and claws is so magnificent that it cannot be overlooked and also reflects the culture of the period. The most important requirement of humans since existence has been protection, shelter and security. Many civilizations such as the Hittite, Assyrian, Alexander the Great, Roman and Byzantine civilizations have implemented their culture in Gaziantep. Many of the buildings that have survived to till today have been built by minority masters from the Ottoman period. Many of them are mansion type buildings built in the late 1800's and early 1900's. It also reflects the brightest period of stone,wood and iron workmanship. Of course, in time due to the environmental factors and climate conditions the historical structures over time faced deterioration. As a result, the historical buildings have been damaged and transferring the cultural structures to the next generations will not be possible. This study contains general information about the traditional Gaziantep houses, the entrance doors, the accessories on the doors. The doors are the first to be noticed in traditional Gaziantep houses, reflecting the culture of the period and the craftsmanship is impressive.

2.GENERAL FEATURES OF TRADITIONAL HOUSES

2.1. Historical and Geographical Features of Gaziantep

Gaziantep, is one of the first settlements in the Anatolia region and is located at the junction of Mesopotamia and the Mediterranean Region. Throughout history of Gaziantep has been a center of attraction for many civilizations, cultures and religions. The oldest settlement is the Dülük region. Gaziantep has been a center of culture and trade throughout its history. Gaziantep is a city that has witnessed history with its castle, inns, baths, castels, mansions and traditional houses. As well as been an industrial city one quarter of Gaziantep land is plains suitable for agriculture. Neighboring provinces of Gaziantep is Kilis, Hatay, Şanlıurfa, Osmaniye, Adana, Kahramanmaraş and Adıyaman.

2.2. Traditional Gaziantep Houses

Gaziantep houses are made of soft calcareous stones called havara or keymıh. The houses are generally one or two stories however there are some which are made of three stories. Gaziantep houses which carry the traditional features are mainly located in the city center, Eyüboğlu, Türktepe, Tepebaşı, Şehreküstü, Bostancı and Kozluca neighborhoods and also on the outskirts of the castle.

The structures which emphases Gaziantep character are the houses, mosques, inns and the bath houses. The climate, topographic features, vegetation and social life of the region have been important in the formation of the functions of these masonry structures. The courtyard is often seen in architecture of Gaziantep houses due to the hot climate. Since most of the time is spent in the courtyards of the houses, it is considered as (the place where life passes by) therefore it is called 'life".

Figure 1. Traditional Gaziantep Houses, Uğurluer, M, 'Gaziantep House Adorned With Ceiling Pictures', Yorum Magazine 35: 11–23 (2000).

Figure 2. Traditional Gaziantep Houses, Uğurluer, M, 'Gaziantep House Adorned With Ceiling Pictures', Yorum Magazine 35: 11–23 (2000).

2.3.Doors

The first thing that stands out in Traditional Gaziantep houses is the impressive doors that are crafted by the skillful craftsman. Starting from the garden gate and continuing on the entrance door, the craftsman art can not be overlooked. Other than the outer window frames, shutters and wooden section under the roof the doors are the first cultural value that welcome you. It also varies in size and shape.

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Figure 3. Example of Traditional Gaziantep House Door Uğurluer, M, 'Gaziantep House Adorned With Ceiling Pictures', Yorum Magazine 35: 11–23 (2000).

The external doors are usually made of wood, however they are covered with tudia to the prevent damages that could be caused by the climatic conditions. Thereafter, a wooden frame of the same size of the door is placed on top. The sheet metal cladding is nailed to the wooden door with headed nails. Various motifs are made on the door with these nails. These motifs usually consist of flowers, cypresses and geometric shapes.

When we examine the inner face of the doors, as opposed to the vertical boards used on the outer face horizontal planks have been used to secure the door. Next to the lock there are different sizes of latches. Apart from the bolts and locks, there is also a large iron door latch mounted on the wall. This latch is locked after the whole household is home. This system is also used in the window interior doors based in the rooms. Most of the doors are an single piece. It is made as a rectangular shape. In the arched structures, the upper part of the door has a semicircle shape.

2.3.1.Accessories of the Doors

Gaziantep houses generally use door accessories consisting of gavel, temples, wheels, locks and bolts. These door knockers, which carry the cultural characteristics of the region, are generally used extensively in the exterior doors of the Southeastern Anatolia Region. The Door knockers which are made in various shapes are generally made from cast iron, bronze and brass. It is frequently seen that animal figures and shapes are made from cast iron. Among the figures, lion head and birds are the most frequently made models. On the other hand, the most striking and artistic accessory is the door knockers.

Figure 4. Traditional Gaziantep Houses Door Accessories Uğurluer, M, 'Gaziantep House Adorned With Ceiling Pictures', Yorum Magazine 35: 11-23 (2000).

Figure 5. Traditional Gaziantep Houses Door Accessories Uğurluer, M, 'Gaziantep House Adorned With Ceiling Pictures', Yorum Magazine 35: 11-23 (2000).

Door knockers were an important art indicator during the Seljuk and Ottoman periods. Door knockers are important in terms of giving an idea about the culture level of the period in which it was made. It is possible to understand the level of art in the late Ottoman Empire period by examining the door knockers the doors of Gaziantep houses. Foundry and iron work had its best period in the early 1900s. We are able to understand this from the resulting works.

We can see that the most commonly used model for the door knockers is the 'hand" which is holding ball in its palm or a fruit that is similar to an apple. Hand-shaped door knockers made of brass, bronze or iron are made according to the size of the door and are placed in the middle top part of the door. If the door knockers are in the form of a hand, it is definitely the right hand, and the middle finger has a ring on it. The message that is been transmitted is the strength of the right hand and the ring symbolisms that a family lives in this house. For large doors, large door knockers are made and it resemble a male hand. For small doors, smaller door knobs are made and it resembles a more elegant female hand. The mirrors where the knockers hit on the door are decorated with geometrical and floral motifs. In addition to the hand-shaped door knockers, there also hammer-shaped door knockers. Iron door knockers with animal figures are seen on the doors of simple houses rather than mansion type houses.


Figure 6. Traditional Gaziantep Houses Door Accessories Uğurluer, M, 'Gaziantep House Adorned With Ceiling Pictures', Yorum Magazine 35: 11–23 (2000).

On the outer side of the Gaziantep houses apart from the doorknobs there is a ring called 'slapstick'. Unlike the door knobs, the mirror at the bottom of the temple is made larger and is decorated with geometric and floral motifs. There have round and also oval slapstick. The knob used to knock on the door, such as the door knockers, also acts to pull handle of the door. Double leaf doors have two slapstick.

Some doors have a door knocker and a slapstick together this has a separate feature. It was used to understand the gender of the guest knocking on the door. The male knocked on the door using the gavel and the woman or the children would knock by using the slapstick. In this way, it would be understood whether a women, a man or a child has come to visit. This rule belongs to this region and was known by everyone. The latch found to keep the door closed is called the ark wheel. The wheel is used in rooms and also halls.

The most important mechanism of the doors are the locks and they were made in different models according to the size of the door and the craftsmanship of the master whom is making it. The lock is on the inside face of the door. Locks are also unlocked with keys made in various models. A final accessory of the doors is the nails on the tin covering the outer surface. It is seen that they used flower motifs in a vase.

3.CONCLUSION AND RECOMMENDATIONS

Gaziantep, which cradled great civilizations, was in complete ruin with the French occupation during the War of Independence. Many historical buildings were damaged, and many were destroyed. The city, which has been restructured, settled by building concrete structures that require less labor and craftsmanship. Demolished or damaged structures were not repaired. These structures which shed the light of history were therefore unable to be preserved and could not be left to the future generations to examine and cherish.

As a result of the research, we see that the doors and door accessories are actually the most important building parts reflecting the culture of the period. It is clearly seen that all the materials used and the motifs on the doors reflects the periods value. The researches of these important works should be turned into written documents by using the city history archives and building surveys to be transferred to future generations. As these values are not known today, these works are damaged and even unconsciously doomed to be destroyed by being dismantled and removed.

Today, it should be our most important duty to transfer the awareness of historical culture to the future generations. While doing this, all sources should be scanned and all information should be recorded. The most important heritage that will be left to future generations is to raise aware on preservation of historical buildings.

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Building with Rammed Earth in The Desert, Riyadh Saudi Arabia

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ABSTRACT

Building with Rammed Earth in the Desert in one of the most sustainable building technique. The author has built a small building using available materials and manual rammers. The walls came out in good shape. The roof was made out clay tiles on top of steel structure. The windows are made from wood.

Keywords: Rammed Earth, Saudi Arabia

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History, Heritage and Reuse as a Tool for The Tourist Development. Restoration of Ancient Convicino (Sassi of Matera – Italy)

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ABSTRACT

The oldest part of the city of Matera, known as Sassi, is an architectural and urban complex the oldest part of the city of Matera, known as Sassi, is an architectural and urban complex consisting of built and carved out structures that stretches over a karst plateau. The Sassi consisting of built and carved out structures that stretches over a karst plateau. The Sassi neighbourhood are UNESCO World Heritage since 1993. Moreover, the city of Matera has neighbourhood are UNESCO World Heritage since 1993. Moreover, the city of Matera has been chosen as European Capital of Culture for the year 2019 because of its unique been chosen as European Capital of Culture for the year 2019 because of its unique architectural heritage that testifies the ability of humankind to dig shelters in the rock since architectural heritage that testifies the ability of humankind to dig shelters in the rock since prehistoric times. This paper illustrates a conservative restoration of a whole prehistoric times. This paper illustrates a conservative restoration of a whole neighbourhood, currently abandoned and degraded, located in the Sasso Caveoso aimed at neighbourhood, currently abandoned and degraded, located in the Sasso Caveoso aimed at its rehabilitation as a tourist building. This neighbourhood develops along two different its rehabilitation as a tourist building. This neighbourhood develops along two different rocky planes with constructions facing to one side on a driveway and to other one on a rocky planes with constructions facing to one side on a driveway and to other one on a series of small squares with walking surfaces following the trend of the underlying series of small squares with walking surfaces following the trend of the underlying rupestrian houses roofing. Both carved out and built structures have affected by different rupestrian houses roofing. Both carved out and built structures have affected by different forms of physical and chemical degradation phenomena, mainly due to capillary rise of forms of physical and chemical degradation phenomena, mainly due to capillary rise of water. In this conservative restoration, binders based on natural lime were employed to water. In this conservative restoration, binders based on natural lime were employed to obtain mortars or plaster compatible with the original materials and silicone acrylic resins obtain mortars or plaster compatible with the original materials and silicone acrylic resins were used as waterproofing. The severely affected ashlars were replaced by the rip-and-sew were used as waterproofing. The severely affected ashlars were replaced by the rip- and -sew technique with calcarenitic blocks taken from a quarry located in close proximity to the City of Matera.

Keywords: Architectural heritage; Conservative restoration; Sustainable tourism development

1. INTRODUCTION

The old part of the city of Matera, named "Sassi" that means "stones", is an outstanding architectural and urban system characterized by the coexistence of built and dug structures. The Sassi extend along the eastern slope of a karst upland, identified as "Murgia Materana", of which they seem a natural extension. The landscape is furrowed by a ravine, locally called "gravina", that is an erosion valley with canyon shaped having steep and far between sides, which contains abundant water only during rainy periods. The gravina highlights the stratigraphy of the karst upland: the lower part consists of a compact limestone with high strength, whilst the upper part of limited height is a limestone of biochemical origin, known with the local denomination of calcarenite or, improperly, tuff of Matera, with a typical clear yellowish colour. The calcarenite is characterized by the easiness of quarrying and manufacturing even in complex shapes, but also by the low mechanical strength and the poor resistance to weathering [1, 2].

The importance of the Sassi and the Gravina of Matera is due to the perpetuation of the principles underpinning the practice of settlement for a very long time, from prehistory to modern times.

Since Neholithic age the upper part of the gravina was carved to make shelters, tunnels, underground tanks and over the time elaborate architectural complexes were build. The quarried material, cut into rectangular blocks (tuffs), were used to build houses, dry stone walls and terraces, streets and stairways. The city has developed vertically along sloping rounds where the paths are the roofs of the houses below. The vertical pattern of the city allows the use of gravity to the distribution of rainwater and it protects from the winds that sweep the karst plateau. The houses are immersed in the rock face with deep underground environments; they open to the outside with terraces, and roof gardens. The hypogeum environments are dug into the ground obliquely so that the sun's rays can penetrate to the bottom in the winter when there is more need of heat. In the summer, the sun closer to the zenith radiates only the entrances of hypogea leaving them fresh and moist. The hypogeum environments can be superimposed upon each other for more than ten times. Moreover, on the underground there are dozens of bell-shaped cisterns joined between them by canals and water filter systems. The caves located on the sides are projected outside of underground with structures having barrel vaults, called lamioni, built with blocks of limestone excavated from the caves themselves. In this way, a central courtyard is formed in which there is a large common cistern collecting rainwater from the roofs that are specifically built without pitches. Moreover, the courtyard is the place of the social life of the neighborhood. Advisedly, the Sassi can be cited as an ante litteram example of a green urban settlement where human life takes place in harmony with the specificities of the places and it becomes an all one.

The medieval monasticism give new vitality to the archaic urban fabric. Hermitages, parishes, farmhouses located near to the hydraulic works are the poles of the process of urban growth [3]. Two urban compartments, called Sasso Caveoso and Sasso Barisano, are developed around the two main drainages called "grabiglioni" that provide farmland and humus through the collection of sewage. In the highest part, there is the Civita, the fortified acropolis, the old shelter in case of danger, where the cathedral stands. Figure 1 illustrates the planimetric development with the localization of the Civita, Sasso Caveoso and Sasso Barisano.

During the Fascist era, the fragile and unique ecosystem of the Sassi was compromised by destructive interventions. The gabriglione was buried and paved and entire neighborhoods were destroyed. Since then the urban fabric becomes incomprehensible and the loss of meaning allows any subsequent destructive action [3,4].

In 1950, about 15,000 people lived in the Sassi amounting to 70% of the entire population of the city of Matera, in 2,997 houses of which 1,641 defined "troglodyte dwellings " because they are carved into the rock and they were without restrooms [4]. For this reason, the city of Matera was considered a "shame" for the whole of Italy.

Ever since a program of evacuation of all the inhabitants and the resettlement in new suburbs were started. The Sassi were completely abandoned until their insertion in the UNESCO World Heritage List in 1993 when an ambitious program to restoration and revitalization has been launched.

The Sassi's inclusion in the UNESCO heritage has promoted a self-propelling capacity to recover the city. The approximately 5,000 people who have returned to live in the Sassi and the growing presence of national and international tourism make the case of Matera a model of proper recovery of the old city together with the overthrow of the city's reputation: from national shame to world heritage site and to recent award of European Capital of Culture for the year 2019.

Figure 1. Planimetric development of Sassi.

This paper describes the rehabilitation project of an entire neighborhood, named **Ancient Convicino**, located within the Sasso Caveoso, currently in a state of completely abandonment and degradation, aimed at its rehabilitation as a tourist structure.

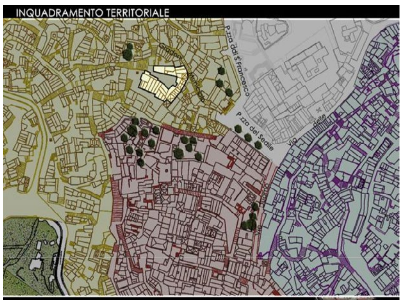
2. THE ANCIENT CONVICINO NEIGHBORHOOD

The **Ancient Convicino** is a neighborhood with a typical central courtyard, located in the Sasso Caveoso, dating to the first half of XVII century [3]. It develops on two rocky levels with different constructions facing to one side on a road and at the other side on a small square that is the original courtyard, whose bottom-walking surface follows the path of the ceiling of the underlying hypogeum dwellings. All the environments on the first and second floor have independent access directly from the court. Figure 2 shows the localization of the **Ancient Convicino** within the Sasso Caveoso and its perspective view.

The vertical structures are made of blocks of calcarenite, while the horizontal structures consist of vaults carved into the calcarenitic rock and built barrel vaults. Both the excavated and constructed structures are affected by different forms of degradation phenomena due to the synergistic action of physical, chemical and biological agents that are present in the environment surrounding the construction [2]. The most important environmental component is water which acts directly or indirectly on all kinds of decay of calcarenitic stones. Their surface is hydrophilic: the negatively charged oxygen atoms of the carbonate attract the water molecules and form hydrogen bonds with them. Water wets their surface and easily penetrates into them by capillarity through their high open porosity.

The exterior surfaces are severely deteriorated by the alveolization phenomenon of calcarenite. This decay consists on the stone surface formation of interconnected cavities (alveoles) of variable shapes and sizes due to the salts crystallization in preferential areas where there is an accelerated erosion as well [2]. The masonries are also affected by the presence of patinas, surface deposits, efflorescence, delamination due to freezing-thawing cycles, algae, musks, lichens and infesting vegetation. Figure 3 shows the degradation of the facades of the constructions overlooking the little square.

The interior surfaces exhibit detachments and in some cases also swellings of the plaster made during restorations carried out in the past. The deteriorated plasters are composed by a binder mixture of cement and lime (Fig. 4) or by organic polymers pigmented (Fig.5). The detachments of the plasters containing Portland cement are due to the different behavior to thermal expansion of the finishing compared to the stone substrate. In some areas, these plasters have also swellings because of the formation of expansive hydrates sulphate salts caused by the presence of sulfate ion (SO_4^{-2}) coming from the cement and moisture in the masonry. The detachments of the plasters based on organic polymers are caused by the vapor pressure that derives from the vapor permeability reduction due to the formation of occluding polymeric films on the masonry surface.



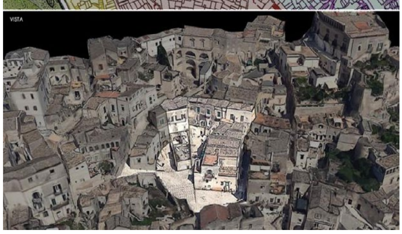


Figure 2: Localization of the Ancient Convicino (light yellow) within the Sasso Caveoso.
Figure 3: perspective view of the neighborood.

Figure 4: Degradation of the facades of the constructions overlooking the little square.


Figure 5. Decay of interior plaster basedon organic polymers.
Figure 6. Decay of interior plaster based on pigmented organic polymers.

3. THE REHABILITATION PROJECT

The rehabilitation project has the purpose of recovering the abandoned neighborhood of the **Ancient Convicino** in order to use it as tourist accommodation. The project is inspired by the criteria of conservative restoration that tend to preserve the uniqueness of the architectural heritage through the use of materials and techniques as near as possible to those originally used [4,5]. Thus, it is provided to not change the structural settlement that is in good condition and to restore the deteriorated surfaces. The project also includes the functional adaptation of spaces to modern living standards with the facilities of toilets and heating and electrical systems. Figures 6 and 7 show the distribution of the spaces of the first and second floor, respectively, and their functional adaptation to the use of the **Ancient Convicino** as tourist structure.

The restoration of surfaces has been divided into the following phases: I) polishing; II) consolidation;

protection. The polishing is a delicate and irreversible operation. Its incorrect execution could cause irreparable damage to the architectural heritage. In this case, because of the extreme vulnerability of the calcarenitic stone, it was chosen the manual polishing performed with hand tools, such as spatulas and scrapers, without the use of chemical agents. This technique has been used to remove patinas and organic and inorganic deposits from the exterior surfaces and for scraping the internal surfaces of the plaster performed in previous interventions with materials not compatible with the stone substrate.

Figure 7. Functional distribution of the rooms on the first floor.

Figure 8: Functional distribution of the rooms on the second floor.

The phase of consolidation must improve the internal cohesion of stone and restore its mechanical strength avoiding other alterations of physical and chemical properties. The phase of protection has the purpose to turn the partial hydrophilic character of the stone surface into a high hydrophobic interface. An acryl-silicone resin was applied by brush in alcohol solution on the external and interior surfaces to fulfill the requirements of the consolidation and protection. This hybrid polymeric product was synthesized and commercialized in order to overcome the drawbacks and the poor durability of the acrylic resins, largely used in the past in restoration works [2].

The severely affected ashlars were replaced by the rip-and-sew technique with calcarenitic blocks taken from the quarry of Montescaglioso located in close proximity to the city of Matera, having the same chemical, physical and mechanical properties of the original calcarenite used in the construction. Table 1 shows the chemical composition of calcarenite coming from the quarry of Montescaglioso determined in accordance with ASTM C114. Table 2 lists the physical and mechanical properties measured on three samples of calcarenite coming from the quarry of Montescaglioso. A bedding mortar used for the volumetric reintegration of severely damaged ashlars was prepared by mixing slaked lime, acrylic-silicone resin and fine sand, locally named "tufina", coming from cutting blocks of calcarenite was. The same type of mixture was used for internal plasters. The volume reintegration involved also the reconstructions of some ornamental details of the facades of particular aesthetic value that was carried out by local craftsmen specialized in the working of calcarenite. The restoration of the exterior facades was completed with the application of lime whitewash and the reconstruction of downpipes with cups of terracotta according to the ancient local tradition. Figure 7 shows the neighborhood of ancient Convicino on the side overlooking the small square after rehabilitation work.

Table 1. Chemical composition of calcarenite from the quarry of Montescaglioso

	Mass percentage
Calcium oxide (CaO)	53,20
Magnesium oxide (MgO)	1,32
Potassium oxide (K_2O)	0,82
Sodium oxide (Na_2O)	0,30
Sulphuric anhydride (SO_3)	0,12
Ignition loss	43,75

Table 2. Physical and mechanical properties of samples of calcarenite from the quarry of Montescaglioso

	Sample A	Sample B	Sample C
Compressive strength, MPa	3,06	3,18	3,69
Resistance to freezing thawing after 48 cycles, MPa	2,78	2,95	2,98
Flexural strength, MPa	1,00	1,03	1,07
Open porosity, mass percentage	34,94	35,37	38,21
Bulk density, kg/m^3	1,805	1,803	1,848
Water absorption by capillarity, kg/m^2·sec ^{0,5}	7,1	7,3	7,5

Figure 9. The neighborhood of Ancient Convicino on the side overlooking the small square after rehabilitation.

4. CONCLUSIONS

The events of the Matera city show how the adverse conditions can become valuable resources in a scenario of enhancement and preservation of architectural heritage. Returning to live in the old neighboroods of the Sassi, which are characterized by spaces excavated in the rock, does not a lag behind the modernity, but it is a tool for sustainable development able to preserve the memory of an ancient people. In restoration works, the use of materials and technologies compatible with those originally employed preserves the architectural heritage and ensures the durability of the intervention. Their correct restatement stems from a careful survey work and from the understanding of the existing parts of the building. Such cognitive activity forms part of the necessary preliminary studies of the restoration project.

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Challenges of Local Participation in Governmental conservation projects in Yazd World Heritage Site

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ABSTRACT

The most important role of people in solving problems of the urban society has made citizen participation as a necessity in the planning and management of the city. In this paper due to the importance of the historical contexture of Yazd city registered by UNESCO and the governmental conservation projects by different organizations and less participation among residents and city management, tried to study to effort the challenges and to identify the factors that affect the participant rate. The research method is descriptive by using documentary, library studies, field observations, and semi-structured interview (with officials and urban managers) technics.

Conclusion indicates that the level of participation in governmental conservation projects in relation to the criteria's (inter-organizational participation, trust, voluntary, development from low to high, consultation with people) has been weak, and its results include: people's participation in only one conservation project, lack of inter-organizational interaction, lack of trust between citizens and city management, failure to hold specialized and democratic meetings.

Keywords: governmental conservation projects, local participation, World Heritage Site, Yazd.

1 INTRODUCTION

If we consider everyday needs and the share of future generations from resources in urban development, we should manage the cities wisely based on participatory urbanization and citizen's informed participation. The presence of citizens in decision making, being with officials and professionals and the immediate access of their needs by living conditions social and economical through the process of participation planing is possible [12]. Also, public participation is essential to the success of conservation programs [8]. The people's participation is now recognized as one of the main basics of urban planning and management, which is possible at different levels. At the lowest level, citizen participation in the planning process can gain more sustainable, more credible decisions based wider requirement of people, and at the highest level, it can promote democracy through consultation methods. Currently, the concern of urban planners is that, in what ways can participation planning be implemented successfully [13].

2 PARTICIPATION, AN EFFECTIVE APPROACH IN CONSERVATION PROJECTS

Since the 1970s, the need for participation in the process of urban planning theories was more than ever anticipated with the dominance of rational planning and participation theories [1], and it also involves a process through which people having a share in contributing to the managerial decisions on development. This is a system of management in which individuals influence on developmental decisions. In recent decades, participation is a process in which people participate in social decision making [2] or defined as some planning activities such decision making and policy by the responsible organizations [10]. From another point of view, they considered political participation to involve people, groups, organizations, and society in the planning process.

2.1 Two Successful Experiences In Historical Contextures Of The World In Prague and Cairo

Prague: Prague is one of the most beautiful European cities in the Czech Republic. This city is one of the few European cities that have not been seriously bombed in World War II, and therefore its monuments and buildings have remained healthy; so, there are various phenomena of neoclassical styles, Gothic, Renaissance, Baroque and Arnoou among the buildings. The city's history dates back to the 19 century, and all 886 hectares of the old city's contexture registered in the UNESCO World Heritage in 1992, is more than a thousand years old**.** The programs that have raised in Prague for participation are as follows:
- One of the objectives of the Prague conservation plan is to use the potential of the city to protect the texture Compilation of participation projects.
- The executive actions aimed to promote the role of people in Prague are such as: promoting technical education, more training personnel, and plans to strengthen the care of families living in the texture.
- In the environmental field, one of the plans is to solve strategic issues with public participation, including long-term implementation of educational projects related to environmental education.
- In the field of safety and security, increase public participation, and give support volunteer activities to the fire department.

Cairo: Cairo is the capital of Egypt and the largest city in the Arab world and the Middle East that founded in the 10th century and flourished in the 14th century. The traditional and Islamic architecture of this old city was registered in the UNESCO World Heritage in 1979 with mosques, Islamic schools, and famous baths. It is one of the most important centers of Islamic civilization in the Middle Ages, and today it includes historical mosques, ancient Egyptian museums, and Islamic history, libraries and publishing institutions, and is considered to be the center of Islamic and Arabic intellectual development. It also has the oldest and largest film and the music industry in the Arab world. The Al-Azhar University, which was built as a school in 970, is the second ancient educational institution in the world. Projects in the field of participation are as follows:

- One of the goals of the Cairo in participation project to cooperate with Egyptian institutions to create an organizational structure and a new institutional framework for better management of the site.
- Holding a workshop for stakeholders to present and discuss work processes due to creating a communication network between them.
- Inviting institutions to participate in an organized training activity.
- social participation.
- In the regeneration project, Cairo considers the different institutions of the community, including local governments, government agencies and different classes of society in the process of decision making, and participation programs.

What can be learned from these experiences is that the participation discussion is one of the important basis for achieving the projects, and education, the involvement of all organs, democratic and public institutions in conservation projects are the subjects that can be generalized in this research.

2.2 Criterions And Indices Participatory planning

In pursuit of participatory planning as a set of processes through which diverse groups interact to agree on a plan and how o to dit (Dyeran, 2008: 43), and also, to increase the participation in conservation projects, various researchers in diverse researches have provided criteria and indicators that are as follows**:**

Rowe & Frewer (2005), they know the Successful projects in participation field if they consider public participation and consult with people on it. Nejati (1380), He has considered organizational participation for Participation in projects thatinvolve inter-organizational participation and development from bottom to up. Zarei (1999), aproject is successful when people voluntarily participate in it. Dwyeran (2008), points out to create participatory fields in powerful individual or group projects, their opinion should not be imposed on others, and the parties involved must exchange information together to complement them, and understand each other's views to reduce the conflicts. No individual or group should be dropped in the process of reaching an agreement. Rafieian (1394), mentioned the following characteristics for modeling participation in participatory planning: be rational, comprehensiveness, transparency, be effective.

Habibi and Saeedi Rezvani (2006), to create participation, have discussed the following issues:
- Real participation is possible when planners and managers believe in citizen participation.
-The decision making authority is left to the citizens.

- If participation is considered as a goal by itself aimed, we get closer to realone.
- Citizens' opinion polls.
- Having the right to protest the plan.
- citizens Supervision.
- The flow direction of information and the intensity of flow is a factor in determining the extent and type of participation.
-The intellectual and philosophical support from participation.

Mousavi (2006): examines participation in two categories: the first, social participation (including trust-consultation with others- the priority of public interests to individual interests), and the second is participation in institutions (including membership in institutions- donations in meetings and establishment of institutions) [3] [4].
According to information which has presented, the requirement criteria to creating the participation are in Table 1.

Table 1. Criteria and Indices for conservation Projects in Participatio

Criteria	Definition
Consult with people	Information flows from people to officials. In this process there is no formal dialogue between the people and the authorities
Development from bottom to up	The existence of a local administrative mechanism and a lack of top-down look
Voluntary	Creating a tendency for citizens to take part in Voluntary Participation
Inter-organizational Participation	Exchange of information between urban organs and urban managers to establish extensive cooperation
The trust	Creating transparency at all stages of the project in order to obtain the confidence of citizens

Table 1- There are some criteria in this table that considered as the main components of the participation, and as a result, they are used to create and increase that in any field.

3 METHODOLOGY AND OPERATIONAL FRAMEWORK

The method of this research is descriptive due to study the principles of participation in governmental conservation projects in Yazd World Heritage Site. Also, the goal of this research is practical. Different methods and tools are used in the different steps that are: in the first step, as well as reviewing the history, the concepts and foundations are discussed by using documentary studies. In the second step, the criteria and indices of the research are discussed by using the descriptive method, and the data collected with documentary studies (plans and reports), field observations and semi-organized interviews with urban management (Municipality and world heritage base historic city of Yazd). Finally, by excerpting the appropriate criteria for research, these criteria and the extent to which they are realized in governmental conservation project will be assessed.

3.2 Case Study

Yazd city is located in the center of the desert of Iran and has a semi-tropical climate. The Historic city of Yazd was registered as the first historical city of Iran and the Twenty-second historical monument of the country and one of the first cities of the world on 9, Jul 2017 at the forty-first meeting of the UNESCO World Heritage Committee. Then, according to the priority of the global registration of the historical texture of Yazd, urban plans and projects provided that government conservation projects can be mentioned. Between 2017-2019, about 92 conservation projects have been executed. The data of these projects are grouped into three groups of executive, design, and managemental in Table 2.

Table 2. Conservation projects in the Heritage site of the Historical City of Yazd after the Global Registration

governmental Protective Projects	Number of Projects	Type of projects		Executor (governmental)		Project Contractor	
		Physical	Non-physical	Municipality	world heritage base historics city of yazd	Governmental	Private
Executive	78	✓	-	-	6	6	72
Design	6	✓	-	72	6	6	-
managemental	8	✓	-	-	8	8	-

(Reference : Municipality and world heritage base historics city of yazd, 2019)

Table 2- One of the challenges is the conservation projects implemented in the world heritage is that they pay attention to physical problems and ignore the non-physical ones. The contracting parties were mostly the private sector (based on information obtained from private sector projects by 16 private companies) that shows the widespread communication between public and private organizations which will be a strong point to increase further participation in conservation projects in the field of world heritage.

4 FINDINGS

As already mentioned, the indices (inter-organizational participation, the trust, voluntary, development from bottom to up, consulting with the people) are considered as the criteria for governmental conservation projects. According to the studies and interviews, it has been determined that the selected criteria have not a significant impact on conservation projects, and each project has some weaknesses aboutthat. As a result, these projects have been weak in these criteria due to project conditions that did not discuss participation, and also officials and managers did not pay attention to this. And citizens only enter into controversial discussions when they want to build their personal properties. It is remarkable also that people do not accompany to many performed projects in the heritage site of Yazd city and sometimes they have requested to world heritage site to have some projects based on their need in their place. Now the world heritage site in the historic city of Yazd is seeking to increase this communication and trusting residents to identify the needs of each neighborhood and resolve them by themselves. This cooperation caused the residents to be willing more to participate in the run and after the implementation of projects related to the conservation of historical texture of Yazd and other urban organizations. According to an interview with authorities about implemented or ongoing projects, people have not participated on themyet, and only one of these 92 projects, which called Qiam street project, people have been participating with the municipality. As a result, we can say that there are other shortages that we face, the lack of unified and coordinated management of municipalities and other urban organizations, the lack of trust between managers and the people to participate voluntarily and an executive mechanism that is up to bottom.

5 DISCUSS

Regarding the purpose of the research in the challenges, it is shown that people have not yet been able to communicate with urban managers, and face with challenges that can be categorized in some groups such as managemental challenges, organizational and cultural challenges.

The managemental challenges that we face are including:
- Management organizations in Yazd World Heritage Site have not set up mechanisms for stakeholder participation.
- Time is one of the basic principles, because the project process from design to implementation may take a long time, so it may have different executive managers who have different visions and motives around the project that finally reduces the motivation for local participation between people and even urban management.
- There is no expert management.
- Failure to hold specialized and public meetings to motivate and encourage citizens to volunteer in participation.
- Absence of proper education of citizens in the field of participation.

Organizational and administrative challenges include:
- Inter-organizational participation in the ratification process until the implementation of the projects caused less awareness of urban managementabout others, which makes participation out between organizations only at the level of supervision.
- Inaccessibility to urban projects, resources and information.
- Administrative processes.

Cultural challenges include:
- The lack of mutual trust between citizens and city managers due to unsuccessful experiences and projects, and the prejudices that prevent participation.
- Not participating in urban planning.

6 CONCLUSION

A residence as one of the topics discussed at UNESCO, concerning the universal register of historical texture of Yazd city with people who live there, are the main drivers of development. Having projects based on counselor and employer's orders, and prepared without regarding the needs, demands and priorities of the people, caused lower participation in projects and plans implementation and reduces citizens' housing and belonging. One of the key ways in which to provide participation is that people propound their own needs themselves. Therefore, all conservation projects should be exposed to the public and ask them for opinions. These polls will provide a feedback to improve conservation projects. Also, we need some resources to develop and increase participation in all stages of conservation projects that can respond to the challenges appropriate to the culture and living conditions of the residents. In this regard, we can choose some groups (includes: people, city administrators, authorities, and higher education) among stakeholders in World Heritage Site as contributing groups to plan the projects which facilitate participation.

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The Use of Adobe Material and Mortar in The Traditional Kula Houses and Sustainability

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ABSTRACT

In Anatolian cities and towns, before the 20th century, remarkable housing and a living culture were formed. Traditional houses have been changed and developed with the organic texture. Anatolian traditional houses were built from the beginning of the 17th century until beginning of the 20th century. However, to the present day, the architecture of the residence, which survived from the late 18th century to the beginning of the 20th century.

Traditional housing has evolved in the historical process as a result of the harmonious relations of people with nature. On traditional residential architecture, there are many design criteria that carry sustainability features. Manisa-Kula, one of the districts where traditional residential architecture is densely built, is a living residential museum that has survived to the present day.

The traditional houses of the Kula are mainly designed in the 18th century open hall plan type. In Kula traditional houses, there are many buildings, open sofas and two storey houses. Traditional houses of this type appear as early examples in the Kula. In later periods, the internal and middle hall plan type was seen. However, in terms of building orientation, usually belonging to Muslim families of dwellings of the courtyard looks inside and others look into the courtyard. However, the structures were changed many times in the following periods. There are many sustainable criteria in the design and selection of materials. As building materials of Kula traditional houses which are mainly seen is wood, regional black stone and adobe brick.

In the study, the use of adobe material in Kula traditional houses will be examined. The study was started with observations and measurements in Kula's traditional urban fabric. In addition, the similarities and differences of traditional houses of building materials seen in other Anatolian regions will be investigated.

Key words: Traditional House, Sustainability, Building Material, Adobe Brick

1 INTRODUCTION

Culture can be defined as the totality of all material and spiritual values created in the process of historical and social development. And it is defined as all of the factors used in reaching the next generations, which show the extent of human sovereignty to the natural and social environment (URL 1, 2019). Culture is transmitted from generation to generation. The preservation and maintenance of culture depends on this transfer. The transfer of culture to generations defines it as a heritage and makes culture important.

Kuban (2000) states that the transformation of concepts and objects into symbols for various reasons in the life of societies constitutes culture. The concept of Cultural Heritage has evolved as a definition and scope in historical time. In the early period of the formation process of the cultural

heritage was confined to important monumental structures. Within the later processes, the scope expanded and included civil structures, urban and rural areas. Cultural heritage has been developed by including intangible values, cultural and artistic branches (Korumaz, 2015).
Each of our districts and cities in Anatolia reflects a certain culture. The most important criteria that make up the identity of our cities are traditional architecture. Traditional life indicates the city's social structure and relations. Traditional values of cities and their architecture, which are uniformed by the effects of globalization and lost their identity. In particular, cities and settlements which have unique traditional architectural features should maintain these values. Because traditional architecture is formed on the basis of harmonious relations between people and nature, it has many sustainable design criteria.

Anatolian cities and towns, before the 20th century, a great residential tradition and culture of living has been formed. The traditional residential structure is developed with different designs, organic street texture and different facades. Kula traditional houses were built from the beginning of the 17th century to the beginning of the 20th century. However, to the present day, housing architecture, which has remained from the late 18th century to the beginning of the 20th century, has generally survived.

2 METHOD

Before the 20th century, there was a great tradition of housing culture in Anatolian cities. The traditional house or the Turkish dwelling house was established in the Ottoman period in the cities and settlements of Rumelia and Anatolia. This building culture continued for about 600 years (Eldem; 1968). Traditional house or Turkish house continued in the lively house scheme that we saw examples in Anatolia. Traditional Anatolian houses that survive to the present day start from the beginning of the 17th century to the beginning of the 20th century.
The study started with observations and measurements in the traditional urban fabric of Kula and to identify the existing traditional houses. In this context, the subjects investigated within the scope of the study are as follows.

- Traditional Kula traditional architecture,
- Use of mud brick and mortar material in traditional architecture,
- Sustainability of Historical cities

3 TRADITIONAL KULA HISTORIC URBAN AREA

a. Location of Kula Town

Kula is 118 km from Manisa and 75 km from Uşak. The town is limited with Demirci-Selendi districts in the north, Salihli in the west, Alaşehir in the south, Uşak in the east.

Figure 1. Location of Kula

Kula is located on the Ankara-Izmir state highway, 140 km from Izmir. The Kula urban protected area is 500 meters away from the main road, connecting the two major cities.

b. **Historical Process of Kula**

It can be said that Turks settled in this region at the beginning of the 14th century. Yakup Bey, one of the Germiyanoğulları, left the Anatolian Seljuk Sultanate in 1300. He conquered the settlements within the borders of Byzantium in Western Anatolia. In 1304, the settlement near Kula surrounded Alaşehir (Philadelphia). Meanwhile, the Catalan forces arrived as a result of the Byzantine Emperor's calling for help. A number of researchers write that after the siege of Alaşehir and the withdrawal of the Turks, the Catalan forces occupied Kula. Kula, again under the control of the Germiyanoğulları Principality, at the end of the 15th century, passed to the administration of the Ottoman Empire (Bozer, 1988).

Information about the settlement of Kula in the Ottoman Period can be seen in Evliya Çelebi's Travelogue. Evliya Çelebi stated that in 1671 there were 24 mosques, 3 baths, 6 inns and 1200 houses in Kula (Evliya Çelebi, 1935). Some historians wrote that in the 18th century there was a large bazaar, 8 inns, 11 fountains, mosques and 3 schools. The district was connected to the Central Sanjak of the Anatolian Province of Kütahya, but later (1864) it was connected to the Saruhan Sanjak of Aydın.

At the beginning of the 19th century, Kula became a quiet settlement where different religious groups lived together. Muslims and non-Muslims live together in the historical city area. In the first half of the 19th century, Kula has 30 mosques, 2 orthodox churches, 3 baths, 2 inns, 1 market, 35 shops, 10 coffeehouses, 12 warehouses, 15 fountains, 4 bakeries. "Texier", who came to the town in the first half of the 19th century, mention about town's people and cleanliness of the street. The population of the town for this period is said to be between 4000-5000 people. In general, it is stated that black stone belonging to the region is used in the building and white houses and mosques are located in the city skyline.

At the end of the 19th century, Şemsettin Sami gave information about Kula and stated that there were 30 mosques, 3 baths and 15 fountains. The French Traveler Vital Cuinet refers to similar informations. According to İlter, in 2001, 18 mosques and masjids, 1 tomb, 1 bath, 3 khan, 1 ribat (caravanserai) inscription, 1 fountain and the mirror stone of a fountain were reached from this period. The original state of some of these structures has changed. At the beginning of the 20th century, 2 of the 11 neighborhoods consisted of Greek-Christian populations. In the district, there are 3 churches belonging to this religious group (Bozer, 1988).

After the second half of the 20th century, the district has lost its importance. From 21st century is an important settlement in Turkey with the traditional urban texture and rich volcanic areas. This urban texture consists of bazaar – housing neighborhoods. There are important examples of traditional residential architecture in the historical urban texture. It is a museum city that preserves its original life (Bozer, 1989, Tosun, 1969).

The sustainability of traditional houses is reflected in the architecture of the buildings. The historical area, which includes the traditional housing texture and commercial area, was protected in 1979 as "Kula Urban Conservation Site Area". Churches are important buildings used by Greek-Ortodox in 19th century cosmopolitan structure of Kula. (İlter, 2001).

Aya Yorgi Church and Virgin Mary Church are small buildings which are compatible with urban historical texture. Today, "Aya Yorgi (Hagios Stefonos) Church" has not been restored. The "Church of the Virgin Mary" was renovated in 2011.
Monumental Buildings in Kula:

- Mosques: Eski Mosque (Cami-i Köhne), Hoca Seyfettin Mosque, Yeni Mosque (Cami-i Cedid), Hacı Abdurrahman Mosque, Necip Mosque, Paşa Mosque, Çarşı Mosque, Mustafa Bey Mosque, Esenyazı Mosque, Carullah Bin Süleyman Mosque, Kurşunlu Mosque.
- Mascids: Uşaklı Mahallesi Mescidi, Derbağlar Çarşısı Mescidi.
- Tombs: Süleyman Şah Tomb,Tahir Efendi Tomb, Yunus Emre Tomb.
- Baths: Kula Sungur Bey Bath (This bath is renowed to cafetaria and exhibition space)
- Thermal Baths: Emir Baths
- Fountains: Eski Fountain, Beş Ulalı Fountain
- Bridges: Bahas Bridge
- Churches: Virgin Mary Church, Hagios Stefonos Church (This church was burned and destroyed in 1986)
- School: Zafer Primary School

Figure 2. Kula, 1960 (Kula Municipality)

Figure 3. Kula Conservation Site Area and Geological Site Area

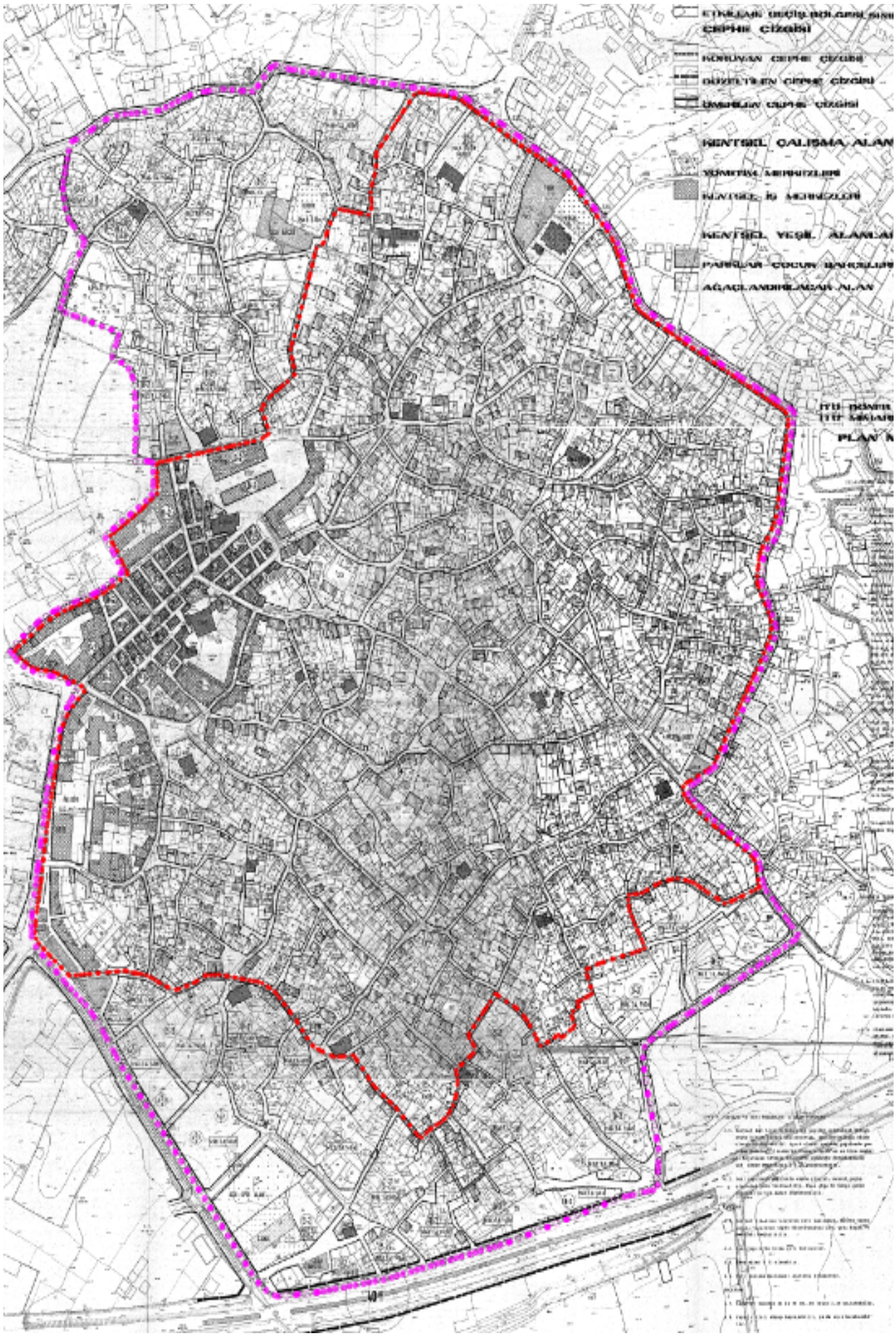


Figure 4. Kula Conservation Site Area (Kula Municipality)

Figure 5. Kula Conservation Site Area (Kula Municipality)

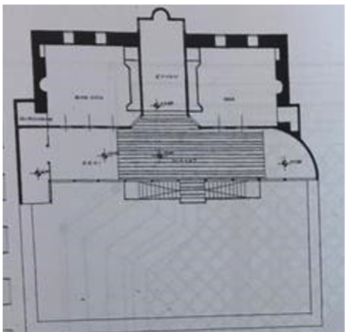
c. General Characteristic of Kula Traditional Houses

Anatolian people have created traditional Anatolian dwellings using local materials such as stone, wood and earth. Studies on the traditional dwelling show that the formation of the dwelling is influenced by religious, cultural and local factors as well as the nomadic Turkish culture. Anatolia traditional housing architecture has not formed in a few centuries. Some characteristic features of the traditional housing architecture are dated to the Hittite period. The oldest residential structure in Anatolia is "Amcazade Huseyin Pasha Coastal Residence" and Safranbolu- Bağlar House which belong to the 17th century. Apart from these examples, the traditional residential architecture in Anatolia usually belongs to the 19th and 20th centuries (Bektaş, 2013).

The traditional house and its room have been subject to various researches in terms of origin and its typology. Anatolian traditional houses are generally described as hall (sofas) house type. This plan type was a design developed by the agricultural community in rural areas. In this period, Anatolia society has been under the influence of Islam and Islamic rules. The indoors life experience of Anatolian woman has been an effective factor in housing design. The formation of an inner courtyard, which is one of the common house types in the Mediterranean Region, is caused by the intention to isolate the woman from the outside world due to the conception of privacy. Traditional housing is formed by the combination of type diversity and different lines. In particular, traditional houses are elements of evolution. It is understood that in the 21st century, the historical textures and traditional houses are an integral part of urban culture (Bektaş, 2013).

Historical Kula houses are generally built in attached style. The street patterns are relatively narrow in the housing and commercial areas. The streets are made of rubble stone. Narrow and curving streets with various building projections provide characteristic and varied street patterns.

In historical Kula houses, the main typology is room opening to sofa (Figure 5). Sofas are the main circulation space of the house and they are also use for living and sitting area. The courtyard and gardens are perceived as an important living area as well. Usually in the courtyards, hearths, fireplaces, coking places and laundries were found.



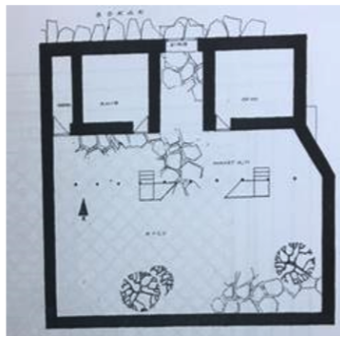


Figure 6. 7. Hacı Recepler Houses Ground Floor and First Floor Plans (Tosun, 1969)

Figure 8. 9. Hacı Recepler Houses 1969, 2018 (Tosun, 1969, Atalan, 2018)

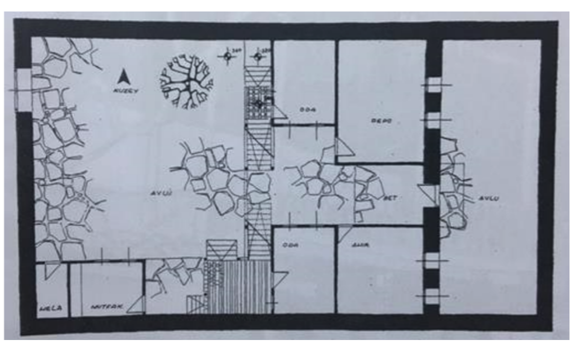


Figure 10. Bozerler Houses Ground Floor Plans (Tosun, 1969)

Figure 11, 12. Bozerler Houses (Tosun, 1969)

Figure 13. Bozerler Houses, 2018

Kitchen and toilets were placed in the courtyard or in the house itself. Pitched roof with various solutions is the regular roof type with pantile ("alaturka" roof tiles). The eaves were wood, either undecorated or decorated. They can also be made with wood with mortar cover. Many houses had writings and decorations on their eaves. The paintings with miscellaneous decorations were also seen in the interiors of some of the houses. Wood, gypsum and stone decorations were also found.

The timber construction on the projections provides an architectural character to the building pattern in the area. These structural wood projections are framed with wood elements in the facade as well. The supports for these projections can be made of wood, stone or metal.

Most common frame types in the facades for windows are door are stone projections. On some buildings have windows and doors with arched projections with keystones. The width of the windows on the upper stories are usually 60-100 cm, height 1.40-1.90, and on the lower floors the dimensions of the living area windows can be 10 cm less. The basement floors which covered the service areas usually have square shaped windows with metal frames for security.

The entrance doors are usually heightened 2-5 steps from the road surface. Stairs made up of either stone or mosaic threads and rises gave way to the entrances to the houses with arched projections and double doors. Later period historic houses may have carving and moldings on the doors and the arches.

Most of the houses in the conservation are from the 19th century. The ethnic backgrounds of users and builders have been an influence on the architectural character of the houses. Together with that the Middle Anatolia and Aegean Region socio-cultural relationships and other regional characteristics such as climate and building material resources had been a major part in the shaping of the architectural character of these buildings.

Traditional Kula Houses were generally built on two floors. On the ground floor of the houses, there are places like stables, pantry, storage, kitchen and service places. There is a toilet on one side of the courtyard and an oven for making bread. The courtyard is surrounded by a high stone wall. In the early examples, the entrance to the courtyard is seen from this stone wall, while in the late period, the entrance to the building and the transition to the courtyard is seen. In the second half of the 19th century, house schemes with inner and middle sofas are seen. The houses planned in this scheme have two gates, the street gate and the courtyard gate. The courtyards are furnished with slate stone.

Although open plan scheme is often seen in Kula houses, types of plan with inner hall and middle hall are also seen. In open-plan houses, one-room, two-room or multi-room plan schemes with kiosks and iwans are also seen. Researchers and academicians Rüstem Bozer (1988) examined in depth the traditional dwellings, with their sofas and room layouts, are quite remarkable and the majority of the buildings are large in size. Under the sofa, there are wooden pillars or supporting columns that carry the sofa. Some houses also have a mezzanine.

Figure 14. Kula Zabunlar House (2019)

Kula traditional dwellings were built with wooden carcass architecture in general. The ground floors of the houses built as masonry stone, the upper floors are adobe fill between the wooden carcass systems. Some of the buildings were completely built as stone masonry. Black stone and kofeke stone brought from nearby volcanic area were used as stone materials in the buildings. Today, stone masonry structures are in better condition than wooden carcass structures.

Figure 15. View from the sofas, (2019)

Figure 16. Traditional Stone Kula Houses

Figure 17, 18. Traditional Carcass Kula Houses

d. **Traditional Kula Houses Construction Techniques**
e. **Adobe Material**

Adobe is a composite building material obtained by mixing straw or other additives into clay soil, kneading with water, pouring into molds and shaping and drying outdoors. The mud brick was used by people for a long time as a building material. There have been mud brick houses in Anatolia, whose main material has been soil since the early periods of history. The most beautiful samples of mud brick made of soil which was revealed in Çatalhöyük excavations around Konya-Karaman at the process of B.C. 5700-5500 years. This building tradition has continued until today and has been used in buildings with many useful purposes.

The clayey soil which found in every region used in the construction of mud brick material is widespread. The construction technique is easy. It is a second activity for the people living in rural areas except agriculture. Cost of Construction with adobe material is economical.

Figure 19. 20. Konya Adobe Material in Konya Region, (Koçu, Korkmaz, 2016)

Figure 21. 22. Structures made with adobe material in USA

Figure 23. Adobe material and Mortar Plaster (URL3)

Figure 24. Adobe material and Mortar Plaster in Kula House


Figure 25. 26. Adobe material and Mortar Plaster in Kula House

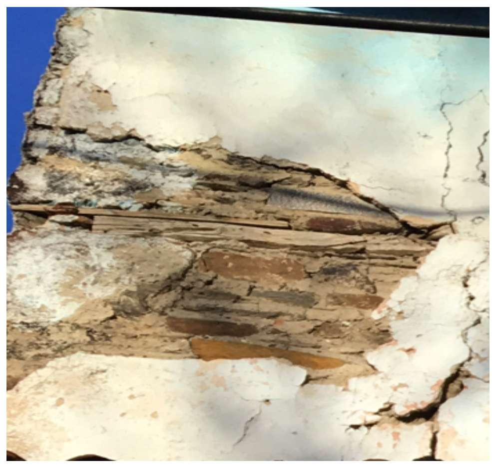



Figure 27. 28. Mortar Plaster in Kula House

f. Usage of Adobe Materials in Traditional Kula Houses

Kula historic buildings have peculiar characteristics with construction techniques and materials, plan types, entrances, window types, shutter types, stone projections, balcony metal works, projections, projection supports and decorative elements. Elaborated by these elements, there are two basic building types in the Kula Conservation area.

- The first construction typology is masonry construction type, made of stone, brick or adobe. Generally they are one or two storied house with cut stone basement floors in all building material types.
- The second construction typology is timber frame houses. In this typology ground floors are stone construction with second floor wood frame with stone or earth fillings. Stone walls are about 50-60 cm thick and second floor is about 20-30 cm thick with mortar surfaces.
- Generally, mud brick and mortar materials are used as filling and covering elements in Kula Traditional Houses.

Figure 29. 30. Traditional Carcass Kula Houses with mortar surface

4 RECOMMENDATION FOR A SUCCESSFUL CONSERVATION AREA INITIATIVE

It has been argued in this article that the conservation area in Kula possessed certain evidential, historic, aesthetic and social values. This value makes a conservation approach for the Kula Conservation area. Current approaches of policy making, planning and design circles also expect it to be a sustainable one.

Sustainability is a criticism and also a vision of the past, present and future trends of growth of populations, pollution, diminishing of natural resources and increase in social and health problems and imbalances and many other problems of humankind-environment interaction. Beside the problems of perceiving and solving the unsustainable behavior of the society in general, even attempts for defining the sustainability concept have become a discussion because of the complex and paradoxical set of issues. The English Heritage conservation principles provide a model approach which goes parallel to Campbell's Sustainable Triangle (Atalan &Özkeresteci, 2014). These principles are as follows:

- **The historic area is a shared resource**: A record of human activity our historic areas have been shaped by people responding to the surroundings they inherit, and embodies the aspirations, skills and investment of successive generations.
- **Everyone should be able to participate in sustaining the historic area:** Equal opportunity must be provided to everyone to pass and share knowledge of the value and vision of places and things.
- **Understanding the importance of places is vital**: Distinctive identity, significance of places building and objects and the value generation must be respected and protected.
- **Significant places should be managed to sustain their values:** Change in the historic areas is inevitable, but any intervention in the conservation areas must be approached in a collective and sustainable approach.
- **Decisions about change must be reasonable, transparent and consistent for along time:** Decisions about change in the historic area demand the application of expertise, experience and judgment, in a consistent, transparent process guided by public policy. Public participation and sharing of information is important for communication.
- **Documenting and learning from decisions is essential for conservation**: Conservation is a continuous effort. Sustainability is a long term goal. For all these goals continuous and healthy recording of all efforts and measures must be recorded and shared.

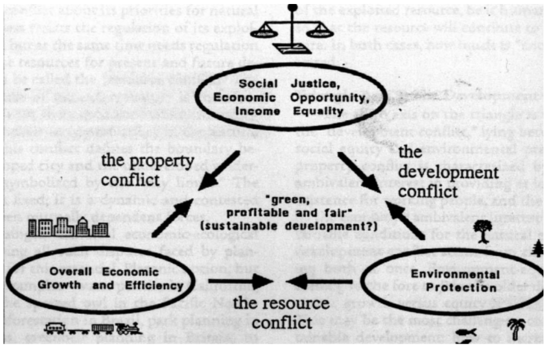


Figure 31. Sustainability Triangle (Campbell 1996, Atalan & Özkeresteci, 2014).

The above principle can be guidance for Kula Conservation Area plan. A principle based approach will certainly create a more systemic a long term effect on the policy making, plan making and architectural intervention of the conservation areas.

5 CONCLUSION

Historical areas are an indicator of the creativity of societies with their admirable general appearance. With these special meanings, historical environments are the areas that must be protected and kept alive. Together with the studies, researches and meetings carried out since the mid-20th century, the development of historical environmental awareness and the necessity of the historical city texture and culture of the historical buildings were understood.

The change of historical areas over time should be controlled. When the degree of change begins to undermine the character of the city for years, the local identity is also damaged. In order to ensure the sustainability of historical environments, it is necessary to protect the quality of life, to revive the old cultural environments and at the same time to harmonize with the living conditions of the city.

Historical areas which belong to city is combined today's living conditions. Historical building and texture should be re-functionalized. The urban and regional identities of historical areas need to be preserved. Because of the rapid development and pressure of change, the emphasis on urban historical elements is important for sustainable conservation. In particular, historical urban sites such as Kula should functionally integrate with the developing city. These areas and historical building should be given new functions of current life. The design principles of the historical buildings must be maintained. The use of local materials should be supported and the continuity of historical urban identity should be ensured.
In particular, it can be said that the construction techniques and the use of mud brick and mortar material in the Kula traditional houses, which are researched within the scope of the article, are similar to many of the traditional housing textures of Anatolia. The conservation of this local building system will not only contribute to the protection of urban identity, but will also help to restoration of the historical Kula Houses.

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Bio-Inspired Structural Design for Sustainable Future

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ABSTRACT

Nature has always inspired humanity by solving the basic needs with minimum material and sustainable solutions. Observation of nature enables architects and engineers familiar with highly developed structures and lead to the creation of new forms. The designs that are produced by learning from nature lead to practical engineering solutions in terms of sustainability. Since, life sciences has already been the case for solving problems for the universe and the humanity for centuries, yet recently used in technological development for structures and in architecture.

Structure is the way of arranging the parts or forming a whole in a particular way by putting the parts together by a specific order. The structural orders in natural structures dynamically change and gain stability in respect of the function for the whole system to obtain maximum efficiency with minimum material usage. Therefore, unfolding of space, minimum energy shapes - Platonic Solids are examined for analyzing structural efficiency in nature since the understanding of biological models can lead to more ecologic, new, efficient and sustainable structural systems.

The aim of this paper is to highlight bio-inspired design process approaches for ecoconsious architecture and pointing out the structural efficiency inspired by natural structures while proposing novel structural system and the possibilities for integration with earthen like buildings for sustainable future.

Keywords: bio-inspired design, structure, part and whole, efficiency, sacred geometric structures

1 INTRODUCTION

The assembly of the materials and the way how the parts integrate shows a culture's perspective and their relationship with the era. The changing needs of the social life developments in the building technology and economy embody the build structures. Structural system is significant, as without which nothing can exist. The design process of the structural components and the materials need appropriate considerations for gaining performance of the structure in order to provide sustainable future [1].

Earth is the material of sustainability, by its qualification of being used from primitive ages to our era, also, earth will be the material of the future. The earthen buildings can be integrated with bio-inspired structural systems for efficient building technologies within the needs of our century.

Vitrivius points out the buildings should have three main objectives "firmitas, utilitas and venustas", "strength, utility and beauty", which are also the nature's aspects. The earthen buildings are providing opportunities for building holistically in all aspects not only materially but also eco-conciously. In todays building technologies, earth have not gain its importance because of building difficulties and structural limitations. However, earth is the most breathing material while enclosing a space as providing inner and outer equilibrium for the comfortable living criterias.

Bio-inspiration from nature to further technological outcomes - practical engineering solutions, has been named in many terminologies such as "Biomimetics", "Biomimesis", "Biomimicry" and "Bionics". Biomimetics is a multidisciplinary approach by understanding, analyzing and abstracting for applying biological principles to human designs in a wide diversity of domains like electronics, informatics, medicine, biology, chemistry, physics, mathematics, art, architecture and many others.

Benyus [2] declared that biology can be a model, measure and mentor for all disciplines. As we see nature as the mentor, our relationship with our environment will change. Jenaine Benyus pointed that our challenge is to take these time-tested ideas and echo them into our lives. It is the point, when we come not to learn about nature but to learn from nature, by integrating with the ecosystem.

The fact that biology is chosen as an inspirational source for unlimited possible new innovations is because of the potential it offers to create a more ecologic built environment. For a sustainable development, biologically-inspired design, BID has gained its significance. The bio-inspired innovation design process of the technological outcome has been classified in two main categories.

First one is to define a human need and design problem in the way how the organisms solve is "design looking to nature". The second is to identify a particular structure or function in an organism and translate it into human designs is "biology influencing design". Helms, Vattam and Goel [3] classified the approaches as problem-driven approach and solution driven approach in their study on their cognitive study of BID. The technological outcome's success depends on how deep the model was analyzed.

An example from industrial field is the 'Lotusan' which is a self-cleaning paint. Whenever the self-cleaning properties of the lotus leaf are understood well enough, the notion of self-cleaning buildings begins to be questioned. In that respect, the 'Lotusan' paint come to life as an innovation for progression shown in Figure 1.

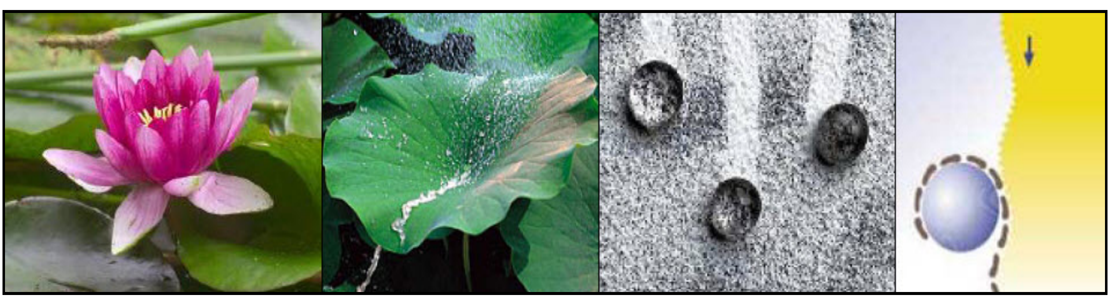


Figure 1. Self cleaning learnt from lotus [4]

An example from solution-driven approach to architectural field is The Eastgate Building, an office complex in Harare, Zimbabwe shown in Figure 2. Learning from termites' mounds about how to create a sustainable building which has an air conditioning system such as in mounds that have self-cooling and maintain the temperature inside within one degree, day and night - while the temperatures outside change from 42 °C to 3 °C. By analyzing the ventilation system in mound, the building uses 90% percent less energy for ventilation than conventional buildings [6].

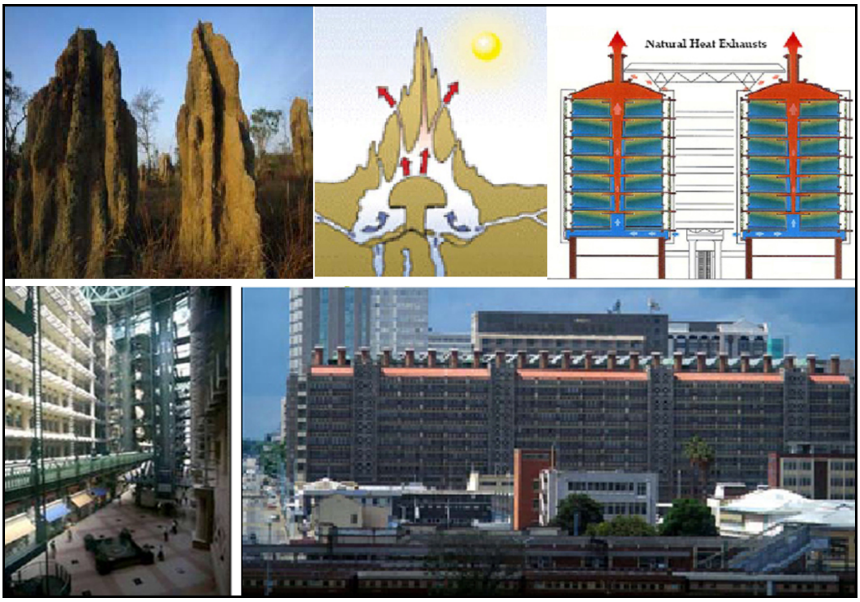


Figure 2. Ventilation System learnt from Termites, The Eastgate Center [5]
1-2 Termite Mound and its Ventilation system, 3. Building Ventilation Schema, 4-5. Eastgate Centre

Briefly, most of the indirect approach is a design process of choosing the biological model, structure, learning the specific ability of the model, and applying to the desired field. Since, this process starts with learning the biological model, the technological innovation depends on how deep the research analyze the model. Deeper analyzes lead to more ecologic solutions.

Earthen buildings create the building envelope of a space, enclosed for a defined usage. The protective outer layer appeared in all scales in nature, such as the membrane of a cell, outer surface of an organ, the skin of the body which provides inner and outer equilibrium for vitality. In plant structures, protective layers of a seed, the weaving principles of tree trunks can also be taken as a biological model for analyzing deeper for structural efficiency. The protective layers can be one of the biological models inspiring for the building techniques on strength, beauty and function. The structures that are learned from nature can also be applied for earthen buildings for material efficiency and structure durability and provide new building techniques.

2 BIO-INSPIRED DESIGN BY LEARNING FROM NATURAL STRUCTURES

The clues from nature provide richness and efficiency in the design process. The minimum way of close-packing property and the structural order in the building sequence in natural structures are treasures to focus for efficient structural systems. The organic structures are always tending to be in the state of minimal energy configurations, forming close-packing and spherical configurations in each level from atom to the whole universe. Natural structures are successfully efficient not only by their minimal energy configurations with less material usage but also their minimum effects by their interactions on our environment [7].

Analyzing and learning from nature is rooted back to the main need of shelter. From the primitive ages, human beings are always concerned about the structural systems for protection from environmental conditions such as bird nests to yurts, mushrooms to columns and radiolarians to domes shown in Figure 3.

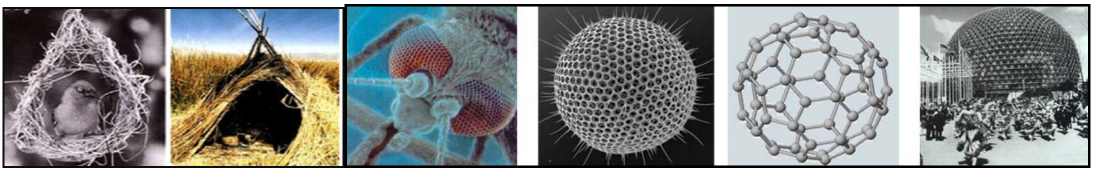


Figure 3. Bird nest and yurt, bee eye, radiolaria, the molecule of Carbon60 and Geodesic Dome [8]

One of the most important architects is the Barcelona architect, Antonio Gaudi who was famous for his biomorphic forms in 19th century. Gaudi observed and interpreted nature in his design process. It is clear that he observed the construction techniques of the nature by analyzing the anatomy of the skeleton and bones which appear in his buildings. The other important architect in 20th century who pointed to design in harmony with nature is Frank Lloyd Wright. He declared in his writings that he inspired by the branching of the trees and the mushrooms for the columns and consoles.

Buckminster Fuller and Frei Otto are among the leaders who tried to analyze the process of the natural forms in the perspective of lightweight structures to apply in large span with less material. They used biomorphic forms not only for inspiration but also for learning the construction techniques. Buckminster Fuller, developer of the Geodesic Dome and synergetic structures, highlighted the internal properties of nature with its dynamic, functional and lightweight structural configurations from his deep analysis of the natural forms. In Figure 3, it is seen that the formation of geodesic dome can be found in nature from the bee eye, radiolarian and Carbon 60 molecule, Fullerene.

Geodesic domes are the geometries that surrounds the largest volume with minimum material usage and creating a whole structure with minimum different sized parts and gain specific properties such as aerodynamics and material - structure efficiency.

Bio-inspiration design process can also be found in the landmarks which are vital for community life. The way the organization of the space usage provided by architectural point of view affect the society deeply. Eden Project by Nicholas Grimshaw and Water Cube, 'National Swimming Centre Beijing Olympics 2008' by the Australian architectural firm of PTW and China State Construction and Engineering Corporation (CSCEC) and Arup are some of the architectural applications based on analyzing natural forms.

3. THE STRUCTURE EFFICIENCY LEARNED FROM NATURAL STRUCTURES

Natural structures, from molecules to high levels of order have a capability of changing their forms from one rigid phase to another in minimum energy configurations. In that case, analyzing the nature's building code is a significant field to be explored in the design process. Ingber [9] pointed out that organic structures are composed by a universal set of building rules. The rules that nature applied recurrently can be found at every scale from simple molecules to highly complex organic structures (proteins, nucleic acids, cells) appeared as patterns, spirals, triangulations and hexagonal growth. Nature's building code is a treasure for analyzing principles, organizations, patterns, optimization in natural structural systems. The natural structures provide innovative and ecologic solutions for every aspect questioned deeply.

3.1 Minimum-Energy Shapes, Close-packing

Close-packing is related to the proposition between the boundary and the area, or between the surface to volume. It is one of the main problems that nature seems to solve by parting the limited area in the most efficient way. The circle encloses the largest area within the minimum boundary, gaps left in between while filling an area. In the aspect of efficient space filling of the circle and stability of the triangle, hexagon is playing the key role for tiling a space and gaining support at their junctions by three-arm node as each balance the stresses shown in Figure 4. The repeated or iterated pattern of hexagons is widespread in nature and seen in every scale, from unaided eye to micro-scale, as it is related to close packing in natural structures such as in Figure 5.

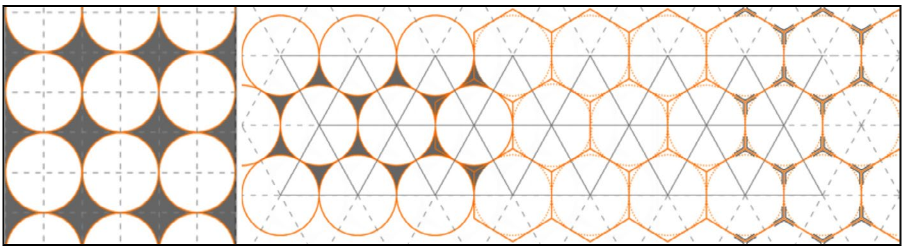
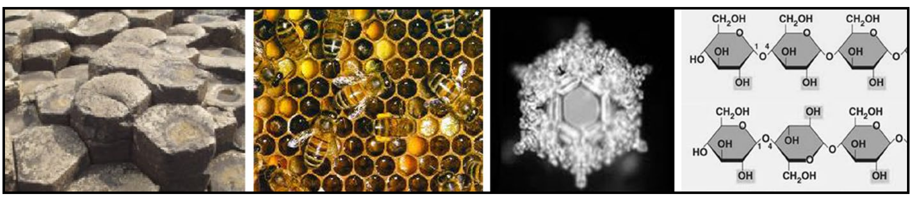


Figure 4. Equal circles; square and triangular packing, and hexagonal efficiency in close-packing.



1. Basalt blocks on the Giants Causeway , 2. Honeycombs, 3. Snow Flake, 4. Glucose monomers

Figure 5. Some examples of hexagon close-packing in natural structures [10]

3.2 The Economic Unfolding of Space, Platonic Solids

The sphere encloses the most volume with the least surface, and the tetrahedron encloses the least volume with the most surface of all regular polyhedrons [11]. Tetrahedron is the prime solid, which is the first and most economic unfolding of space. After tetrahedron, the next is octahedron. The icosahedron is the third regular grouping of sphere which is also in triangulated configuration [12]. Dual of the solids can be obtained by connecting the central points of each plane from each intersection points. The tetrahedron is its own dual, the hexahedron is the dual of the octahedron and dodecahedron is the dual of icosahedron. These solids are the Platonic Solids which are the basis for minimum material maximum efficiency structures.

The most important reason that the platonic solids are chosen for space-filling is that they are composed of same size rods, same size plates and identical nodes. The other specific reason is their property of being the most economic unfolding of space. However, when these five solids are constructed by bars, the cube and dodecahedron will collapse as not being triangulated at their nodal points, differently from the other three, tetrahedron, octahedron and icosahedron as shown in Figure 6. Triangulated systems are very stable, even with flexible nodes and gives strength to the structures even before the physics of materials is taken into account.

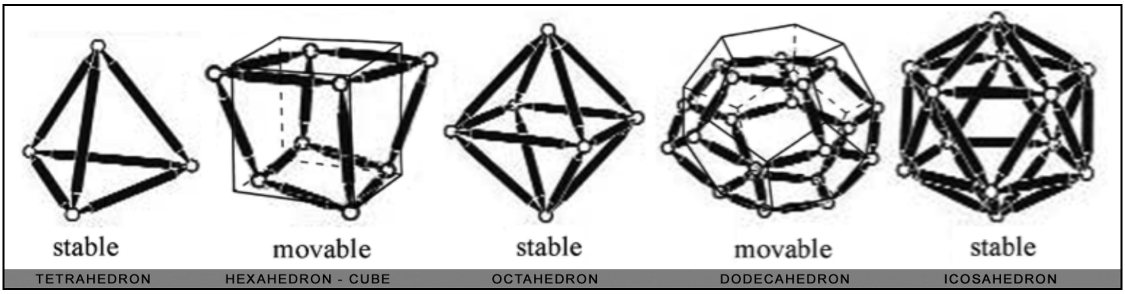
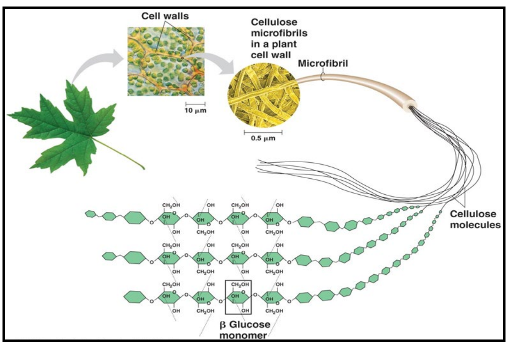


Figure 6. The stable and movable bar structures of Platonic Solids [13]

3.3 Structural Order and Part and Whole Relationship (Structure & Function Correlation) in Natural Structures

One of the main themes of biology is "Form and Function correlation". From molecular level to biological any other scale organization is composed of parts and creating a whole, bigger than its parts. An eye for the molecular level, the molecules gain stability in the defined function of the structure; however, they modify their structural form as the function changes. The molecules are in dynamic equilibrium, gains its structure by its function and when the function needs another configuration, the structure changes to another dynamically stabile form. The architecture of a large biological molecule helps us to understand how nature works.



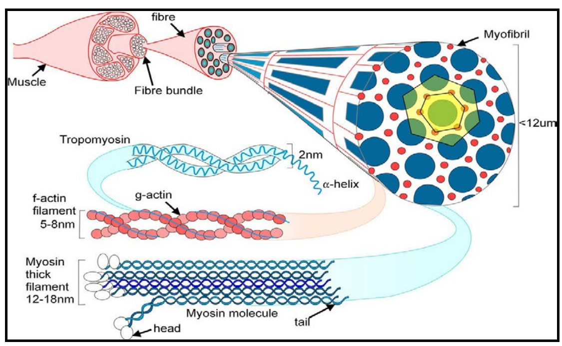


Figure 7. Arrangement of cellulose in the process of forming plant cell walls [14], Arrangement of myofibrils in the process of forming muscles [15]

In nature's structural and physical hierarchy, building up is the process, as complexity starts even in the molecular level, not processing down. There are many routes for understanding the complex systems in nature. Even in the cellulose and muscles arrangement as shown in Figure 7, there is a structural order in the process of making up the upper levels. The lower levels build in the minimum energy configurations to build up the upper levels. The whole of a structural group became a part of the upper levels. Nature provides clues for whole and part relationship which gains its importance in neural sciences. That's the reason analyzing from the molecular level is vital for understanding the building code and the geometry of space enclosing. David Boal [16] explains the logic behind the shape is for enclosing a given area with minimal energy configuration just like building a minimal town wall for a defined field is by a circular wall.

Structural system exists for all the living creatures in the same manner [17], [18]. That's the main reason studying the living creatures not only in terms of species; animals, plants and so on but also in terms of biological structures are significant for understanding deeper and applying for sustainable future. The structures that are learned from nature have great potential to gain durability with minimum material usage.

4. ToL – BIO-INSPIRED KINETIC NODE FOR EFFICIENT STRUCTURES

The structural orders in natural structures dynamically change and gain stability in respect of the function for the whole system to obtain maximum efficiency with minimum material usage. The biological model choosen for bio-inspired design process is related to the questions that are asked for technological outcome. The main question in the design process is to find a modular technological outcome for building up the unstable Platonic Solids, which provide appropriate volume for architectural applications. In that respect, the cell membrane is chosen as the biological model for understanding the components' geometric aspects for efficient structural systems. The cell membrane components; carbohydrate, lipid, protein and nucleic acids formation is analyzed to be inspired and create solution for structural configurations. The analyzes from the components give inspiration for a kinetic node in the aim of gaining variable efficient structural systems with modular components. The nodes of a structural system is crucial for enclosing a space with minimum material usage. ToL (triangle of Life) is a kinetic node with which different stable structural systems can be built with identical nodes, shown in Figure 8.

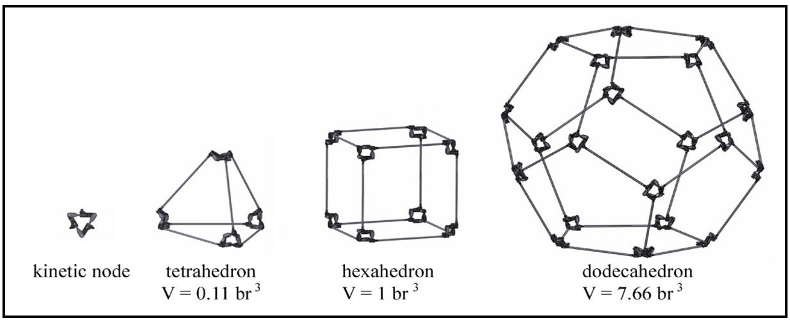


Figure 8. The variety of volumes defined by the same kinetic node [10]

Kinetic node, ToL, also, acquire structural efficiency and easy application techniques for geodesic dome structures. Recently, geodesic dome applications are taking its place in the world especially in ecologic areas for the ones building up their living areas. The integration of efficient structural systems and mud can give possibility for lessen the labor and the amount of materials used for an enclosed space.

In Figure 9, there are examples of two applications, one is in a city and the other is in rural area covering with mud. The Geodesic structures, sacred geometric structures can be applied in different scales, different forms and with a variety of materials.

Figure 9. Examples of geodesic dome applications in city and with mud [19], [20], [21].

ToL, bio-inspired kinetic node is in the period of research and development because of its geometric and structural performance on minimizing the materials that are needed for dome applications. Sustainable future depends on the materials and techniques that are used for the built environment.

5 CONCLUSION

There is an increasing recognition that buildings play a vital role on the environment and society. These impacts force the designers to question *structure, space and time* correlation. Structure which affects the form should response to the pressures acting on it with the demands of time, and even environmental or sociological. Bio-inspiration supply sustainable solutions in using the resources and energy efficiently, controlling the hazardous substances, supplying functionality to the materials and structures and providing profits for our environment.

> 'One could almost redefine biology as the natural history of deployable structures. An organism is successful partly because it uses minimum amount of material to make its structure and partly because it can then optimize its use of that material so that it can influence as much of its local environment as possible' [8].

Sustainable construction techniques and the resource and energy efficiency is one of our century's challanges. Adobe, rammed earth, mud and compressed earth blocks; the earthen construction materials are the very obvious solution for the challanges. Universal local availability, minimal processing, minimal transportation costs, simple construction methods and outstanding thermal storage properties are the inherent qualities of earthen construction materials. Unfortunately, there are still regulation obstacles that prevent the widespread of the earthen buildings from being widespread. [22]

There are big clues in nature for ecologic and holistic concious applications. The construction techniques that concern structure and material integration can be inspired, learned from nature for sustainable future.

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Life Cycle Assessment (LCA) of Adobe Building Block

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ABSTRACT

Although adobe is a traditional material of earthen building system which is environmentally friendly and sustainable with low embodied energy in life cycle process, it has low compressive strength and sensitivity against humidity. In spite of the fact that earthen building products are generally perceived to be healthy due to their natural composition, matters such as asbestos, silica, and radon found in these products can cause important health problems during their life cycle.

The Life Cycle Assessment (LCA), which is one of the methods aimed at reducing the environmental damage caused by buildings and products, evaluates possible impacts of a product on the environment after raw material acquisition, production, sales, application, usage and recycling and/or disposal processes throughout a product life span. A number of many methods and studies found in the literature have dealt with LCA of building products since the 1990s by leading organizations in the world. Various software assessment tools were used to evaluate the system such as BEES, Envest, Environmental Profiles, Team, Ecoinvent, GaBi, SimaPro software programs. In addition, Woolley (1997), Tuna Taygun (2005), Gültekin (2006), Karaman Öztaş (2014), who obtain the decision support tools or checklists for building product selection, assessment methods have been developed. The goal of this study is to evaluate the environmental impacts of the adobe block in terms of LCA and the method developed by Gökçe Tuna Taygun (GTT) is implemented.

During the application of LCA to adobe building block product; the study aims to have information about possible environmental impacts in life cycle process and to provide the method of GTT to be applied. At the end of the study, it is concluded that several enhancements can be made to the development and improvement of GTT assessment method and adobe building production system.

Keywords: Adobe Building Block, Sustainability, Life Cycle Assessment, Life Cycle Assessment of Adobe Building Block.

1 INTRODUCTION

According to the data of the United Nations (UN), the population of the world is estimated to reach 9.7 billion in 2050. As a result of rapid construction to meet the housing needs; natural resources are destroyed and it causes environmental problems in the life cycle of a building. For this reason, more and more countries around the world sustain ecological design and prefer renewable and life cycled materials in building production. Soil is known as one of the oldest building materials used by mankind for solutions of housing needs in the past. Findings obtained from the oldest examples of the transformation of soil into the adobe block and being used in shelter/building production present that this technology has been used through future years and production of the adobe building has been continued until recently. In the historical process, the adobe construction technique has been formed by using soil materials with the auxiliary building elements and certain method at some regions where adobe structure is widespread. Building materials have significant environmental impacts in their life cycle. The assessment of these impacts reduces the environmental impact of materials and enables the selection of environmentally friendly products.

The main purpose of the research is to identify and examine the problems encountered during the life cycle assessment (LCA) of a building product. In this context, it was aimed to evaluate the environmental effects of the adobe building block. In order to identify these impacts, the existing LCA tools; assessment levels and handling of life cycle processes are analyzed in accordance with national context and applicability. In this study; the aim of this study was to evaluate the environmental impacts of the adobe building block by the method developed by Gökçe Tuna Taygun (GTT).

As a traditional material, Adobe is an ecological and environmentally friendly building material from the production stage to the usage and consumption stage. According to the research, the following sub-objectives were achieved by emphasizing the importance of the adobe material in the literature review.

- To have knowledge about possible environmental impacts in the life cycle processes of adobe building products,
- Ensuring that GTT method is tried,
- To contribute to the production of adobe and building products and to make suggestions for the development and improvement of GTT method,
- Reviewing an assessment of environmental impacts of the building product existing in the local market in Turkey are the sub-objectives of this study.

In the scope of this study, the visual, physical, chemical, mechanical and economic properties of the building product were selected and environmental impacts were evaluated by selecting the adobe building block construction system.

The adobe, which finds its own use especially in the central and eastern regions of Anatolia, evolved in the slow development of history, developed and adapted to the requirements of the era and continued to be the main building material of the people of the region. In the second half of the 20th century, the widespread use of industrial construction technologies, especially reinforced concrete in Anatolia, led to the loss of adobe structures as well as all traditional building types. In this study, Balaban houses, which are called as the adobe capital of Anatolia, are examined in the application and usage processes of the building product. Darende - Balaban is one of the best-protected areas of the adobe architecture in our country.

2 LIFE CYCLE ASSESSMENT (LCA)

Building materials have a significant impact on the environment through their life cycle. The assessment of these impacts provides the reduction of environmental hazards and the selection of environmentally friendly products. Life Cycle Assessment (LCA) is a commonly used method for evaluating the environmental impacts caused by building materials and the whole life cycle of a building. The application of Life Cycle Assessment (LCA) to construction materials provides a useful inside to the energy embodied in their production and contributes towards educated decision-making regarding the choice of the most environmentally friendly product [14]. This study focuses on the cradle to cradle LCA of the adobe building block. Life Cycle Impact Assessment (LCIA) is a phase of LCA in order to quantify various environmental impacts based on inventory analysis. Therefore, the holistic approach of the LCA is analyzed firstly. Definitions, principles, aims, usage areas and users of LCA which are accepted by international organizations are referred to in this article.

2.1 Life Cycle Assessment of Building Products (LCA)

The environment is complete of relationships and environments in life. The building is an artificial environment in order to meet the needs of users by characteristics of building products. The life cycle of building products is a set of successive and interrelated processes starting from the acquisition of raw materials constituting the product, until the destruction of the product as a result of ending usage. Life cycle processes of building products; Raw material acquisition, production of building product, application of building product to the building, usage of building product, maintenance and repair, repetition of usage, recycling of building product, destruction of the building product (see Figure 1) [10].

The life cycle can be closed or open;
• Closed loop; recycling of the construction product whose use has ended, to be used in the production of the same construction product,
• Open loop; recycling of building product for use in the production of a different building product
Building products interact directly or indirectly with the environment throughout their life cycle processes. In order to make the right product decision; information about the product-environment interaction is to be collected in life cycles for designers.
Building product;
• Visual (format, size, color, etc.),
• Physical (unit weight, moisture and water properties, heat properties, etc.),
• Chemical (effect of water and moisture, the effect of gases, corrosion effect, etc.),
• Mechanical (behavior against tension and pressure, shear and shear stresses, etc.),
• Technological (deformation, fracture, impact resistance, etc.),
• Economical (production, transportation, storage cost, etc.) properties or information is contained on usage in the building (see Figure 2).

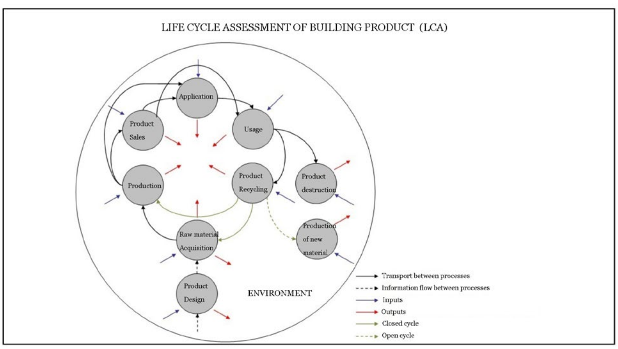


Figure 1. Life Cycle Assessment of Building Product (LCA)- Tuna Taygun, G. (2011) [10].

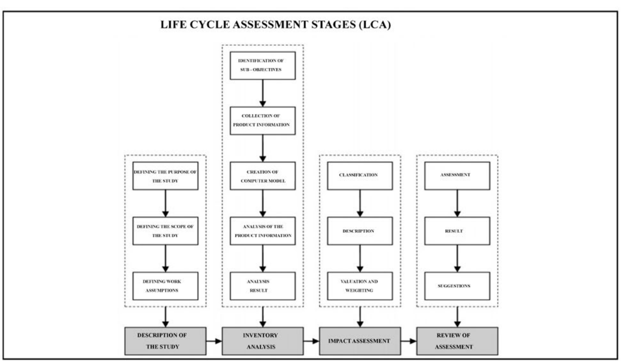


Figure 2. Life Cycle Assessment Stages (LCA)- ISO 14044, Tuna Taygun, G. (2011) [4].

2.2 GTT Method Stages and Processes

Gökçe Tuna Taygun's methodology consists of five main steps [6].
The first step is to define the building product; a purpose-filled information form is completed. In the information form; general information about the building product and the LC processes of the building product. The second step is to collect information on the interaction of the building product and environment in its LC process. In this step, the LC process of the product must be defined. Every inputs and output for each process affecting the environment is being identified. Information cards are prepared for the outputs that may affect the environment and the affected environmental groups. The third step is to evaluate the environmental impacts of the building product in the LC process; the output of the previous step is quantified and the limit values of the environmental impacts are determined. Environmental impact values of the outputs are compared with the limit values. In the fourth step, the evaluation is completed and a proposal for the outcome is presented. In the fifth and last phase of communication, assessment results are explained by illustrated tables (Figure 3).

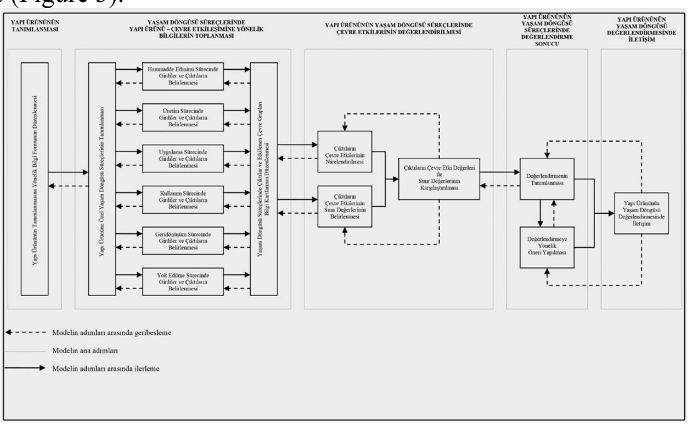


Figure 3. Life Cycle Assessment Stages (GTT Methodology)- Tuna Taygun, G. (2005) [6].

3 LCA ANALYSIS OF THE ADOBE BUILDING BLOCK AS A BUILDING PRODUCT

Life Cycle Assessment (LCA), which is one of the studies carried out with the aim of reducing the damages to the environment of building and construction products, is the acquisition of raw materials throughout the life of a product, production; sale, application, usage, and recycling of the product after completing its useful life assess the possible effects.

In this chapter; the steps of the assessment of the environmental impacts of the adobe building block is developed by Gökçe Tuna Taygun (GTT) by five subheadings. In the application and usage processes of the LCA model, adobe buildings in the Malatya-Balaban region were observed on site. The building material of the Balaban houses, which are usually built on two floors, is adobe and wood. Adobe walls with a thickness of 60-70 cm are raised on a stone foundation.

Wooden beams are thrown in between to increase the strength of the adobe. Stacking technique is used in the adobe material or in the form of filling wood frameworks. The houses of the Balaban houses, built in an intertwined position, are called “Castle City" and have a unique and traditional pattern [3].

Figure 4. Balaban Houses / Malatya [12].

3.1 Description of the Adobe Building Block

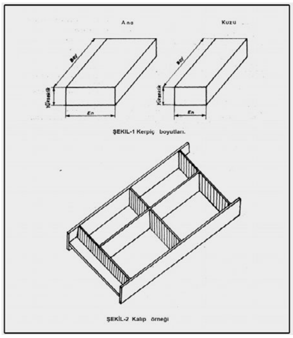
The adobe material is a soil structure product with low compressive strength and sensitive to moisture to be used in different forms within the soil construction system although low embodied energy, sustainable and recyclable building material in the life cycle process. Building products that release asbestos, silica (as well as many other particles) and radon gas found in soil have the potential to become hazardous health effects [7].

Adobe is a building material formed by kneading and molding the soil by water and drying it in the open air. Its main material is soil. Adobe is used in the construction of human and animal shelter. Binding materials added to the soil during the manufacturing process have some effects on improving the mechanical properties of adobe. The most important benefit expected from the addition of various binder materials to the adobe soil is to increase the water resistance of the adobe and to increase the compressive strength [1].

Soil building construction is produced due to regulations and standards in Turkey. TS 2514 (Adobe Blocks and Construction Rules), TS 2515 (Adobe Construction Rules) Standards and Earthquake Regulations are used in soil structure production. TS 2514 Adobe Blocks and Construction Rules; Material and Labor Criteria are examined in details. Another subline is the test to determine the suitability of the soil material.

TS 2515 Design Criteria, Roof and Basic Production Criteria are the topics examined in detail within the scope of Construction Rules of Adobe Buildings. Adobe Block Construction Rules (TS 2514): [1]

- Preparation of the mixture for the construction of adobe (clay soil, straw and vegetable fibers, water)
- Characteristics of the cutting place, determination of site,
- Tools for Adobe cutting
- Cutting of adobe (molding)
- Drying and protection



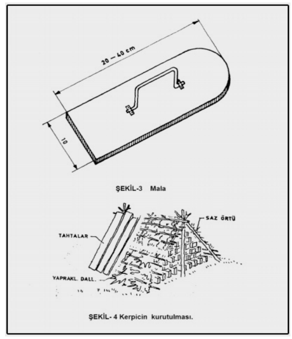


Figure 5. Dimensions of Adobe & moulding-TS2514 [1].
Figure 6. Trowel & Drying of Adobe-TS2514 [1].

The admixtures used with clay soil, which are binding in adobe production, vary as materials such as straw, reed, plant stems, sand, hair, wool, plaster, lime, wood ash, salt according to the opportunities offered by the geography where the material is produced. Straw, which is often added to the adobe paste, is added to the mixture by crushing into small pieces. Beken (1949) summarizes the production of adobe as respectively, digging clay mudbrick soil previously opened and poured into the pit, poured on top of the required amount of water and small pieces of straw are added to wait for a sufficient time, and then hoeing into the mold to mix and slurry is shaken. After the adobe sludge is poured into wooden molds prepared in certain dimensions, the adobe is dried in the sun and made ready for use. During the production of adobe; it is important to use the right amount of water in order to mix the adobe paste well and to compress it in the mold where it is poured to allow it to dry. For example, over-use of water during production may result in shrinkage by prolonging the drying time, while under-use may make it difficult to shape the dough. On the other hand, improper compaction of the adobe paste placed in the mold may result in the formation of gaps in the adobe and causes decrease the strength [13].

According to the calculation values for the walls given in Building Thermal Insulation Rules Standard (TS.825), it was found to be applicable because the value is smaller than the "U" values (UD = 0.50 W / m2K) recommended at buildings in Malatya located in 3rd Climate Region. It was found out that it provides the required building physics conditions and the necessary comfort for the walls at the calculations of TS.825. It is found that the thermal conductivity coefficient U =0.50 W / m2K is recommended for cold climate zones in TS.825 if the wall thickness of adobe houses is 50-70 cm [11].

3.2. Collecting Information on the Adobe-Environment Interaction in the LCA Process

In the second phase of the model; life cycle processes of the adobe building block were defined, inputs and outputs that have impacts on the environment were identified and data sheet tables of each environmental groups were prepared in the life cycle processes (see Table 1 – 10). The life cycle processes of the adobe building block, as in other products; raw material acquisition, production, sales, application to the structure, use, recycling or destruction after completing its useful life.

Table 1. Data sheet for identification of building building product.

GENERAL INFORMATION ABOUT BUILDING PRODUCT					
NAME OF BUILDING PRODUCT			**ADOBE BUILDING BLOCK** (WHOLE-HALF)		
LEVEL OF BUILDING PRODUCT	Equipment	**Component**	Constituent	Element	Unit
PHYSICAL DESCRIPTION OF BUILDING PRODUCT	Shape		Whole – half (Ana – kuzu)		
	Dimensions*	Width	*I.class* 12x19x40 cm 9,12 dm^3 10-12 kg (half)		
			II.class 12x30x40cm 14,40 dm^3 15-25 kg(whole)		
		Length	*III.class* 12x18x30 cm 6,48 dm^3 7-11 kg (half)		
		Height	*IV.class* 12x25x30cm 9,00 dm^3 10-15 kg (whole)		
		Thickness	External wall thickness 40 cm Internal wall thickness 25 cm (minimum dimensions)		
	Weight (average unit)		1.2-1.6 g/cm^2		
	Size Tolerance (shrinkage 5%) *		The adobe bricks should be in the form of a rectangular prism and should not be cracked or broken.		
CHEMICAL IDENTIFICATION & MECHANICAL PROPERTIES OF BUILDING PRODUCT	Mixture		Clay soil, straw, other vegetable fibers, water		
	Compressive Strength*		8 kgf/cm^2		
	Water Resistance *		It should not be dispersed before 45 minutes.		
	Breaking stress *		Mud is not used below 50 g / cm^2.		
	Thermal conductivity coefficient		0.49 W/m^2K		
MANUFACTURER INSTITUTIONAL INFORMATION OF BUILDING PRODUCT	Manufacturer Name		On site Production (local)		
	Manufacturer Address		…..		
	Manufacturer Phone		…..		
	Manufacturer Web Address		…..		

* TS 2514 / February 1977 Turkish Standard [1].

Table 2. Data sheet for the identification of building product- Raw material acquisition 1

INFORMATION ON THE LIFE CYCLE PROCESSES OF THE BUILDING PRODUCT- CLAYED SOIL				
RAW MATERIAL ACQUISITION	Raw Materials of Building Product	Raw materials 1		Clayed soil
		Raw materials 2		Straw and other vegetable fibers
		Raw materials 3		Water
	Raw Material 1: CLAYED SOIL	Location of raw material source	Abroad	…..
			Domestic	Local
		Raw material acquisition system		Soil extraction, Excavator
		Raw material acquisition method		Excavation, loading, transport and pouring. A good mudbrick should pass about 40% of the soil through a 0.063 mm sieve, i.e. 60% above the sieve.
		Equipment used in raw material acquisition		Truck, excavation equipment, sieve.
		Amount of raw material obtained **		91 kg
		Number of employees in raw material acquisition		…..
		Special conditions for employees in raw material acquisition		…..
		Type of waste output in raw material acquisition		Heavy fuel oils
		Amount of waste output in raw material acquisition		…..
		Type of energy consumed in raw material acquisition		HFO (kWh) Heavy fuel oils
		Amount of energy consumed in raw material acquisition **		0.683 kWh (soil extraction)
		Properties of soil (based on clay proportion) *		Fat free (20% clay), medium fat (35% clay), fat (50% clay) and very fat (70% clay). There should be no vegetal soil and peat in the soil to be made of mudbrick, with large stones and pebbles in it, roots should be extracted. *

* TS 2514 / February 1977 Turkish Standard [1].
** For the production of 9 adobe bricks (30*45*5 cm) [2].

Table 3. Data sheet for the identification of building product- Raw material acquisition 2

INFORMATION ON THE LIFE CYCLE PROCESSES OF THE BUILDING PRODUCT - STRAW AND OTHER VEGETABLE FIBERS				
RAW MATERIAL ACQUISITION	Raw Material 2: STRAW AND OTHER VEGETABLE FIBERS	Location of raw material source	Abroad	…..
			Domestic	Local
		Raw material acquisition system***		On-site procurement, purchase ***
		Raw material acquisition method		Collection, storage. It should not be dry, rotten, coarse and thick enough to disrupt the workability of the blend. Long plant materials should be sawn 10-12 cm tall.
		Equipment used in raw material acquisition		Truck
		Amount of raw material obtained **		2.29 kg
		Number of employees in raw material acquisition		…..
		Special conditions for employees in raw material acquisition		…..
		Type of waste output in raw material acquisition		Heavy fuel oils
		Amount of waste output in raw material acquisition		…..
		Type of energy consumed in raw material acquisition		Electric (kWh)
		Amount of energy consumed in raw material acquisition **		0.0114 kWh (Straw pre-mixing treatment)
		Characteristics of straw and other vegetable fibers (for 1m3 soil) Lean soil: 5-7 kg of vegetable fiber Medium fat soil.: 7-10 kg of vegetable fiber Oily soil: 10-15 kg of vegetable fiber Very fatty soil: 15-20 kg of vegetable fiber should be added. *		Straw or other vegetable fibers used by adding to mortar to prevent cracking. Reed plants, coarse grass, hemp fibers, straw, residual straw collected from barn feeders, dry shrubs, pine needles, tree branches, saw and grater shavings and substances. *

* TS 2514 / February 1977 Turkish Standard [1].
** For the production of 9 adobe bricks (30*45*5cm) [2].
*** 1 bag unit price: 15-20 TL (2019- Darende).

Table 4. Data sheet for the identification of building product - Raw material acquisition 3

INFORMATION ON THE LIFE CYCLE PROCESSES OF THE BUILDING PRODUCT -WATER				
RAW MATERIAL ACQUISITION	Raw Material 3: WATER	Location of raw material source	Abroad	…..
			Domestic	Local
		Raw material acquisition system		Ground-water
		Raw material acquisition method		Well
		Equipment used in raw material acquisition		Water tanker, hose pipe
		Amount of raw material obtained **		37 kg
		Number of employees in raw material acquisition		…..
		Special conditions for employees in raw material acquisition		…..
		Type of waste output in raw material acquisition		…..
		Amount of waste output in raw material acquisition		…..
		Type of energy consumed in raw material acquisition		Electric (kWh)
		Amount of energy consumed in raw material acquisition **		0.0057 kWh (water supply)
		Characteristic of the water to be used *		There should not be enough oil in the water to be used, rotten substances, salt and swelling. There should not be any wastes from the factory and substances that are harmful to human health and which will cause the clay to become colloid.

* TS 2514 / February 1977 Turkish Standard [1].
** For the production of 9 adobe bricks [2].

Table 5. Data sheet for the identification of building product- Production

INFORMATION ON THE LIFE CYCLE PROCESSES OF THE BUILDING PRODUCT			
PRODUCTION	Production Site		Production site is to be smooth, horizontal and rigid. If necessary, these areas should be trimmed and shoveled, watered and rammed.
	Distance of raw material to production		Variable
	The way of transportation of raw materials to the production site		By vehicle
	Production Method		The mixture is prepared for the construction of adobe as in TS 2514 standarts. This mud mixture should be allowed to stand for at least 1 night (12 hours).
	Products used in production*		Clay soil, straw, other vegetable fibers, water
	Production equipments		Mold, wooden trowel, bucket or tin, fine straw, wheelbarrow or trimming
	Type of waste output in production		Casting wastes, drying losses
	Amount of waste output in production **		13.03 kg / 23.45 kg
	Type of energy consumed in production		Elektric
	Amount of energy consumed in production **		0.0114 kWh
	Number of employees in production		Variable
	Production conditions for workers	Characteristics of employees	Craftsmen
		Properties of production structure	The area of the site should be 1/3 of the required adobe..
	Packaging conditions after production *		The area is to be suitable for 60% of the adobe blocks and 40% of the distance (10-15 cm) between the adobe bloks for the adobe production.
	Storage conditions after production *		It is useful to cover the mudbricks with grass, reeds and straw during the drying process. Spilled mudbricks should be turned in two-day intervals. Drying period is 1 to 8 weeks depending on the block size and weather conditions.
	Distribution after production	Distribution distance	Production in the field of application
		Type of waste output in distribution	Particule
		Type of energy output in distribution	Heavy fuel oil and man power

* TS 2514 / February 1977 Turkish Standard [1].
** For the production of 9 adobe bricks [2].

Table 6. Data sheet for the identification of building product – Application

INFORMATION ON THE LIFE CYCLE PROCESSES OF THE BUILDING PRODUCT		
APPLICATION	Application Site	Load bearing wall, partition wall, cladding
	Distance of raw material to application	On-site production
	The way of transportation of raw materials to the application site	On-site production
	Application Method	The adobe building block is made in two different sizes of whole and half in "wooden beams masonry mudbrick"and techniques.
	Application equipment*	Trowel, spirit level, plumb, mortar trough, plaster, gauge, wood material, timber
	Type of waste output in application	Adobe pieces, mortar, particule
	Amount of waste output in application	Variable
	Type of energy consumed in application	Man power
	Amount of energy consumed in application	......
	Number of employees in application***	V.0907 Code Sludge mortar carrier mud brick construction and knitting work
	Employee quality in application ***	Simple worker (construction worker)
	Specific conditions of application**	The adobe blocks are 30 * 30 cm (main) and 15 * 30 cm (half). The walls made of two different sizes of mudbrick, one of which is half of the other; with the names of mother and lamb are 45 cm. In these houses, the exterior walls are one and a half and the interior walls are made of adobe blocks. With a large mudbrick, a thicker wall can be built and more loads can be carried.
	Construction techniques of Balaban houses **	The main construction material is wood and adobe. Juniper tree was used in the construction system. Thick tree trunks are used as uprights, and openings in the pavements are crossed with beams called hezen. Covering boards are placed on the secondary beams and adobe filling is done.

* TS 2514 / February 1977 Turkish Standard [1].
**Malatya-Balaban Houses (Eyüpgiller, 2017) [3].
*** Unit Price Codes & Analysis for Building Construction Turkish Standard [4].

Table 7. Data sheet for the identification of building product- Usage

INFORMATION ON THE LIFE CYCLE PROCESSES OF THE BUILDING PRODUCT				
USAGE	Usage Site			Load bearing wall, partition wall, cladding
	Distance of raw material to usage			Variable
	The way of transportation of raw materials to the usage site			By vehicle
	Specific conditions of usage*			The exterior and interior walls of the building were plastered with straw-added mud; the interior walls were cross-bleached and whitewashed with lime. To make whitewash, the creamy earth called cross is used and the soil melted into water is applied with a cloth.
	Specific conditions of users			Any users
	Type of waste output in usage			Damaged adobe blocks, mortar, plaster, coating waste, dust.
	Amount of waste output in usage			There is no waste unless the product is damaged.
	Relationship between building product and energy in usage (embedded energy)***			0,033 MJ./kg***
	maintenanc - repair	At site	Maintenance	The adobe block surfaces are wiped and plaster is applied with lime.
		Outside of usage	Maintenance	No Information
	Equipment used in maintenance and repair			Filling mortar, plaster, scraping, surface correction materials.
	Type of waste output in maintenance and repair			No Information
	Amount of waste output in maintenance and repair			Variable
	Type of energy consumed in maintenance and repair			Man power
	Amount of energy consumed in maintenance and repair			Variable
	Specific conditions of Balaban houses at usage proces**			The original pattern was partially lost and some of the structures were destroyed. Some of the traditional houses have remained today with sheet metal roofs added for protection purposes. Cement plaster was made instead of adobe plaster, and wooden windows were replaced with plastic windows.

* TS 2514 / February 1977 Turkish Standard [1].
** Malatya-Balaban Houses (Eyüpgiller, 2017) [3].
***Calculated for 1 kg adobe building block [2].

Table 8. Data sheet for the identification of building product – Closed Cycle

INFORMATION ON THE LIFE CYCLE PROCESSES OF THE BUILDING PRODUCT		
RECYCLING (CLOSED CYCLE)	Recycling Site	At the production site
	Distance of raw material to recycling	Variable
	The way of transportation of raw materials to the recycling site	By vehicle
	Recycling Method	The adobe blocks are broken and ground according to the dimensions. It is sieved and powdered. Lime is added to certain proportions and turned into adobe mud. (Local conditions)
	Products used in recycling	Adobe block fractures, straw and vegetable fibers, water, lime.
	Recycling equipments	Crusher, mixer, pre-screen filters, mold, wooden trowel.
	Type of waste output in recycling	The data in the production process is valid as well.
	Amount of waste output in recycling	
	Type of energy consumed in recycling	
	Amount of energy consumed in recycling	
	Number of employees in recycling	
	Specific conditions of recycling	

Table 9. Data sheet for the identification of building product- Open Cycle

INFORMATION ON THE LIFE CYCLE PROCESSES OF THE BUILDING PRODUCT		
RECYCLING (OPEN CYCLE)	Recycling product name	Plaster Adobe Block (ALKER)
	Recycling Site	At the production site
	Distance of raw material to recycling	Variable
	The way of transportation of raw materials to the recycling site	By vehicle
	Recycling Method	The adobe blocks are broken according to the dimensions and the pieces are wetted and the mixture is prepared again. Adding lime, gypsum, pozzolan and bitumen emulsion to the adobe paste increases the durability. In order to increase the static resistance, 10% gypsum is added to the adobe paste. Dimension Tolerance-Shrink to 1.8%. *
	Products used in recycling	Lime, gypsum, pozzolan, bitumen emulsion, vegetable fibers (flax fiber, cotton stalk), water
	Recycling equipments	Crusher, mixer, drying or baking oven
	Type of waste output in recycling	Particules
	Amount of waste output in recycling	No Information
	Type of energy consumed in recycling	Heavy fuel oi, man power and electric
	Amount of energy consumed in recycling	Variable
	Number of employees in recycling	Craftsmen
	Specific conditions of recycling*	In this study, it was found that gypsum, which is the least cost, could form matrix easily by adding cement to mudbrick sludge more easily, and it should be encouraged to use this material as an additive since gypsum can easily be produced everywhere with gypsum. *

* Acun, S., Gürdal, E., "Sustainable Materials: Adobe and Plaster adobe" [5].

Table 10. Identification of inputs and outputs that may affect the environment in life cycle processes.

LIFE CYCLE PROCESES		INPUTS	OUTPUTS
Raw Material Acquisition		Energy, man power, vehicle, fuel, water, excavation equipment, sieve, excavator	Raw material waste, fuel waste, stone and gravel, CO-CO_2 - NO-NO_2 -SO_2 -particles
Production	Raw material preparation	Clay soil, water, straw and other plant fibers, energy, man power, tools and equipment	Mud clay, clay, particles, waste
	Cutting	Cutting tools and materials, wooden trowel	Adobe in shape
	Forming &Molding	Wooden mold	Formed adobe blocks, molding wastes
	Drying	Shaped adobe block, solar energy and wind	Shaped adobe building block, drying losses.
	Protection	Grass, reeds, straw (to cover)	
Application		Trowel, spirit level, plumb, mortar, plaster, gauge, wood material, timber, energy, man power	Adobe building blocks, plaster mortar wastes, particles
Usage		Building element, built with adobe block, man power for maintenance, cement, lime plaster.	Mortar and coating product parts, dust, maintenance product wastes
Recycling		Lime, gypsum, pozzolan, bitumen emulsion, vegetable fibers (flax fiber, cotton stalk), water, energy, man power, transportation vehicles	Adobe block fractures, fuel waste, CO-CO_2-NO-NO_2 -SO_2 -particles
Destruction*		Adobe block fractures, destruction tools and materials, energy, man power	Heavy fuel oils.

* After the demolition of the old mudbrick structures, the soil is reused as mudbrick plaster on the inner Walls

3.3. Environmental Impacts of the Adobe Block in the LCA Process

Outputs that may affect the environment in the life cycle processes of the building product and environmental groups are recorded on data sheets and prepared for the evaluation stage (Table 11).

Table 11. Outputs that may affect the environment during the life cycle of the adobe building block and the data sheet of environmental groups.

<table>
<tr><th rowspan="4">PROCESS</th><th rowspan="4">OUTPUTS</th><th colspan="9">ENVIRONMENT</th></tr>
<tr><th colspan="4">LIVING ENVIRONMENT</th><th colspan="5">NON-LIVING ENVIRONMENT</th></tr>
<tr><th rowspan="2">HUMAN</th><th rowspan="2">ANIMAL</th><th rowspan="2">PLANT</th><th rowspan="2">MICRO ORGANISM</th><th colspan="3">NATURAL</th><th colspan="2">ARTIFICAL</th></tr>
<tr><th>WATER</th><th>WEATHER</th><th>SOIL</th><th>BUILDING</th><th>BUILDING PRODUCTS</th></tr>
<tr><td>Raw Material Acquisition</td><td>Carbon monoksit
Asbestos*
Silica*</td><td rowspan="2">Headache, nausea, vomiting, dizziness, Respiratory diseases, shortness of breath and lung cancer</td><td colspan="3" rowspan="3">It has negative effects on animals, plants and microorganisms due to emissions to air and water.</td><td rowspan="6">WATER POLLUTION</td><td rowspan="6">AIR POLLUTION</td><td rowspan="6">SOIL POLLUTION</td><td colspan="2" rowspan="2">Particules affect the indoor air quality.</td></tr>
<tr><td>Production</td><td>Carbonmonoxide
Carbon dioxide
Sulfur dioxide
Hydrogen Chloride
Nitrogen oxides
Asbestos*
Silica*,Chloride</td></tr>
<tr><td>Application</td><td>Asbestos*</td><td>Respiratory diseases, shortness of breath and lung cancer</td><td></td><td></td></tr>
<tr><td>Usage</td><td>Asbestos*
Radon*</td><td rowspan="3">Respiratory diseases, shortness of breath and lung cancer</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Recycling</td><td>Asbestos*</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Destruction</td><td>Asbestos*</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

*The effect of earthen building products on human health during their life cycle [7].

3.4. LCA Result of the Adobe Building Block

It has been concluded that the negative impacts of the adobe building block on the production processes are acceptable. The evaluation result of the 4th stage of the GTT method is shown in Table 12. According to the result determined in the previous stage; for acceptable value, the building product has no negative impact on the environment, for unacceptable value, the building product has a negative impact on the environment; LC process output amounts calculated according to 1 kg adobe building block were compared with the limit values of the output. It is represented by colored icons as shown in Table 13.

Table 12. The result of assessments in the life cycle processes of the adobe building block.

RESULT OF ASSESSMENT	DESCRIPTION OF ASSESSMENT	SYMBOL
For acceptable value	No negative environmental impact in the production of adobe block	●
For unknown value	Not enough information on the acquisition of soil raw materials	○

Table 13. An assessment form for evaluating the environmental effects of the outputs of the building product that may affect the environment during the life cycle processes

LC PROCESS	OUTPUTS THAT MAY AFFECT THE ENVIRONMENT AT THE LC PROCESS	AMOUNT OF OUTPUT	LIMIT VALUE OF OUTPUT	RESULT OF ASSESSMENT		
				Acceptable value $a \leq b$ ●	Not acceptable value $a > b$ ●	Unknown value No information of a or b ○
Raw Material Acquisition Production	Carbon monoxide (CO)	0,909 mg**	150 mg/Nm^3***	●		
	Carbon dioxide (CO2)	1,750 mg**	No Information			○
	Nitrogen oxides (NO-NO2)	3,61 mg**	800 mg/Nm^3***	●		
	Sulfur dioxide (SO2)	10,25 mg**	2000 mg/Nm^3***	●		
	Hydrogen Chloride	9,25 mg**	No Information			○
	Particules	3,41mg**	150 mg/Nm^3***	●		
	Heavy fuel oils (kWh)	0,0104**	No Information			○
Application Usage Recycling Destruction	Silica	Asbestos-Silica-Radon Maps did not find any reserve in Malatya Balaban region.*		●		
	Asbestos			●		
	Radon			●		
	Energy (kWh)	0,0015**	No Information			○

* MTA. Turkey Asbestos Inventory. Energy-Industrial Raw Materials, Metallic Mines Map [9].
**Calculated for 1 kg adobe building block. Cradle to site LCA of adobe bricks [2].
*** In accordance with the Air Quality Assessment and Management Regulation, Air quality limit values for 2017 [8].

3.5. Communication in the Life Cycle Processes of the Adobe Building Block

After completion of the evaluation stage in the life cycle processes of the adobe building block, the negative impacts of the building product on the environment are examined and identified. In addition, these negative environmental impacts are analyzed with the limit values of the output amounts and recommendations are made for the evaluation result. Communicating the results and recommendations of this evaluation to the society constitutes the step of "Communication in the Life Cycle Process of the Building Product ". The society includes both the professional relationship with the building product such as architect, product designer, and manufacturer, as well as users.

4 CONCLUSION

Soil is an ecological material that does not harm the environment. In this context, ecological design approach which is based on resource and energy efficiency and reduces waste generation has been used in the environment production. Adobe building technique only used in the production of soil structure in Turkey, no other regulations and standards related to production techniques are outside the adobe soil structure.

The research on adobe material should be continued and the production of adobe to be ensured by cooperating with the industrial sector in order to meet the needs of the age, the adobe production should be provided in accordance with the standards and turned into a material preferred by architects and building owners. In terms of sustaining our traditional architecture elements; a good organization, mass production, serious workmanship, and problems should be minimized and the application area of adobe and composite adobe materials should be expanded in a short time. The construction of adobe buildings should be continued in order to keep the traditional architecture, culture, and art alive. Renewable, environmental, sustainable, ecological and contemporary material in accordance with today's technology to develop and mass production of scientific research on the provision of mass production should be continued. Studies should be carried out on the restoration and protection of existing adobe buildings that form part of our building culture.

In this study, the method of LCA developed by GTT was tested; all processes are positively expressed by individual checklists. It was concluded that the numerical equivalents of the inputs and outputs were not always given at stages. The usage of LCA method in the production system in Turkey, building products and inventory list of the product database that comparison can be made. In the scope of this work; it is concluded that building products have a wide and long-life span within the scope of life cycle evaluation of a construction product and there are difficulties and uncertainties in obtaining environmental information of the products.

It can be observed that the adobe building block does not take its place in the construction sector despite all the advantages it provides. The adobe material does not disrupt the ecological balance and does not cause the consumption of energy resources in its production. Since the natural structure of the adobe material does not deteriorate, it can be reused. In terms of building biology, the properties of adobe material are also important. It has been seen that adobe material has significant advantages over other materials in providing the living conditions of comfort indoors and it is concluded that Adobe is a sustainable building material.

Finally, suggestions for further LCA-based research and development projects, which should focus on the applicability and the future profit for the Turkey construction sector, are made. It is assumed that the LCA model developed for Turkey will be a reference for the selection and production of sustainable building materials in Turkey's construction market.

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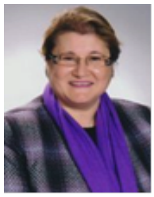
Earth Buildings and Fire Safety

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ABSTRACT

This study focuses on characteristics of earth construction material in terms of fire safety. Earth is used for its superior thermal properties for ultimate fire-resistant structures with its long record of success as a building material.

There is very limited space given to earth construction material in building codes/standards resulting hindrance to its contemporary use. However, there is failure to address fire ratings of this material in widely used codes and standards. Its values regarding reaction to fire and resistance to fire needs to be qualified to open up new ways of using this earth friendly material.

Earth as construction material, has advantages together with challenges when it comes to its fire performance. Its testing in accordance with up-to-date standards will help improve the ways for its contemporary use with confidence and overcome the challenges.

Keywords: fire-safety, reaction to fire, fire-performance

1 INTRODUCTION

1.1 Earth Fire and Human

Earth has been an easy to find and easy to use building material and served men building their houses [1]. Earth, as building material has been used and developed over the centuries on every continent. Practical and effective traditional regional adaptations to the culture and climate, the sun, and local resources, came together with variety of forms, techniques and material compositions [2]. It is currently estimated that almost half of the world's population live in earthen dwellings [3].

Fire, on the other hand, has a long history with humans as well. It has always been an important part of humankind's existing and survival. It has been influential factor either by the benefits it provides, or the risks came along with it.

2 EARTH and FIRE RISK

2.1 Uses of Earth

There is a growing interest in more environmentally friendly and sustainable buildings and earth houses made of natural building materials are among them. New Zealand is one of the countries earth homes and large executive style houses have been constructed or are currently being constructed. It is estimated that well over 100 earth buildings have been built during the past 10 years in New Zealand.

The construction techniques covered below are limited to those described in the related standards in New Zealand [4] and UK having a long history of use of earth building materials [5].

2.1.1 New Zealand

Rammed Earth

Monolithic wall panels, usually cement stabilised earth, are compacted between stiffened shutters well supported to prevent lateral spread. This technique is best suited to well graded sandy or gravelly soils. Compaction is normally done in 100-150mm layers by pneumatic tamper or hand rammers.

Adobe

Air dried "mud-bricks" made from a puddled earth mix cast into a mould. The earth mix contains sand, silt and clay and sometimes straw or a stabiliser which is also used to mortar the walls.

Pressed Earth Bricks

An earth brick that is formed in a mechanical press either machine or hand operated. A "CINVA ram" is a common hand press. Walls are usually laid with cement mortars.

2.1.1 UK

Traditional earth building methods in UK as described in HES Tan 6 1996, are listed below [6]. There are various types of traditional earth building methods.

Mud and stud: Very popular in centre UK.

Adobe/Unfired earth brick: Earliest method and most common building type in the world. Not very popular in Scotland. Referred as clay lamp in the rest of UK. Great for conservation of massed earth walls.

Cob (slow no formwork method): Very popular in throughout UK.

Clay dabbin (quick method): Solway Firth. Better remaining examples can be found in the south of the firth, due to historic tenancy agreements

Wattle and daub (non-load bearing used in partitions): Used in urban and rural areas, more popular in the south of England than in Scotland.

Stake and rice (structural or infill on timber framed walls): Stabs or poles interwoven with ropes or brush bush. Commonly used as structure for large canopy structures.

Blackhouses (earth core): Scottish western islands mainly. Load bearing wall in most cases.

Excavated: Areas where peat was being extracted, and peat depth was enough for a wall

Fale: Large fibrous block normally in form of parallelogram used for building purposes.

Fale and divet: Introduction of a layer of thin grass turf (divet) between layers of fale.

Turf: Rectangular blocks of soil of well-maintained pasture.

Stone and turf: Alternating layers of turf and boulders.

Earth/clay mortar (bedding mortar for masonry building): Possibly the most extensive use of earth in urban areas and large construction, such as castles and tower houses.

2.2 Need for Fire Codes

Humans have been learning how to control, prevent and handle risks of fire with years of experience, incidents and tragedies. Regulations for fire safety are the result of these lessons learned from fire and have been developed from the Code of Hammurabi to today.

2.2.1 Risks Related to Contents

One content related fire risk of earth building material is asphalt, bitumen and tar used in making of plaster, mortar and bricks.

Plaster and Mortar:
It appears that the most frequent use of bitumen was as mortar in building construction. Three materials were employed: bitumen, mud, and plaster, of gypsum or lime, intimately linked to surface use was the role played by each of these substances as a mortar [7].
In general, at Babylon bitumen and mud, or bitumen and reed straw, were the materials regularly used as mortar, according to Koldewey [8]. Because of the scarce of fuel was needed to melt bitumen to mix it with mineral and vegetable temper, it was not cheap in quantity, so normally used extensively only in royal building projects.

Bricks:
It was thought that bitumen was not incorporated in the clay mix in antiquity however, it has been shown in more recent experiments of Paulus [9] that bitumen was found in clay mixes as well. The asphalt and tar have been used to prevent the commune of moisture in building foundation and walls, also they used lime commune as a good cohesion to prevent moisture in the building, foundations and walls.

Sun-dried and kiln-fired in southern Iraq, where the ground water is extremely saline, rising damp is a persistent danger. Salts, drawn up into a wall by capillary action, recrystallize as they dry causing the brickwork to crumble. Thus, whoever could afford it employed baked brick and bitumen for damp-courses. [7]

One type of asphalt that have been used are called "cutback" asphalts. These are asphalts that have been mixed with gasoline. kerosene, etc., to make them thinner so they can be mixed without heating them. They can be used with soil, but they are not as good as emulsions. After a soil is treated with a cutback asphalt, it must be spread out to allow most of the gasoline or kerosene to evaporate before it can be made into blocks. Cutback asphalts can catch fire if you get them near an open flame [10].

Figure 1. Detail from the 'Ur-Nammu Stela', found at Ur, showing the King Ur-Nammu (c.2112-2095 BC) officiating at a temple-building ceremony. He carries the tools for builder: axe, basket, builder's dividers, ladle for bitumen mortar, and a flat wooden trowel. [7]

2.2.2 Risks Related to Organic Natural Materials

Other risks of earth buildings come together with use of combustible natural materials such as timber and plant-based components. Special attention is needed during planning design and detailing to limit the risks.

3 RESISTANCE & REACTION to FIRE

Two key aspects to fire testing are fire resistance and reaction to fire and there is often confusion between them. Fire resistance is the measurement of the ability of a material or system to resist, and ideally prevent, the passage of fire from one distinct area to another. Reaction to fire is the measurement of how a material or system will contribute to the development and spread of a fire, particularly in the very early stages when evacuation is crucial [11].

3.1 Fire Resistance

Each constructive element behaves differently when coming into contact with fire, and its resistance is measured based on the following parameters (or their combinations). This classification is usually accompanied by a number (in minutes: 15, 30, 45, 60, 90, 120, 180, 240 or 360) that indicates the time in which these parameters are met [12]. As an example, an REI 90 indicates that a constructive element maintains its stability (R), integrity (E) and its thermal insulation (I) for 90 minutes.

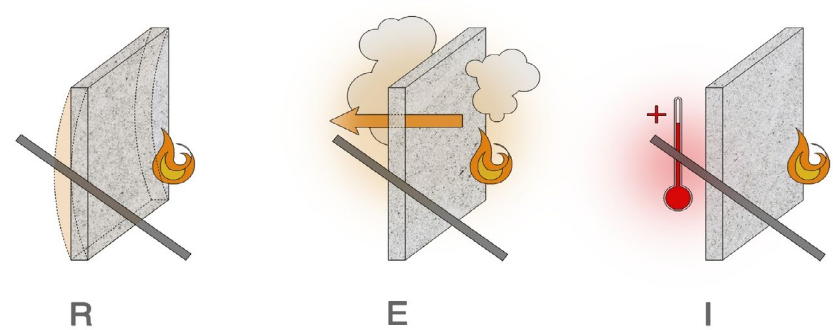

Figure 2. R Supporting Capacity, **E** Integrity and **I** Isolation [13]

3.2 Reaction to Fire

Materials and products can be classified into different classes according to the way they react to fire. To understand this classification, it is important to consider the generalized sudden combustion or flashover, which is the moment when combustible materials that were not involved in the original fire begin to burn, increasing the temperature in the room and increasing its speed of propagation [12]. These 7 different Euroclasses are: A1, A2, B, C, D, E, F (not tested).

Additionally, there are two other criteria one of which is related to smoke generation and divided into S1, S2, S3 opacity and smoke production from low to medium to high). The other is related to formation of droplets and divided into D0, D1 and D2. D0 Produces drops or particles. D1. Produces drops and/or non-inflamed particles. D2. Produces drops and/or inflamed particles.

Table 1. Indicative performance descriptions and fire scenarios for Euroclasses. [14]

Class	Performance description	Fire scenario and heat attack		Examples of products
A1	No contribution to fire	Fully developed fire in a room	At least 60 kW/m^2	Products of natural stone, concrete, bricks, ceramic, glass, steel and many metallic products
A2	"	"	"	Products similar to those of class A1, including small amounts of organic compounds
B	Very limited contribution to fire	Single burning item in a room	40 kW/m^2 on a limited area	Gypsum boards with different (thin) surface linings Fire retardant wood products
C	Limited contribution to fire	"	"	Phenolic foam, gypsum boards with different surface linings (thicker than in class B)
D	Acceptable contribution to fire	"	"	Wood products with thickness ≥ about 10 mm and density ≥ about 400 kg/m^3 (depending on end use)
E	"	Small flame attack	Flame height of 20 mm	Low density fibreboard, plastic based insulation products
F	No performance requirements	–	–	Products not tested (no requirements)

4 ADOBE AND REGULATIONS

4.1 Turkey

There are three standards TSE published related to earth (kerpiç) buildings. Two of these standards are withdrawn.

4.1.1 TS 537: Cement Treated Adobe Bricks [15]
This standard is based on the sources below:
DIN EN 1169 Precast concrete products
DIN 18951: Earth Building Code
DIN 18952: Construction soil
DIN 18953: Construction soil and earth building elements
DIN 18955: Construction soil, earth building elements, moisture protection
DIN 18956: Plastering earth building elements
DIN 18957: Earth shingle roofing

Only DIN 1169 is current and other standards are withdrawn.

Adobe Seminar, organized by ITU (Istanbul Technical University-İstanbul Teknik Üniversitesi) and İmar ve İskan Bakanlığı in 1964. İmar ve İskan Bakanlığı is the ministry (1958-1983) which is now named as Ministry of Environment and Urbanisation.

Adobe research theses of ODTÜ, (Middle East Technical University-Orta Doğu Teknik Üniversitesi).

Soil Construction, book published by State of Israel Ministry of Labour in 1957 [16].

4.1.2 TS 2514: Adobe Blocks and Production Methods [17]
This standard is withdrawn in 2011 and was based on standards and sources below:

DIN 18951: Earth Building Code
DIN 18957: Earth shingle roofing
Eyyüp Kömürcüoğlu, Yapı Malzemesi Olarak Kerpiç ve Kerpiç İnşaat Sistemleri

Necmettin Sönmez, Zirai Yapı Malzemesi Olan Kerpicin Özellikleri Üzerine Araştırmalar

İmar ve İskan Bakanlığı Deprem Araştırma Kerpiç Semineri Tebliğ ve Tutanakları
Levha Kerpiç Yapılarda Nelere Dikkat Etmeli

4.1.2 TS 2515: *Adobe Buildings and Construction Methods [18]*
This standard is withdrawn in 2011 and was based on standards and sources below:

DIN 18951 Earth Building Code
TS 2515
Kerpiç Semineri Tebliğleri
Afet Bölgelerinde Yapılacak Yapılar Hakkında Yönetmelik
Deprem ve Depreme Dayanımlı Yapılar

4.2 America

4.2.1 US
In the USA there is a brief mention in the UBC documents, there are state codes in Arizona and New Mexico and some local County codes. These standards generally are brief guideline documents that give information about overall structural form and materials with some indicative Strengths [4].

4.2.2 New Mexico
New Mexico Adobe and Rammed Earth Building Code, CID-GCBNMBC-91-1 [19], comprises of provisions related to; adobe mortars, pressed-earth-block production, stabilized adobe bricks, and adobe construction in seismically active areas [20].

4.2.3 Canada
Starting in 2005, the national model building code for Canada adopted an objective based system for evaluating and adjudicating proposed designs that also applies to rammed earth buildings. A comprehensive set of objectives and functional statements are key provisions of the code, defining the regulations goals in terms of safety, health, accessibility, fire and structural protection and the environment (Canadian Commission on Building and Fire Codes 2015) [21]. There are challenges and opportunities raised by this code system [22].

4.3 Germany
The DIN standards are used as a basis for creating technical specifications for the individual trades, for defining fields of application, for determining construction work regulations, and for describing the difference between associated services and additional services [1]. The standards related to earth buildings some of which has been withdrawn are listed below.
DIN EN 1169 Precast concrete products - General rules for factory production control of glass-fibre reinforced cement is the German version EN 1169:1999. This standard is current and used also within European Union.
DIN 18951 Earth Building Code
Part 1: Regulations for construction work
Part 2: Notes
This standard is one of the first German earth building standards introduced in 1951 by the German NSB. DIN 18951 was withdrawn in 1971 and not replaced due to increased industrialized production of building products displaced the production of earth-based building materials and earth building all but died out for over three decades.

DIN 18952: Construction soil
Part 1: Terminology, types (1956–2005)
Part 2: Testing construction soil (1956–2010)
This withdrawn standard is about assessing the suitability of construction soils, applied the cohesive strength.
DIN 18953: Construction soil and earth building elements
Part 1: The use of construction soil (1956–2005)
Part 2: Earth masonry walls (1956–2005)
Part 3: Rammed earth walls (1956–2005)
Part 4: Cob walls (1956–2005)
Part 5: Light-clay walls in frame construction (1956–2005)
Part 6: Earth floors (1956–2005)
DIN 18955: Construction soil, earth building elements, moisture protection
(1956–2008)
DIN 18956: Plastering earth building elements (1956–2008)
DIN 18957: Earth shingle roofing (1956–2005)

4.4 NZ and AU

4.4.1 New Zealand

Standards for earth buildings in New Zealand are developed as number of earth buildings increases in this country. Growing interest in earth housing has necessitated builders and engineers liaising in detail with building authorities to establish the viability of various earth building techniques. Active people drawing public interest are helping widespread acceptance within the building regulatory system [4]. The standards bring regulations on (sun dried brick), rammed earth and pressed brick construction including reinforced and unreinforced walls. Design approach of these standards is based on existing masonry and concrete standards.

NZS 4297:1998 Engineering Design and Earth Buildings establishes performance criteria for mechanical strength, shrinkage, durability, thermal insulation and fire resistance. This Standard specifies design requirements and design methodologies for earth buildings limited to wall heights of 6.5m. The standard also sets the performance criteria for durability, strength, shrinkage and thermal and fire insulation of earth elements [4].
Thermal, acoustic, fire resistance and construction requirements generally govern minimum wall thickness. In accordance with 5.5.1 of this code, the fire resistance of earth construction shall be taken as 120/120/120 for a wall thickness of 150 mm unless proved greater than that by testing in accordance with NZS/AS 1530 [24].

NZS 4298:1998 Materials and Workmanship for Earth Buildings, defines requirements for materials and workmanship. General requirements are given for all forms of earth wall construction. There are specific requirements for the three most common forms of construction in New Zealand at present such as adobe, pressed brick and rammed earth. Guidelines are also given for other forms of earth construction including in situ adobe, poured adobe and cob [4].

NZS 4299:1998 Earth Buildings not Requiring Specific Design. This part is applicable for adobe, pressed earth brick and rammed earth buildings with less than 600 m2 (or 300 m2 per floor) and provides constructive solutions for walls, foundations and lintels. In New Zealand the earth building regulations are dependent on the building height. For heights less than 3.3 m there is no need for a specific project, by an engineer although the earth walls should respect the provisions of NZS 4298:1998. As for the buildings with a height between 3.3 and 6.5 m they shall be designed in accordance with NZS 4297:1998.

NZS 4299 Earth Buildings Not Requiring Specific Design.
The Standard sets down the design and construction requirements for adobe, pressed earth brick and rammed earth buildings not requiring specific design by an engineer and is intended to be approved as a means of compliance with the relevant clauses of the New Zealand Building Code. Buildings covered by the standard are restricted to those with single storey earth walls and light or heavy timber framed roof or with single storey earth walls and a timber first floor, timber walled second storey and a light timber framed roof. Earth wall heights are restricted to a maximum of 3.6 m or 3.0 m depending on the earthquake zone factor [4].

4.4.2 Australia
Some rammed earth buildings constructed by English settlers still survive from the 1830's in Australia. Temporary earth buildings were used earlier to a limited extent by Australian Aborigines [23]. In 1952 earth building gained impetus when Architect/Engineer George Middleton wrote Bulletin 5 Earth-wall Construction for the Commonwealth Experimental Building Station. Together with revisions became the defacto standard for earth construction and was accepted by many local authorities [4]. While there has previously been references to earth wall construction (The CSIRO Bulletin 5, 1987, Earth–wall Construction) in the Building Code of Australia it was removed in 2008 as the CSIRO document was obsolete and no longer available. A replacement document is being developed by the Earth Building Association of Australia, but it is not yet suitable for use in the Building Code [25]

4.5 Africa
SADC ZW HS 983:2014 Rammed earth structures–Code of practice
This standard is the national adoption of Southern African Development Community Cooperation in Standardization's (SADCSTAN) regional standard [26]. This standard does not have any provisions related to fire safety.

4.5 Other
There are prescriptive earth building standards in China, Peru as well [4].

5 IMPROVING FIRE SAFETY WITH EARTH

5.1 Design
It is known adobe or sun-dried brick material has fire-resistant qualities [27].

In the eastern region of Orissa-India, hard-crust laterite is cut into blocks for buildings. It is also one of the few rain prone regions where one finds earth used as roofing. These sloping roofs are coated with earth on the inside to protect against cooking fires and covered with plant fibres on the outside to prevent rain infiltration [28]

Mud as one type of earth building material is used also as fire retardant for combustible building types such as wattle and daub [29]. Fire is often cited as a problem, but the mud plaster actually protects the framework, and considerably delays combustion. Tests on date palm panels, for example, have shown destruction by fire at just over 1 minute for unprotected material, and limited damage by fire after 18 minutes for a panel plastered with mud [30].

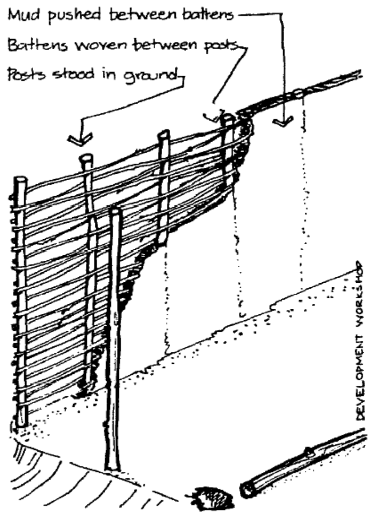

Figure 2. Wattle and Daub: This is one of the simplest and cheapest forms of wall construction. The structure of the wall is provided a framework of vertical posts set into the ground. Branches, reeds or bamboo, are woven horizontally between the posts to form a lattice. Mud is applied to the framework on both the inside and the outside, at a sufficiently wet consistency for the mud to be squeezed between the branches [29].

Light earth involves tamping a clay mix containing a lot of straw into a timber framework and then cladding both faces. This method uses the good insulation qualities of straw and gives it a fireproofing of clay.

5.2 Standardisation and Certification

Regulations in today's world are limiting the possibility of using building materials. In the table below, when earth building construction is compared to typical construction, issues related to Codes and standards needs more development in favour of earth building constructions.

Table 2. Multi-criterion table of evaluation on sustainability issues showing studies and introduction of new codes and standards are needed for earth building construction [31]

Evaluated issues	Typical construction	Earth building construction
Materials	🟥	🟩
Flexibility of the construction and accommodation (recycling aspects)	🟥	🟩
Cost	🟥	🟩
Codes and standards	🟩	🟥
Embodied energy and energy of use	🟥	🟩
Development in high levels (the city as we know it)	🟩	🟥

Testing and certification procedures, together with standardisation of applications will help this sustainable material to be used widely.

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In the shade of the palm tree and soil: Sustainable architecture

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ABSTRACT

Today, architecture is looking for a solution to the sustainability and use of existing tools to create an architectural building. Relying on and turning threats into opportunities has always represented a major part of the path of progress among different nations.

"*Kapar*" is one of those constructions in Iranian architecture, a hut made of palm branches and straw; which is built by using natural materials in the area. *Kapar* is a canopy residence, which is used in warm regions of southern Iran; especially in Bushehr, Kerman, and Balochistan. *Kapar* is mainly made of the palm branches as both tensile and non-tensile structural elements. Besides the palm tree, the stems of the tamarisk tree and soil are used as fillers at the base of the walls. In the past, this residence was often built in the palm groves or next to the farms to take advantage of its shadow or as the main residence of the farmers.

Nowadays one of the main reasons that this residence is vanishing is, inhabitants lifestyle changes, migration, lack of knowledge and neglecting the problems and needs of the dwellers of this region. "ShahrDeraz" is one of the villages in the southeastern part of Iran where the majority of its inhabitants are currently employed in agriculture. Today some of them, who suffer from financial problems, have settled in *Kapars*.

The purpose of this article is to document this heritage and to prevent the extinction of this structure. This research introduces the area and its features, construction techniques and materials types, how to run *Kapars*, running time and advantages and disadvantages.

Keywords: Kapar, palm tree, Balochestan, local architecture

1 INTRODUCTION

Shahr Deraz is a village in suburb Rural District, in the Central District of Iranshahr County, Sistan and Baluchestan Province, Iran. In the 2006 census, its population was 3,101, in 654 families. [1] The geographical properties of the area have shaped the lives of the residents, who necessitated the production of specific creative solutions throughout the history. Characteristic climate and natural conditions of the region has made residents to search for new and unique solutions in settlement, architecture and construction techniques. It was observed that the local construction techniques, which are the subject of this research, are in the process of rapid extinction. It is extremely important to transfer the architectural culture, which has been developed by filtrated experience of local people over centuries to future generations. The local construction techniques, which are classified by using the detailed research made in the area and the information obtained from the literature, are explained with detailed drawings and photographs.

2 SHAHR DERAZ REGION

2.1 Location and geographic features

ShahrDeraz south-east of Iran, The geographic location of this area is located on a postal ground. The climate of this region is warm and there are no normal weather conditions[2]; this is what makes them necessary to make canopies. The Shahr**Deraz** also has a rich soil for agriculture. The postal area of this area has rich underground aquiferous and Water from the city will be provided. Suitable soil and sufficient water have led people to choose agriculture as a job. In addition to agricultural land and palm grove, there are also many.

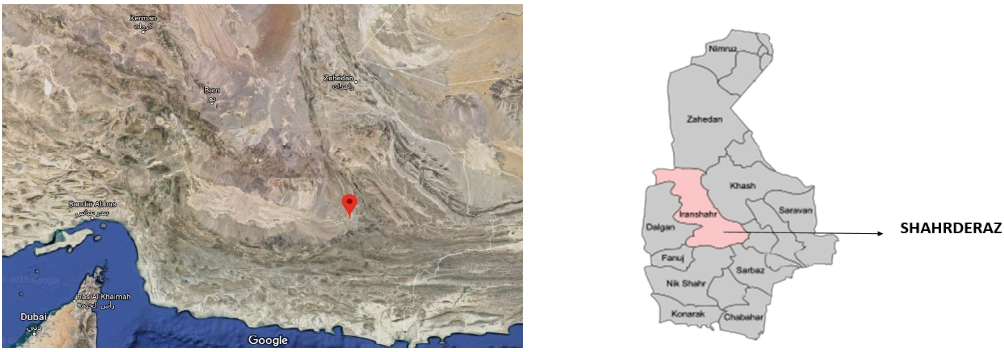

Figure 1. Location Shahrderaz south-east of Iran Region (Credits: *Google Earth 2019* & Wikipedia). [5] [6]

2.2 Settlement and vernacular architecture features

In general, it may be can divide the area into three urban structures.

The first part, which is closer to the city, is just residential. In the second part, there were also residential houses and agricultural land and ultimately the latter part includes agricultural land.

In the first and second categories, most of the buildings do not have a native structure based on their construction and materials. But in the third category, there is a kind of habitation that is a movable residence. People living in this area do not have a land for themselves, they build their homes on agricultural land that they are working on.

Figure 2. Urban structures, ShahrDeraz (Credits: *Google Earth 2019*).

3 STRUCTURAL FEATURES

The palm groves are part of ShahrDeraz, Therefore, palm tree components can easily be found in this area because of its abundance. In the past, people in the area began to create homes with the help of these components. Today, these techniques are used to build homes. The use of major parts of this tree as well as the soil has led to the lack of any other materials for the construction of these houses.

3.1 local construction materials

1."*SOİL*" taken up part of the soil and sift the soil from other elements in it.
2."*DEKREZ*" is a branch of a palm tree that is exposed in free air of light and dried, and its large leaves are separated. The length of the Dekrez is about 2.5 meters. Its features are flexibility and resistance to termite.
3."*SAD*", "*RIS*" or "*CILEK*" are a kind of rope woven from wild palm leaves.
4."*GOMBE*" dried leaves are wild palms that are classified after cutting and placed on them stones and exposed to sunlight.
5."*LEM*" leaves of palm tree, two to two, are tied together in a special way.
6."*ANGERD*" is the same as a mat called the Balochi language.
7."*DAAME*" is a lace that is woven from Sad. [3]

Figure 3. Local construction materials, ShahrDeraz (Credits:Bakhshi, 2019)

3.2 construction techniques

Kapar run on earth. Their builder elements did not have much weight and in fact the "foundation" of them is responsible for their own land. How to connect these walls to the ground with a cavity up to half a meter away from the space they want to build. Kapar form a set of tensile and non-tensile elements and these elements of the walls and ceilings of these houses are included; the structural part of both of these are formed by palm branches.

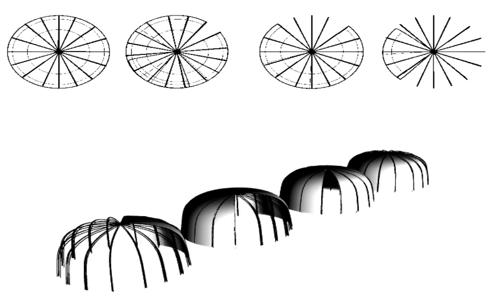

Figure 4. Kapar Perspective and Plan Modeling Kapar (Credits:Bakhshi 2019).

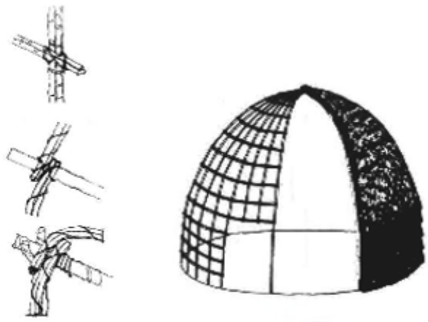

Figure 5. An example of the Structures and connector details *kapar* (Credits: Malekzade 2016).

Figure 6. The objective connection between the tensile elements with the help of the sads (Credits: Bakhshi 2019).

3.2.1 Floor structure

For the floor, these houses are used for Rammed earth. That is, soil in this space acts as a general foundation and they cover it with a carpet made of palm leaves.

3.2.2 Roof structure

The formation of the walls in the "*kapar*" forms an arched roof. To cover the ceiling is usually either a permanent structure or it changes to suit any season. [4] Or alone consists of a woven structure of palm trees or in addition to the palm tree, there is also a plastic cover that is usually used in the winter against rainfall and Finally, in addition to the two above, the leaves of the palm tree are placed on the roof and fixing ropes woven tour.

Figure 7. Roof structure system (Credits: Bakhshi 2019).

3.2.3 Walls structure

The walls are made of tensile pieces. This element is formed cluster the branches. The layout of these categories, in turn, will be different in the geometric form that they intend to architectural plan. If the plan is in the shape of a circle, the bundles are arranged in a circle and In fact, they put each group in front of another on the other side and with the help of several people who are usually residents of the same house The bundles approach the branches from both sides and sad wrapping around them arches are formed.

Figure 8. A view of wall filler system (Credits: Bakhshi 2019).

3.2.3.1 Wall fillers

In addition to these tensile elements, other filler elements are also used. The tree trunk (tamarisk) and shoots are used as filling materials at the beginning of the walls up to a height of 1_1.5 meters. In addition, mud (clay) are used to fill the space between the tree classes and create tight legs for these homes.

Figure 9. A closer view to walls (Credits: Bakhshi, 2019).

3.3 Dimensions and sizes

Dimensions of *Kapar* can not more than one extent given that the length of branches of the palm tree is almost constant and in addition, this has affected the altitude of these homes.

4. ADVANTAGES AND DİSADVANTAGES

Kapar Because of the fact that materials from the same area are made, they do not cost much to build and with just a few auxiliary forces, it can be easily built up. The durability of *Kapars* is between 20 and 30 years and the materials used to make it do not harm nature, and eventually returns to the cycle of nature. In addition, it largely covers the needs of the people in the area and when tightly built, they can withstand lateral loads.

Figure 10. An example of *kapar* that was destroyed after 25 years (Credits: Bakhshi, 2019).

Do not have space divisions so it's not possible to create rooms for different members of the house that have access to them. It is possible to adapt quantitatively to our technology today and the wind and storm will multiply the possibility of firing electrical installations in these homes, the whole house will be destroyed.

5 CONCLUSION

This study demonstrates the close relationship between vernacular construction, Regional resources and human needs. Currently, vernacular architecture in this area of Balochestan is under threat of cultural and architectural homogenization, as it is common all over the world. With its local building materials and construction techniques, the vernacular architecture of the region is a physical manifestation of culture and life style of the local people**.**

Basic human needs and economic activities, in particular the agricultural way of life, played a key role in the development and evolution of the studied local morpho-typologies. Although there are no traditional buildings at the city and district centers of this region, the examples of vernacular architecture still exist in rural areas, where the economic conditions are not so good. The widespread use of palm tree elements as structural Natural material for all kinds of *kapar*, led to the adaptation of construction techniques and solutions to its natural capabilities, demonstrating its potential as a construction resource**.**

from the observations made in the field study, it is obvious that the highly damaged state and loss of character, to which this heritage has been exposed, Lack of proper maintenance and damaging human interventions continue to threaten the existing heritage. In this situation, local builders have adopted modern techniques, so the continuity of the traditional construction techniques that were passed from generation to generation was damaged. In the same context, vernacular heritage's identification with past poverty constitutes a great obstacle to its protection. It should be known that the precondition of preservation is creation of public awareness about heritage protection, and various precautions must be taken in order to transfer the traditional construction techniques to future generations. This research contributes to the understanding of constructive techniques, which have unique properties, and to the literature, as a source for future studies in the era where the worlds' cultures are rapidly losing their properties against globalization.

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Preservation and Reuse of an Adobe Building; Turkes (Türkeş) House and Museum in Northern Cyprus

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ABSTRACT

The buildings registered as cultural heritage are historical documents of their respective period. Particularly, it is difficult to apply mudbrick structures constructed with traditional materials and construction technology to today's comfort conditions. It is not possible for the owners of the mudbrick structures of soil material origin to be owned, kept alive and used as a residence within the current living conditions. Therefore, most of the adobe structures are in danger of being destroyed due to neglect over time. Within the scope of this study, the stages of the restoration of a mudbrick structure, which is an example of civil architecture in the city of Nicosia, located in Turkish Republic of Northern Cyprus, after the loss of its original function will be transferred.

In order to ensure cultural continuity, in order to transfer historical buildings that have lost their original use to future generations, "Re-use" is a preferred practice in terms of protection concepts. The mudbrick structure is not only a physical entity, but also belongs to the group of structures that must be protected because of the information it conveys such as social and cultural lifestyles, traditions, technical level reached, aesthetic perception and social rules.

Keywords: Preservation, reuse, adobe, museum, Cyprus.

1 INTRODUCTION

At the core of the understanding of the re-functionalization of a historical building, there are criteria such as the existence of original architectural details in the building, the maintenance of the original structure and building material, and the harmony of the newly given function and its socio-cultural context. In the continuation of the re-functionalization process, the acceptance and use of the building by the society and the continuation of the historical and cultural values of the building are included. Although it is essential to ensure the continuity of the structures that need to be protected, these structures are meaningful when integrated with life and meeting the needs of life. Re-functionalization is acceptable when the structure does not spoil the original architectural identity. The structure examined in this study is the house where Alpaslan Türkeş, who had an important place in Turkish political history of the period, was born in Nicosia. With the return of the family to the Republic of Turkey, the concept of continuity will be dealt with in terms of refunctioning of the adobe building. This building will be reevaluated with its positive and negative aspects through the perspective of contemporary protection.

2 ARCHITECTURAL PROPERTIES OF THE BUILDING

The mudbrick structure, in which Alpaslan Türkeş was born and which is planned to be re-functional as a museum, is located on the Kirlizade Street in Haydarpaşa Neighborhood of the Nicosia citywalled district of Cyprus (figure 1). A large part of the civil architecture prefixes that make up the urban settlement of Nicosia citywalled have survived to the present day. Like other houses in the region, Türkeş house has a typical of a residential courtyard. The building is located in the courtyard with 3-4 steps from the street level (figure 2). Since no surveying of the original plan of the building was found, any information regarding the original plan scheme could not be reached.

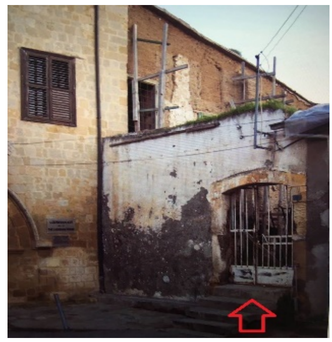

Figure 1. Location of Turkes museum house within the Nicosia citywalled district
Figure 2. Entrance of the house

2.1 Diagram and Construction Technique Plan

Before the decision to functionalize it as a museum, it was found out that the building several levels, the ground floor and 2 more floors. The thick walls (in bold line) shown in the plan belong to the original mudbrick dwelling, while the thin walls (in gray) are additional spaces built during the period (figure 3). Nowadays, it is thought that the upper floor stairs which are reached by 2 different wooden stairs are not original. The Türkeş house is adjacent to the Lusignan House on one side. Maybe, when it was first built, it could be part of Lusignan House structure, but their property has been separate for about 100 years. The wall fragments in the front courtyard suggest that the structure had a different plan type in the past. However, since there was no restitution project, there was no answer to the question of how the building was in its first phase.

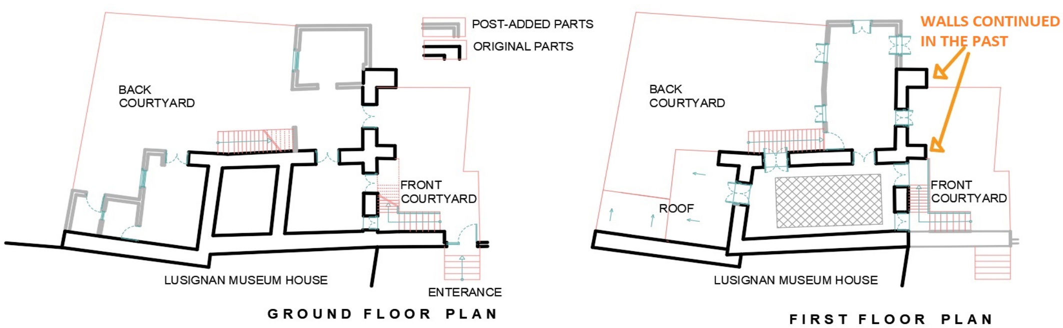

Figure 3. Ground and first floor plan of Turkes' house as survey

It can be observed that the ground floor is constructed of thick stone material, up to about 1.50 cm. at 55 cm in width. The second floor on the ground is made of mudbrick with wooden beams. In figure 3, the surveying of the ground floor and first floor of the building is available, and since the second floor does not exist today, an accurate floor plan could not be created. However, the wooden floor and the beam slots, which are at the level of the second floor, suggest that there used to be a second floor rather than a roof because the height of the wall after the second level is much higher than the height of the wall of such a roof (figure 4). It is seen that brick-mudbrick filling between wooden constructions is applied in some of the additional units built next to the mudbrick structure, and a masonry wall is applied to the press on concrete slab floor (figure 4).

2.2 Facade Configuration

Although the building has two façades facing the front and rear courtyard, the architectural design showing the façade is not understood. On the façade facing the front courtyard, fragments of walls continue towards the courtyard. It gives the impression that there are ongoing parts of the structure, but it collapses over time. Rabitz wire can be seen under mudbrick plaster on the front façade. It can be observed that there is a window gap at the upper level of the door that corresponds to the first floor, but it is closed with mudbrick material in the following period (figure 5). The architectural features of the façade could not be estimated due to the additions on the back courtyard.

2.3 Protection Status

Depending on the intervention of the users, some additions have been made to the structure over the years. Some rooms have been added to the section facing the back courtyard. These added parts were built in the brickwork wall system into the iron constructions. It is understood that the roof covering was renewed in this process.

It is observed that the building was unusable before its museum function. Damages such as destruction of the walls due to abandonment, falling out of plasters, separation in the interfloor slabs, and cracks and breaks in the stairs were detected. The adobe structure, which has an original architectural identity, has been determined by the owners as having completed its functional life as a residence, but its structure survived. Therefore, in order to continue to be included in the urban memory that constitutes the traditional Cypriot housing architecture, a new function has been given and an important decision has been made to rejoin the structure to current everyday life.


Figure 4. Part added to the original structure
Figure 5. Facade of the original mudbrick structure facing the front courtyard

3 HISTORICAL IDENTIFICATION BASED ON REFUNCTIONALIZED IMPLEMENTATIONS

Alpaslan Türkeş, one of the most important touchstones of Turkish political history, was born in this adobe house in Nicosia, Cyprus in 1917, and spent his childhood in this adobe house from his birth. After graduating from the Military Academy Turkey, Turkes has held senior government positions such as the President of the National Security Council, the Deputy Prime Minister and the Deputy of the Republic of Turkey. This mudbrick structure, which has a history of approximately 100 years, has been donated by Türkeş's family and used as a museum. It is planned to be re-functionalized by T.C. TIKA (Turkish Cooperation and Coordination Agency). The re-use of the Türkeş House as a Museum will not only allow the transfer of a cultural architectural heritage to the future but will also allow this historical personality to be recalled and learned by the younger generations.

4 RECONSTRUCTION OF TÜRKEŞ HOUSE AS A MUSEUM

After the repair and restoration works of the mudbrick structure, it was planned to prepare the exhibition-arrangement and exhibition units that would allow both Alpaslan Türkeş's memories to be kept alive and their private belongings to be displayed. According to the spatial analyzes conducted in this direction, it was decided to maintain the dimensions in terms of width / lenght / height and harmony without damaging the fiction of the present situation in terms of form and space relations.

4.1 Space Organization

The spaces determined by the survey are redefined with new functions according to their size. It is planned to consolidate the adobe structure and to include various arrangements in the fiction of the interior space only in line with the function of exhibition, to provide the opportunity to sit in the garden with a wc cabin and kitchen niche to meet the needs of the visitors. In this direction, by selecting the fittings and lighting products suitable for the display technique of the display elements, the display design was created with the least interference to the existing structure. Some of the main decisions taken by trying to establish protection-use balance while giving new function;

• Preserving and using the 2 staircases in the structure in their original location, although one of them was added to the structure at a later period, but both carrying the characteristics of the period annex,

• No enlargement or reduction in existing spaces,

• In addition to those in the building, no additional intervention such as windows, doors or passageway shall be made to the building,

• Not reducing the thickness of the main body walls for display niche or unit purposes,

• Not changing the height or thickness of the garden walls.

Structural elements, building material and bearing system: The structural conditions of the mudbrick walls were examined by the civil engineer and there were no static, crack, breakage or deterioration. Although the interior plasters are preserved, all plasters on the exterior have spills. In order to protect the mudbrick structure from external weather conditions, the plasters were renewed by using rabitz wire (figure 6).

The renovation of the building elements such as the main entrance door, room doors, windows and shutters without changing the size, material and architectural details of the building allows the visitors to perceive the building as a cultural asset. The metal door used as the entrance door was dismantled, its current location, size and form was preserved and the safe and two wings were renewed with wooden material. Only the safe, sash, shutters and windowsills were renewed by keeping the dimensions and locations of all the windows in the building (figure 7).

The original staircase leading to the first floor in the front courtyard was destroyed. However, the first 5 steps from the ground level are partially present and the remaining steps can be traced. The dimensions, location and materials of the staircase in the front courtyard were renewed and their original features were restored (figure 8). Wicker veneer was seen presently in the interior ceiling, as it was installed in the past. In the re-functionalization process, Türkeş's wicker ceiling was applied in the study room as in the original (figure 9).
Naturally grown plants and trees have been cleaned in the garden over the years and the original wall has been renewed with elevation and materials. Over time, the roof construction and top cover material were renewed in Türkeş house and its height was increased. During the re-

functionalization phase, the roof construction was renewed with wooden material and the roof height was reduced.




Figure 6. Renewal areas on plaster
Figure 7. Renewed plaster and wooden Windows in the rear facade




Figure 8. Renewed wooden staircase
Figure 9. Straw ceiling in original condition and after application

4.1 Protection and the Balance of Usage

No changes have been made in the organization of the interior space. The entrance to the museum is provided from the front courtyard on the ground floor of the building. On the ground floor, it is planned to include photographs describing the important historical days of Türkeş in the places where the spaces are available for display. There is also a special corner for his own bust. There is a rest area, service areas and toilets when one goes to the back courtyard. On the first floor of the building, there are display units consisting of explanations and photographs that are used in describing the historical process of Türkeş throughout his intellectual and political life in Turkey. In the explanations in the museum, the information given by Alpaslan Türkeş to the journalist Hulusi Turgut and in the book titled "Memoirs of Türkeş: The Dance of the Falcons" will have been used.

It is thought that the desk and chair that he used while he was alive would be presented to the audience as left. Some of his personal belongings are planned to be exhibited in glass cabins with moisture balance (figure 10). On the other hand, the glassed tables where his notebooks, bags, pens, glasses and other personal belongings, which he took notes of his intellectual and political life, are on the medium volume, in terms of area it occupies (figure 11). The majority of the lighting used in the space are installed in the way the display unit lights are installed in order not to damage the walls or the ceiling. When the air temperature of the geography is combined with the density of the visitors, the air conditioners necessary for balancing the indoor heat quality are placed in a wooden cabinet.

Figure 10. Türkeş's desk, suitcases used during his journeys and Türkeş's personal clothes

Figure 11. Photos and information boards covering important events and days

5 MAINTENANCE AND SUSTAINABILITY OF THE ADOBE STRUCTURE FUNCTIONED AS MUSEUM

Cyclical maintenance always plays a key role in the sustainability of the adobe structure. Upon completion of rehabilitation or restoration work, a program for ongoing care should be initiated. In this re-functional adobe structure;

- Changes in the building should be noted in particular,
- Early stages of cracking, ceilings bulging or bloated wall paint on adobe walls should be monitored regularly,
- The thin capillary cracks in the plasters should be followed and repaired as soon as possible and water intake should be prevented,
- All water damage should be noted in places such as floors, walls, roofs or wet spaces and should be removed as early as possible,
- Plant, animal and insect damage must be stopped before it damages the building severely,
- The roof should be checked periodically,
- Internal surface coatings (paints) and plasters should be checked frequently and repaired or replaced as required.
- All wooden components such as windows, doors, stairs should be checked and moisture-water ingress from windowsills or moldings.
- Mechanical systems must be monitored for malfunctions. For example, the leakage of air conditioning water drain pipes and condensation can cause more damage to the mudbrick building.

Observing mudbrick buildings in thin structures and performing regular maintenance is a policy that needs to be emphasized. Degradation of adobe buildings is natural, but cyclical maintenance can greatly delay this process.

6 EVALUATION AND CONCLUSION

The form, scale, plan type, structural structure and interior dimensions of the re-functionalized structure are very important for the main theme of the exhibition. Physical conditions such as heating-ventilation-lighting can also be considered among the other factors that arise from the data of the historical structure in establishing the main theme of the exhibition. The amount and direction of natural light, current heat, humidity and ventilation conditions should be well evaluated, issues such as artificial lighting, sanitary installations, heating-cooling and ventilation installations to be rearranged in relation to the main theme of the exhibition should be carried out to meet the requirements of the museum function and damage the data of the exhibitions structure should not be given. In Türkeş museum house, the balance between the main theme of the exhibition and the original function of the building was maintained, and a meaningful unity was achieved.

As the result of not allowing the mudbrick structure to be returned to the first period or re-use as a residence, Türkeş Museum House has come to life again, it is very important both in terms of introducing the property owner and cultural and historical continuity. Türkeş Museum house, with its neighborhood texture, contributes to the urban and environmental identity and constitutes the material history of the society. Museums are an important destination for cultural tourism. At the same time, as it is an important visiting center with the adjacent Lusignan Mansion Museum, it will enable visitors to interact with the space and the past. The adobe dwelling structure of Alpaslan Türkeş's family, which is given a museum house function in terms of its historical and cultural qualities, should be accepted as a positive and successful example in terms of reorganization in terms of space organization, protection-use balance, building material and carrier system.

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Behaviour of Stone Masonry Buildings at Ramechhap District During 2015 Gorkha Earthquake: A Case Study


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ABSTRACT

This article describes the failure pattern observed during the field visit of the Makadum Village Development Committee, Ramechhap District central region of Nepal, following the 2015-Gorkha Earthquake. Non-engineered stone masonry constructed with local mud mortar and locally available timbered residential buildings were studied for the categorization of the damage extent. Assessment was done by direct internal and external visual observation of the damaged building. A total of 610 residential buildings and 405 of the cattle shelter (locally called *Goth)* were studied for failure pattern and damage extent due to the 2015 Gorkha Earthquake. 81%, 17% and 2% was the proportion of the totally damaged, partially damaged and general damaged residential houses respectively and 60%, 37% and 3% was the totally damaged, partially damaged and generally damaged percentage of ***Goth*.**

The major failure pattern observed were in-plane failure of the load bearing wall, out of plane failure, delaminating of the wall layer, shear failure in corners, gable wall failure at the top, high extent of the cracking of the wall mainly in vertical direction and cross cracking of the wall, cracks starting from corners of the openings (i.e. door and window of the buildings). Failure due to flexible diaphragm movement was also seen in some particular cases. Failures in roof covering because of lateral movements, tilting of the positions of corners of the buildings were majorly seen. Based upon the structural, construction and material deficiencies observed, recommendations and conclusions were made for further sustainable and earthquake resilient construction in rural housing (stone masonry) in Nepal.

Keywords: Masonry buildings, Failure behaviour, Rural houses, Gorkha earthquake, Stone masonry

1 INTRODUCTION

Nepal has encountered many earthquakes in the past. Even one of the the Kings, Abhaya Malla died in the 1310 earthquake [1]. Since then Nepal has suffered 16 major earthquakes, including the recent Gorkha Earthquake of 25 April 2015 [1]. The devastating earthquake killed 8,891 people, missing 198 people and 22,303 people seriously injured and rendered millions homeless. More than six hundred thousand households were fully damaged leaving around three hundred thousand damaged partially in central and eastern region of Nepal [1]. The main quake originated at Barpak of Gorkha district on April 25, 2015 (7.8 M_w moment magnitude) followed by largest aftershok with the magnitude of 7.3 M_w [2]. The largest aftershock of 12 May 2015 at 12:50 local time struck with the epicentre in Sunkhani of Dolkha district neighbour district in northen region of the case study area with epicentre 76 km North East of Kathmandu. Stone masonry is a traditional form of construction that has been practiced for centuries in regions where stone is locally available [3]. Stone masonry has been used for the construction of some of the most important monuments and structures around the world. Buildings of this type range from cultural and historical landmarks, built by highly skilled stonemasons, to simple dwellings built by their owners in developing countries like Nepal where stone is an affordable and cost effective building material for construction of housing [3].

Masonry building construction in Nepal has its own long history of several thousand years. Mainly rural construction was based upon the local material available and local technique of local people. In Nepal from Terai to Mountainous region, there used to be identical technique and construction material of the houses. In Terai, lack of building stone and availability of clay, wood and grass in forest were the strength of houses construction while in hilly region availability of slate, building stone, clay, timber, bamboo etc. were the strength and in mountainous region lack of bamboo, timber and availability of stone and slate were the strength for the housing construction. Currently many researchers have been interested in local material and rural housing development mainly after the Gorkha earthquake. In the Gorkha earthquake, some of the rural houses that survived 1988 earthquake have been damaged or collapsed. After the 1988 earthquake, the Nepal National Building Code NBC-1994 was established [4]. Following the earthquake, an assessment of the seismic hazard of the entire country the code was developed and adopted mandatorily in 2006 for all the governmental buildings and recommended for the construction in all the municipalities in Nepal [4].

After the Gorkha Earthquake, many studies show that there are mainly five types of settlement in earthquake affected area which may represent the construction of whole Nepal [5]. Construction can be categorized as construction in urban core area which contains RC construction with adaptation of the building codes in core areas like Kathmandu, Bhaktapur and Lalitpur. Construction in urban villages are mainly RC construction adopting Mandatory Rule of Thumb specified by government of Nepal and non-engineered masonry buildings. Historical urban constructions with brick masonry contain architectural appearance in facades with timber and brick face. Other types of construction in rural village construction are mainly with brick and stone masonry and rural remote construction with low strength stone masonry with mud mortar. Following the literature, categorization of unreinforced masonry (URM), are done based upon the extent and type of failure. Figure 1. shows that cracks due to in-plane and out of plane loading, wall separation at the joint, collapse of the roofing system, multiple fracture simultaneously in many number of the structural system. Stability failure due to ground instability is also a major loopholes in the URM buildings.

Table 1. Settlement typology of Gorkha earthquake 2015 affected area of Nepal [5]

S.N.	Zone name	Building Method	Characteristics	Remarks
1	A, Urban core	RCC, Low strength brick masonry, Brick masonry	Engineered building, historical traditional building	Core city area
2	B, Urban village	RCC, brick masonry	Engineered, non-engineered, high corrugated sheet	Periphery of core area
3	C, Urban historic	Low strength brick masonry (Newar)	Non engineered	City and Peripheral
4	D, Rural village	Low strength stone masonry, RCC	High corrugated sheet, non-engineered	Bus access
5	E, Remote village	Low strength masonry	Non engineered	No bus access

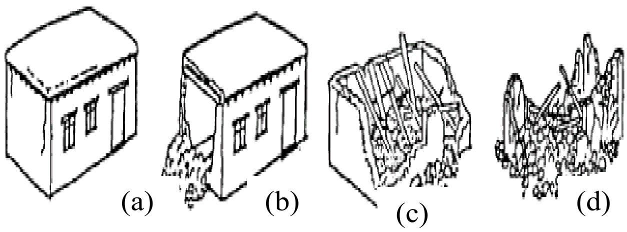

Figure 1. Typical URM building damage, (a) cracks in wall, (b) wall separation, (c) roof collapse & (d) multiple fractures [6]

1.1 Introduction to the case study area

The case study area is Makadum, which is a small Village Development Committee of Ramechhap District in Janakapur zone of Central Nepal. All the houses are made up of local available materials mainly stone, mud, timber, bamboo, thatch etc. All the structures are non-engineered and solely dependent upon the construction technique of local skill mason (locally called ***mistree).***

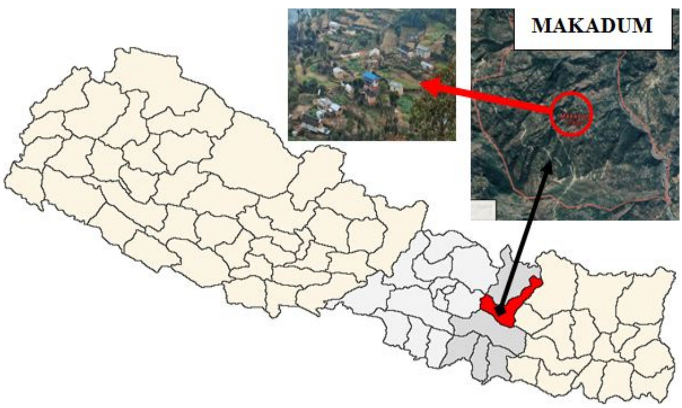

Figure 2. Location of Ramechhap district showing case study area, District Map of Nepal (source:en.wikipedia.org/wiki/Ramechhap_District,www.google.com/maps/place/Makadum)

2 METHODOLOGY

Direct interior and exterior observations were carried out for the classification of damage extent after the Gorkha earthquake-2015. After the observation of the buildings, data was collected on a standard form provided by the National Development Volunteers Service (NDVS) of Nepal, for the categorization of the damage extent and damage pattern. Collected data were analysed based upon the type and pattern of observed damage for damage classification with the help of common structural and civil engineering knowledge. All the buildings constructed in the study area were non-engineered and utilized low strength stone masonry with extensive use of bamboo and timber in the building system.

2.1 Observations

Non engineered stone masonry with mud mortar is the major identical characteristic of all the buildings constructed in this area. Typical building plan and elevations are similar except for dimensional variations in both plans and elevations. Stone masonry houses are built by the owners themselves or by local builders without engineering training. Local available stone, mud, timber, slate, thatch and bamboo are the major construction materials in this area. The majority of the building were covered with corrugated galvinized sheets (CGI sheet), some of them with stone slate, tile and shelter for cattle (i.e. *Goth)* roofings were mainly covered with locally available dry hay i.e. thatch. All the structures were non engineered stone masonry having mud plaster on external and internal wall. Mud plaster on walls are done for aesthetic and safety purpose from rain. All the structures were rectangular in shape having rectangular configurations of external four walls and internal separation wall in some cases. All the houses were opened in either one side wall or in two walls, one long and other in short dimension, while *Goths* were open in one shorter wall i.e. side wall. Two story houses with additional top small gable walled portion for storing purpose were identical in all houses (i.e. attic portion). Single timber beam (*locally named Nidal*) in longitudinal direction of building supported on both side walls is found to be common in all the houses, supporting whole floor system i.e. wooden joist, planks and mud flexible floor finishing.

2.2 Broad Classification of damage

Based upon the extent of damage, all the buildings were categorized in three parts, the first type has minor cracks in wall and minor damage in other structural system named as general failure or general damage under the category of minor damage, the second type has moderate crack and moderate damage in other structural elements named partial damage, and the third type has extreme damage in wall and other structural element named total damage which cannot be restored or repaired. Such classifications were done based upon the observed cracking pattern in the wall, failure extent of corner connection, failure extent of roofing system, failure extent of foundation, failure extent of wall and timber system and overall stability of the building.

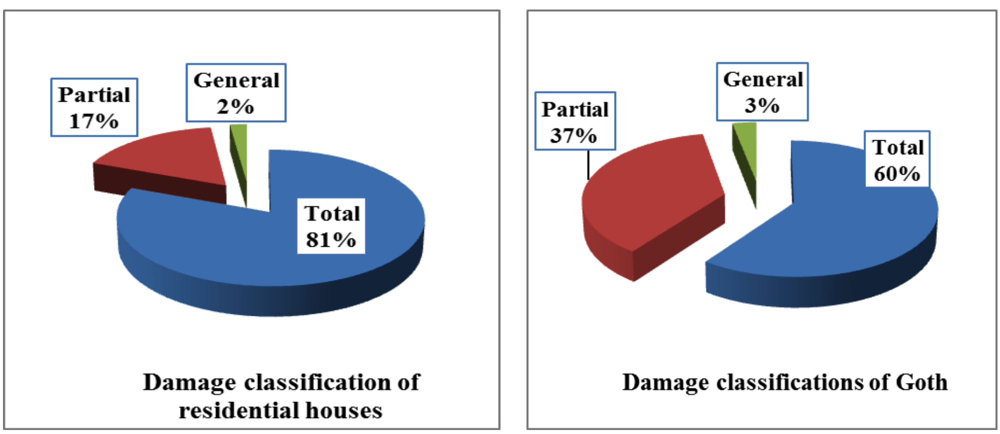

Figure 3. Damage classification of the building due to Earthquake both houses and ***Goths***

2.3 Observed Damage pattern

Buildings made of stone masonry with mud mortar, having extensive use of locally available timber in window, door, floor, roof and verandah portion are the most common construction in this area. Major failure pattern observed during the study are as follows:

2.3.1 Failure of the gable portion

In majority of the case it was found that the top stone fell down initially that caused the cracking of the wall portion starting from top of the wall towards bottom.

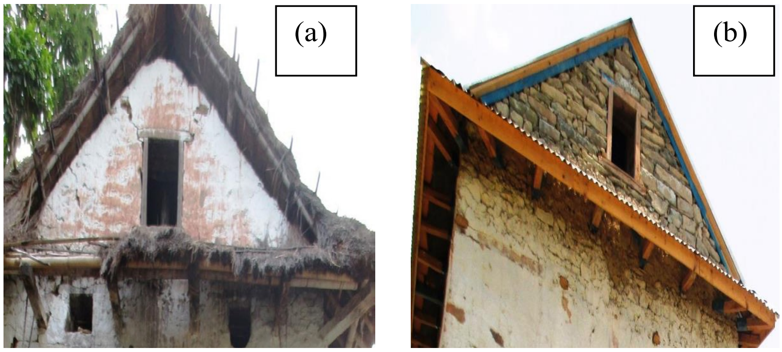

Figure 4. Typical gable wall and roof connection, (a) Poor connection, (b) Good connection

2.3.2 In-plane failure of the wall

It was observed clearly that the cracks on wall were in diagonal directions, the cross cracking was also seen mainly in longer wall of the building. Crack starting from the corner of the opening was also seen as a result of the in-plane force.

2.3.3 Out-of-plane failure of the load bearing wall

When the lateral force is orthogonal to the wall plane this type of failure occurs. The tendency of the wall being laterally displaced in out-of-plane caused failure of the flexible floor, and roof to be separated from the remaining structure that ultimately caused the failure of the wall and connections. Connection between walls to floor, wall to wall, wall to timber, wall to *Nidal* were affected by out of plane tendency that caused horizontal & vertical cracks.

Figure 5. Observed large vertical (shear) crack (a) and (b) out of plane failure of wall

2.3.4 Delaminating of wall

The masonry walls were made up of undressed stone (i.e. un-coursed random rubble or un-coursed semi dressed) with mud mortar in almost all of the buildings. In some of the houses external layer of the wall was more attractive than internal face. Because of the lack of interlocking stones in certain interval of the wall span, delaminating of the wall occurred.

Figure 6. Observed typical connection failure at corner of wall (a) & (b) Delaminating of wall

2.3.5 Connection failure between roof covering and wall/timber

Roof covering slate, tile and stone pieces were more vulnerable to the separation from original position after shaking of earthquake. Because of the lack of proper connection between slate and timber, some slates spalled off. Small wall bearing for timber caused timber to fell down along with the floor and the roof.

Figure 7. Totally collapsed building (left) & failed in out of plane (right)

2.4 Major construction and material deficiencies observed

Termite causes reduction of the strength and durability of timber because of the exposure to the water in rainy season. Old aged structures, poor workmanship, poor construction technique, poor construction materials, improper connection between the various members of the structure, large size of the openings in wall i.e. doors and windows, wall having high span without interior wall partition, avoiding the interlocking stone in wall, filling small stone chips in between two layer of stone in wall etc., were the major construction deficiencies observed during the study.
In some cases sloped ground failed first and causing tilting of the house, movement of the foundation of the building and tilting beyond permissible one.

Figure 8. Typical large size opening in the side wall of the building, which causes large cracking in corner of opening

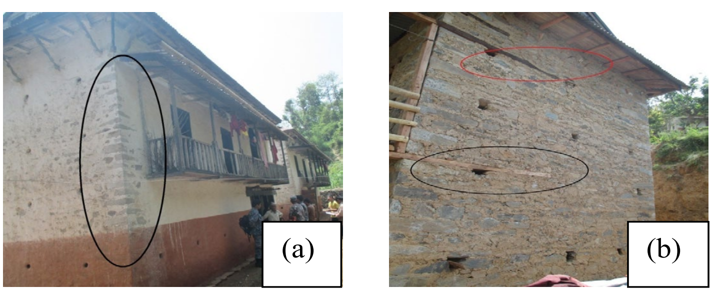

Figure 9. Typical building showing well integrity of corner stone (a) & use of timber in wall corner that work as a band (b)

3 DISCUSSIONS

In this study, masonry buildings with mud mortar were observed for the extent of damage classifications. Comparatively one story *Goths* were less damaged than two story residential houses. Major failures were due to wall cracking because of out of plane failure and in-plane failure. Connection failure was also observed among floor, wall, and roof. Old aged buildings were more severely damaged than newly constructed buildings. Newly constructions were under some technical criteria such as the corner stone integrity was good in new buildings than in old ones.

Delaminating of wall was found mainly in old aged buildings because of lack of provision of through stone. The wall connection at the corners can be improved by providing comparatively long stone in corner of both walls and making good interlocking between corner stone in both joining walls. Wooden corner band may be appropriate for the corner integrity in certain interval. In some cases the failure due to large openings in side wall were observed. Such construction deficiency can be eliminated by providing adequate gap between corner and opening, usually the wall column between corner and opening must be greater than 2 feet. Gable stone can be tied with roof wood to prevent the failure of top stone which is free to move or alternative solution may be replacing heavy wall stone in gable by lightweight materials like timber or CGI sheets. Proper connection between roofing materials like stone slate, tile, and CGI sheet with timber which support the roof must be done to prevent failure of roof connection.

In some cases it was found that the provision of the timber band in base and top of the window performed well, so provision of bands may be timber in top and bottom of the opening must be provided to make box action of the wall system and to prevent out-of-plane failure. In some buildings, it was found that the movement in *Nidal* caused severe cracks in the wall in which it rests, so it should be supported by the wooden post in certain interval inside the building in the longitudinal direction. In some buildings it is observed that the failure of long wall was due to large unsupported length of wall, so the interior space may be divided into two portions with partition wall in transverse direction to the long wall, however, this may cause problem in space usability.

4 RECOMMENDATIONS

Locally available materials play an important role in the economic building construction due to abundant forests in rural areas in Nepal. The availability of building stones and timber in nearby areas enhance the masonry construction with optimum use of local materials which is the strength of the case study area. The nvolvement of the local people in the construction of rural buildings is the key factor for the sustainable construction, so the local masons must be well trained for resilient construction. New construction should follow low strength masonry construction guidelines and standards specified by the local government. As the majority of the buildings were old aged, these must be demolished. Local masons must be trained for transferring proper techniques of construction practices in the rural areas of Nepal.

5 ACKNOWLEDGEMENTS

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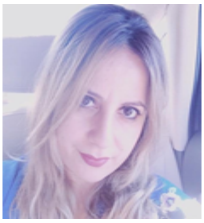
Adobe Architecture In Tokat



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ABSTRACT

Tokat is one of the unique and culturally rich settlement centers in Anatolia with historical findings all over the city. This historical city which was built on River Yesilirmak's fertile land, ruled by various civilizations and many principalities since 4000 B.C., is a gateway connecting the Black Sea Region to the Central and Eastern Anatolia. Because of the geographical value and strategic location of this important province, 14 states and numereous principalities settled here since 4000 B.C. during all this time, many constructs and architectural buildings were built in Tokat's city center and in its 12 districts. Consequently, on various places in this province, it is possible to find historical artifacts that belong to the several periods throughout the Hattites, the Hittites, the Roman and the Byzantine empires, the Danismendi and the Seljuk eras, the Ilhanli time and the Ottoman period. To give some examples, the city's historical and cultural treasures like Hittite settlement, Masat Hoyuk mound, Comana ancient city, Sebastapolis, provide traces of Roman and Byzantine eras. The district named Niksar was the capital state of Danismend seigniory. Tokat hosts many different types of historical buildings such as castles, bridges, mosques, tombs, lodge and zawiyas, hammams, fountains, madrasases, bedesten, khans, mansions etc.

The widespread use of adobe in Tokat is seen as a filling material in the construction of houses built in the 19th century. The Tokat houses, which are usually 2 or 3 storeys, were built with the adobe filling technique between the wooden carcass structural system. In the city, a few examples are seen where adobe was used as the main element of architecture. One of them is a two-storey palace structure with stone-based adobe walls belonging to the Hittite period, which was uncovered as a result of excavations of Masat Hoyuk that is one of the ancient settlements of Tokat. The Pasha Hammam which was built in the 14th century its one side wall was covered with adobe. The walls of Ali Duruoz House, which has been completely ruined today, were made of adobe as well. Finally, the building which has not an inscription called Katircilar Khan by the people, has adobe walls rising over the rubble stone foundation. The khan, which is in a rather dilapidated situation, is not currently used.

Tokat is one of the important Anatolian cities where we see examples of various architectural structures of adobe application.

Keywords: Tokat, adobe, Masat Hoyuk, Ali Duruoz House, Katircilar Khan.

1 INTRODUCTION

City of Tokat, in which 14 states and many seigniories existed and continued their dominance starting from the chalcholithic period around 4,000 BC, is located upcountry in the Central Black Sea Region [1]. Samsun is located to the North of Tokat, which is a rare Anatolian city that has preserved and brought to our day its historical, cultural and natural beauties, Ordu to the northeast, Sivas to the South and southeast, Yozgat to the southwest and Amasya to the west. The fact that it is established on the fertile soil of Yesilirmak Basin has transformed Tokat into a city of conquest and turned it into a centre of population, in which important civilizations existed throughout the history [2].

Different information is available relating to the origins of the name Tokat, which became a city in 1923. The name Tokat is known to have derived from Byzantine Empress Evdoxia, mother of Emperor Theodore, and to have been used as "Dokeia" and "Toh-Kat" meaning a city with walls later on. In fact, Evliya Celebi indicated that the city might have been named after a legendary hero called "Dok-ad" [3]. Having 12 districts being Almus, Artova, Basciftlik, Erbaa, Niksar, Pazar, Resadiye, Sulusaray, Turhal, Yesilyurt, Zile and the central district; Tokat is a fascinating city of history and culture housing works and cultural assets from the Hittite, Phrygian, Roman, Byzantine and Islamic periods. This historical and cultural richness of Tokat has impressed many itinerants, historians and researchers. In his Book of Travels, Evliya Celebi describes Tokat as follows [4]: *"Water flows through gardens and water-melon fields all across this city with nice air. Singing of nightingales in these gardens gives pleasure to human psyche. Its fruits being delicious and nice, they are widely sent as presents. A mansion, pool, fountain and various fruits are available in each of its vineyards. Its people are pleasure experts. They are friends with the poor; they do not hold a grudge or know any tricks and they are tolerant, good natured, honest and gentle people. They have a positive opinion about everyone. They get on well and they are very eager to have beneficient structures built. Their mosques, palaces, mansions and imarets are so beautiful and strong that visitors thereto admire them. The city being a large and cheap place, it is unique on earth. Blessings of its people are abundant in all seasons. Thanks to the beneficent and blessed prayers of Haji Bektash Veli, this old historical city is a "MANSION OF SCHOLARS, LAND OF VIRTUOUS MEN and a BED OF POETS…"* Itinerant and historian Tournefort, on the other hand, cited the following about Tokat in his work penned in 1717 [5]: *"In the early 18th century, Tokat is bigger and more beautiful than Erzurum. Its well crafted houses spread over the surrounding mountains and valley. This scenery can not be enjoyed anywhere else on earth. Tokat is the leading center of trade of Asia Minor. It is a beautiful city with its twelve minarets and its mosques and I admired the ceramics in BLUE MADRASA (Pervane Bey Hospital)."* Distinguished Professor Doctor Süheyl Ünver, on the other hand, wrote the following lines about Tokat in his article titled "Monuments in Tokat" in the edition dated 1st June 1962 of Hür Vatan Newspaper published for the first time in 1961 [6]: *"Let me tell you my feelings about the ancient monuments I visited one by one, travelling from place to place. Believe me, the most beautiful monuments not available in Istanbul, Konya, Bursa and Edirne are present in Tokat. Tokat-the homeland of such connoisseurs as Ibn Kemal, Mullah Husrev, Mullah Lutfi, -a hero of Plevna- Osman Pasha, Sheikh Emin Effendi-is, to my surprise, a magnificient city. It is a city that has the highest number of monuments in Anatolia. The Seljuqs and the Ottomans were, so to speak, in a race with each other, each trying to hand down more works than the other. To be honest, I was not able to count the monuments. Number of relics is as many as the population of Tokat. Frankly speaking, each of these monuments is a "Saint of Tokat" aged between 300 and 800. They have nationalized the city and inspired our spirit."*

As it is possible to see monuments and works dating back to each and every period in the time course extending back to the Hatti, Hittite, Phrygian, Roman, Byzantine, Danishmend, Ilkhanid, Seljuq and Ottoman Periods in all parts of Tokat; Tokat is kind of an open- air museum. The city of Tokat qualifies as the only city, in which works that are very important in architectural terms were built within 900 years beginning from the date Turks entered Anatolia and in which these works can be visited, with monumental and civil architectural examples such as Horoztepe Ancient Settlement in Erbaa district; Masat Hoyuk Archeological Site dating back to the Hittite period in Zile; Sebastapolis with relics from the Roman- Byzantine Periods in Sulusaray; Comana City situated in the city centre of Tokat and Tokat Castle built in the Roman Period; also the historical castle situated in Niksar district, which was the capital of the Danishmend Dynasty; Garipler Mosque, which is the oldest Turkish Mosque built after the Battle of Manzikert; Yagibasan Madrasah; the Blue Madrasah; Yesilirmak (Hidirlik) Bridge; Ali Pasha Mosque, Ali Pasha Mausoleum and Ali Pasha Hammam which are Ottoman structures; Tashan (Voivode Khan); Deveciler Khan; Arastali Bedesten (Present Tokat Museum); Latifoglu Mansion Museum House with the grandest ceiling rose in Anatolia in the civil architecture of the 18th century and also the Mevlevi Lodge of Anatolia built from the most beautiful wood in Europe; Tokat Clock Tower and many more mosques, mauseleoums, islamic monasteries and zawiyahs, hammams, fountains, madrasahs, covered Turkish bazaars, khans. Therefore, Tokat is called "900 Years in 900 Steps", which expresses the historical beauties of Tokat and which has transformed into a slogan [7].

Both monumental and civil structures in Tokat were built using many different construction materials. Use of adobe material as a packing material most often in residences built in the 19th century stands out. However, adobe is also observed to appear as the main construction material in several important structures in Tokat. A palace structure belonging to the Hittite Period- Masat Hoyuk-, which is one of the ancient settlements in Tokat was built from adobe walls. Flank front of Pasha Hammam, which is the hammam structure of the 14th century is covered with adobe material. One of the residential structures which has not been able to come until today, Ali Duruoz house, had adobe walls. Apart from these, adobe application in Tokat monumental architecture is encountered in the khan structure known as Katircilar Khan, which is in a dilapidated situation today.

2 EXAMPLES OF USE OF ADOBE IN TOKAT'S HOUSES AS PACKING MATERIAL

Nearly the same materials and techniques have been used in all of Tokat's houses. Exterior walls of residences have been built as plaster over adobe filler between plasterboard and wooden carcass. Interior and party walls and outbuildings are built as plasterboard. Considering the construction technique, it is observed that a thick horizontal wooden beam has been put on a very short stone groundwork and a wooden girder has been built thereon in each corner. After these girders are joined with wooden beams from above, interior part of the undercarriage is graduated with slittings that are thinner, that distribute the force and facilitate the interspace filling application. The second layer is built with this method as well [8]. After the main carcass of the house is built, adobe filling is spread; gypsum over clay and stray plaster is applied on the interior walls and fibered lime plaster on the surfaces of exterior walls [9]. It is partly observed that the ground floor of some houses were built with rubble stone. In the structures, ceilings of both floors are wooden, part called stony ground or "life" part entered the first in the ground floor are block stone surfacing and areas like woodshed are rammed earth [8].

2.1 Tokat Madimagin Celal's House (19th century)

Whereas it was originally a structure with a ground floor, mezzanine floor and first floor over a basement; the first floor of the residence located in Tokat Ali Pasha district burnt completely as a result of a fire outbreak "Fig. 1". Therefore, today, the attic is placed over the floor covering of the first floor. Garden entrance to the house is situated to the north of the house. Main entrance to the structure, on the other hand, is located in the central stage of triptych front of the structure. Whereas the room situated to the right of the entrance is an extremely simple room, there is a room known as the "main room" with rich decorations to the right of the entrance [10]. Two rooms receiving sunlight through the rear front and used as vault are available in the basement. Structure of the residence is enclosed with a saddle roof covered with pantiles. The residence was built employing the adobe filler between wooden carcasses technique.

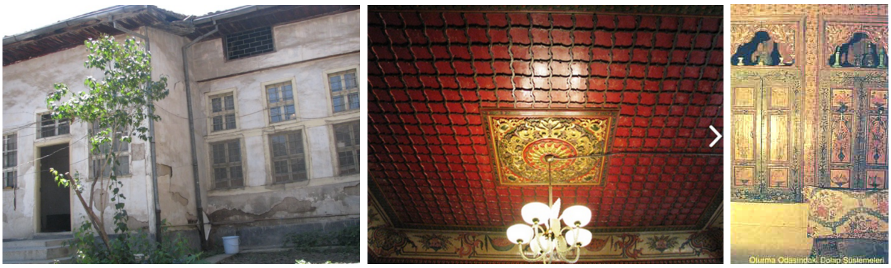

Figure 1. Madimagin Celal's House, http://www.kulturportali.gov.tr/.

2.2 Tokat Atatürk House and Ethnography Museum (19th century-20th century)

Located in Tokat Devegormez District, the house is the structure Atatürk stopped over when he came to Tokat. The structure, which has recently been restored by Regional Directorate of Foundations and which is used as a museum today, is a three-story building inclusive of a ground floor, mezzanine floor and first floor "Fig. 2". Considering its mass as a whole, it is a bit different from the plans of standard Tokat houses with its "U" shape. The ground and top floors are of the two-faced plan type with an interior hall. It was built using adobe packing material between wooden carcass [11]. The mansion, which was expropriated by the Ministry of Culture and Tourism, was reorganized with ethnographic works of its period and entered into service as Atatürk House and Ethnography museum in 2007 [10].

Figure 2. Atatürk House and Ethnography Museum, http://tokatta.com/ataturk-evi-ve-etnografya-muzesi.

2.3 Tokat Yagcizade Mansion (19th Century)

For the two-storey mansion in Tokat Horuc District, Akok said: "*Yagci Zade House is the most notable among all the old houses we explored in Tokat."* [9]. Considering its plan, the structure was designed as a big structure consisting of front, back and side houses. The residence was constructed with adobe filler between carcasses technique. The structure being dilapidated, only the back house is present currently 'Fig. 3' [11].

Figure 3. Yagcizade Mansion, Tokat Museum Archive.

2.4 Tokat Latifoglu Mansion (18.yy)

One of the owners of the mansion situated on Gazi Osman Pasa Boulevard in the city center of Tokat, Fahri Latifoglu, stated that the structure was built in 1746 [10]. Akok, on the other hand, stated that another house existed on the promises of Latifoglu Mansion formerly in the 17th century that was constructed in the exact classical style and that spolia materials taken from the former residence were used in the structure of the residence built later on. Especially this manifests itself in the elements used in the plan diagram and interior architecture of the structure [9]. The mansion was constructed as a two-story structure using adobe packing material between wooden carcasses on a L plan diagram [11]. Expropriated in 1987, the structure was opened to visits in 1990 as a museum- house after it was restorated. The mansion underwent a change especially after the restoration in the 19th century and after the parts were added later on and assumed a new appearance with baroque style decorations. The structure, which is a two-story structure, consisting of three exterior halls and two rows of rooms; it attracts attention with its woodworking and wall decorations. Especially the engraved ceiling in the section called "Bey Room" has rich decoration 'Fig.4' [12].

Figure 4. Latifoglu Mansion, Bilgen (2013).

3 TOKAT MASAT HOYUK

One of the main settlements reflecting the characteristics of Chalcolithic Period in Tokat is Masat Hoyuk. Named as "Hoyuk Tepe" by local people, Masat Hoyuk is 20 km to the South of Zile, 312 km to the northeast of Ankara and 1,500 m to the west of Masat Village (today's Yalinyazi) in the middle of Masat Plain. Marbled limestone blocks of the paleozoic rise in large masses in Masat Plain, which is a very fertile area, which is surrounded by trees and dense forests and which has two stream beds that are dry now but used to meet the water need of the area in the ancient ages. Masat Hoyuk was established on one of these stream beds. The mound, which is 886 m above sea level, falls into the category of large mounds when examined by its size. Masat Hoyuk excavations began in 1945 following the introduction of a Hittite Tablet written in cuneiform and found in the mound by H.G. Guterbock in 1943 in to the world of archeology. However, the main excavation works in the area were carried out by Turkish Historical Society. These excavations were carried out by a group led by Tahsin Özgüç from 1973 to 1979. Excavation works continued between 1978 and 1980, as well. Tahsin Özgüç brought his two- volume work called Masat Hoyuk prepared relating to his Masat Hoyuk excavation works in to the worlds of science and art. In line with the tablet in cuneiform found in Masat Hoyuk, the name of this settlement was identified to be "Tapigga" [13].

3.1 Architectural Characteristics of Masat Hoyuk

Masat Hoyuk has particular importance with regard to its location especially for its own period. This is because the mound settlement lies in the boundary area between the Black Sea Region, which was occupied by the Kaska tribes, and the actual Hittite land. Masat Hoyuk is one of the strongest centers in the area affiliated to Bogazkoy and bordering the Kaska land. Considering the geological advantages of Masat Hoyuk, it meets all possible requirements for the settlement of a Hititian ruler, who was a representative of the Great King that lived in Hattusa. Stratification in Masat Hoyuk is as follows: the 1st strata dates back to the Iron Age, the 2nd and 3rd layers to the Hittite Period and layers below that date back to the First Bronze Age. Three structure layers belonging to the Hittite Period were found in the 2nd layer. Traces of the 3rd structure layer, which is the oldest of the period, were encountered in the citadel. Architectural ruins in Masat Hoyuk are the most significant reflections of Masat Hoyuk. In Özgüç's words; *"Excavations brought to light a magnificient building with a northern wall that is minimum 100 m in length and an eastern wall that is 80 m in length."* This structure having 40 rooms, most of these rooms belong to the basement 'Fig 5' [14].

3.1.1 (Citadel) The Big Palace

When examined in architectural terms, the palace structure displays the characteristics of Hititian monumental architecture in terms of wall technique. Old structures in that area were removed, the ground was tailored before the building featuring the delicacies of Hititian architecture was built and limestone foundations were laid in quite neatly, evenly and in a manner that their width would exceed 1.50 m [13]. It was built as a "L" shaped mass that is 80 m long to the east and 100 m long to the north with 2 or 3 storeys. It has an arcaded yard 'Fig. 6' [1]. Rooms in the palace were designed for different purposes; rooms with furnaces on the first floor were designed for daily living and places where earthenware jars for cereals were lined were designed as storehouses, rooms on the ground and top floors were designed as archives, control points and residence rooms [1].

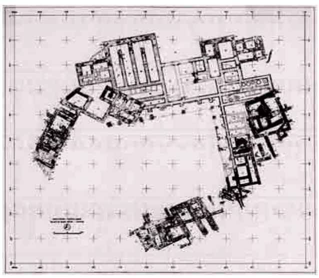


Figure 5 and Figure 6. Plan 1 – Masat Hoyuk Tapigga Palace, Mount II and III Plans of Hititian Floor, Plân der II und III. Hethitischen Schichten von Maşat-Höyük (T. Özgüç, Masat Hoyuk II, Plan 1) and Masat Hoyuk Big Palace 85x70, Yavi (1986).

Walls on sturdy foundations were built from adobe material "Fig.7" and wooden poles were used between these walls. Technique that is dominant in this structure is the fact that the interior and exterior faces of the foundation were bonded with large and clean cut stones and the spaces in between them with smaller rubble stones crankily. Construction of the corners being sturdy, foundation stones and wall adobe are bonded with each other well. Walls on stone foundations were built with large adobes made of sanded clean mud. Exterior walls were built from large adobes and the party walls of some warehouse rooms from smaller adobes. Sizes of adobes exposed in some excavations findings so far are: 63x45x12 cm; 65x45x10 cm; 50x46x12 cm; 46x38x10 cm; 45x40x10 cm; 42x32x10; 40x36x10 cm and 35x30x10 cm 'Fig. 8'. Construction materials used in the palace structure are limestone, adobe and wood. Great care was shown to the top line of the foundation stones in adobe walls so that a straight ground could be insured for wooden girders and adobes. The fact that this structure considered to have been constructed as a palace structure has more than one storey makes us think that wood, which is a light material, was intensely used on the top floor. Walls of the clay and straw plastered structure, in which fewer adobes were used, are plastered in cream, light pink and whitewashed in a reddish colour. The structure as a whole was destroyed in a fire, stones became lime and melted and adobe became hard brick, collapsed and broke 'Fig. 9' [14].

3.1.2 Lower City

Excavation works of the city, which expands downward from the terraces around the big palace, started in 1978. During these excavations, 5 structure layers belonging to the Hittite and Phrygian periods were found. Characteristics of Hititian architecture are seen in the city, which was rebuilt with wars and fires experienced at different times. Walls were put up with adobe on stone foundations raised to the subgrade level and were supported with wooden poles. Floors of houses formed by two-bedroom rectangular sections' coming together were furnished with rammed earth. Some periodical differences are present in city ruins. Whereas a house built completely with wooden beams in the first high part of the lower city is present, there is another structure ruins put up completely with stone in the northeast 'Fig. 10' [16].

Figure 7, Figure 8, Figure 9 and Figure 10. Masat Hoyuk Palace Structure Adobe Walls, Sample Adobe Used in Masat Hoyuk Palace Structure, Adobe that Melted During the Fire that Broke Out in Masat Hoyuk Palace Structure and Masat Hoyuk Lower City Foundations, Yavi (1986).

4 TOKAT PASHA HAMAM

According to the epitaph, Grand Vizier Yorguc Pasha had the hammam, which is located in Sulu Sokak district Ivaz Pasha Locality of Tokat, built in Celebi Mehmed's son Murat II's day and this building was dedicated [15]. The hammam, in its present form, is a structure planned as a single hammam consisting of warm areas, hot areas and a relaxation area called Camegah. Camegah section of the hammam, which was built over an area of 16.90 x 31.25 as a whole, having an area of about 7.35 x 14.25; it is covered with a dome, the transition of which was ensured with pendants and which has a lantern. The hammam was built as a masonry using rubble stone material predominantly. Except from rubble stone, use of bricks in the cover coat and clean cut stone in the door and window frames is observed [16]. Use of adobe brick is seen in only one front of the hammam. The hammam being dormant today, it is in a doomed condition 'Fig. 11'.

Figure 11. Pasha Hammam, Gorgun (2019).

5 TOKAT ALI DURUOZ HOUSE

Ali Duruoz house is one of the four residential structures detected by Mahmuk Akok. Akok stated that this structure was a medium scaled house having the feature of a traditonal type residence and that it was a remarkable structure with its typical plan diagram and classical construction style despite having lost its former glory and part of its features. Stating that winter residential places and warehouses are present on the ground floor, Akok indicated that small- scaled design four-cornered rooms are available around a stepped sofa on the top floor. Ceilings of the rooms are wooden and the floor partition has wooden girders and a wooden floor. Ali Duruoz house is one of the significant vintage houses of Tokat, which overlooks the street with its two fronts and to the garden with its other two fronts, which is covered with bricks at the top, which has a wooden framed cover coat and which- with its walls put up with adobe, its plain style and classical plan diagram- is thought to have been built in the 19th century 'Fig. 12' [17].

Figure 12. Ali Duruoz House, Tokat Museum Archive and Hasan Erdem Archive.

6 TOKAT KATIRCILAR KHAN

Name of the khan located in Sulusokak is not known for sure as it does not have a builder or an epitaph on its year of built. Called as "Katircilar Khan" by the people of Tokat, the structure dates back to the late 18th and early 19th century as of its architectural features 'Fig. 13'. Part of the structure, which is in a quite dilapidated condition today, has been destroyed and burnt. The structure is a two- storey inner- city khan extending in the direction of north- south that has a rectangular plan. The khan, which is entered through a door that opens to Sulusokak on the southern front, was constructed according to a diagram that is planned with four iwans and a patio. Only the southern iwan, which is the entrance iwan, exists today. The iwan situated in the South and rectangular cells on its two sides are in a completely destroyed condition. The structure, which was built with adobe material between wooden carcasses on a rubble stone foundation has a wall that is built from adobe. Face stone was used in the doors and windows of the structure. [3].

Figure 13. Katırcılar Khan, Tokat Museum Archive.

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Earthquake and Vernacular Earthen Architecture

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ABSTRACT

Vernacular architecture refers to a kind of architecture, which has been designed and built by people for people in order to meet needs, comfort, utility and functionality in their dwellings. Local building materials along with local construction processes and inspiration from its environment are the important issues to the success of vernacular architecture and its sustainability till nowadays. The majority of vulnerable constructions that can be subjected to earthquakes are categorized as Unreinforced Masonry (URM) constructions, for which almost no earthquake design requirement has been considered. In structural point of view, vernacular architecture is mainly classified as URM constructions. Thus, in severe earthquakes, vernacular architecture may suffer considerable damage, and eventually collapse, with the consequent economic losses, injuries and deaths.

The earthen material was used since pre-history, to create valuable heritage architecture due to the availability of earth throughout the world. Although many monuments have been built in earthen, due to availability of the earthen material as well as the ease of construction of most of the techniques, earthen architecture is often associated with vernacular architecture. In this paper, first the traditional earthquake-resistance techniques, which have been adopted in different regions of the world to improve the seismic behavior of vernacular earthen architecture, are reviewed. Next, the techniques are categorized based on their features and construction details. Finally, the possibility of using such techniques for retrofitting of earthen architecture is investigated.

Keywords: Earthen Architecture, Earthquake, Vernacular Architecture, Seismic retrofitting techniques.

1 INTRODUCTION

In general, vernacular architecture refers to the architecture that is designed and built by people for people in order to meet needs, comfort, utility and functionality in their dwellings. Vernacular architecture as non-engineered constructions, results from the use of local building materials and construction techniques to reach the comfort and performance desired. The vernacular architecture continuously improves itself to comply with different requirements and demands imposed by the social and physical environment in which is located, such as local climate conditions, extreme loadings, type of use, the available materials and other cultural conditions. Such important features cause the success of vernacular architecture and its sustainability until nowadays (1).

The earthen material was used since pre-history, to create valuable heritage architecture due to the availability of earth throughout the world. Different earthen construction techniques have been developed by human such as adobe, rammed earth, compressed earth block and wattle and daub. Although many monuments have been built in earthen, availability of the earthen material as well as the ease of construction of most of the techniques, earthen architecture is often associated with vernacular architecture.

Earthquakes are one of the greatest natural hazards with a large destruction in terms of loss of life and property to mankind since the beginning of civilization. In the past 2,000 years, earthquakes claimed approximately 9 million lives (2). A large percent of the world's population dwell in non-engineered buildings with poor performance for horizontal loads and, consequently, are vulnerable to earthquakes. The majority of vulnerable constructions that can be subjected to earthquakes are categorized as Unreinforced Masonry (URM) buildings, for which almost no earthquake design requirement has been considered. In structural point of view, vernacular constructions, which are mainly classified as URM constructions, present a poor performance during severe earthquakes.

However, requirements imposed by the social and physical environment cause a gradual improvement to the vernacular architecture during a prolonged time. Hence, this is expected that small or moderate earthquakes influence the vernacular architecture located in the seismic-prone regions of the world. In other word, human seismic experiences affect the vernacular construction practice, and thus improve the structural performance of the vernacular architecture against earthquake. This paper aims to classify seismic-resistant vernacular solutions used in the earthen architecture around the world and to introduce effective retrofitting techniques inspired by such vernacular solutions.

2 LESSONS FROM PAST EARTHQUAKES: SEISMIC CALTURE

Although the vernacular earthen constructions have been usually blamed by engineers for their poor seismic performance, past earthquakes reveal a counter-intuitive finding that some of such constructions can resist seismic actions. Habitants of the regions that host a number of small or moderate earthquakes, learn from post-earthquake observations how build earthquake-resistant earthen dwellings. Consequently, their construction practice has improved gradually, modifying the architectural design and/or incorporating several elements in the vernacular earthen architecture. This has led to a collection of practices, traditions and rules in different countries, called as "seismic culture", that have been developed based on the local knowledge of habitants. Exploring the seismic culture used in the vernacular earthen architecture requires a comprehensive study on the performance of the earthen architecture during past earthquakes as well as a detailed survey on construction practice and technical features of such architecture.

In a multidisciplinary point of view, all the seismic-resistant vernacular solutions, namely as seismic culture, can be classified into two main groups: 1) The solutions that are dealing with the architectural form and design; 2) The solutions that are based on adding some reinforcing elements made of local and consistence material. In the following, some evidence of seismic culture found in the vernacular earthen architecture is explored based on the above-mentioned classification.

2.1 Form-Based Vernacular Solutions

Aiming at exploring the form-based vernacular solutions, different instances from various regions of the world are presented and discussed in this section.

The country of Iran is located on the Alpine-Himalayan earthquake belt, one of the most seismically active areas of the world. The country has experienced significant number of catastrophic earthquakes with considerable economic losses, injuries and deaths. On the other hand, arising from ancient cultures and civilizations, Iran has a vast number of adobe monuments and vernacular architecture with a great built heritage, in particular in its center and southern areas. The most-used earthen construction technique in Iran is adobe. Due to limited sources of wood, adobe buildings in Iran have been constructed with adobe curved roof (dome and/or vault) instead of using wooden roof that is more common in other regions of the world (1). The 2003 Bam earthquakes is an example of severe earthquakes occurred in Iran with destructive influence on adobe buildings. However, contrary to prevailing belief, namely the poor seismic performance of all adobe buildings during the 2003 Bam earthquake, the earthquake showed that many ancient adobe constructions belong to typical Persian adobe vaulted architecture, with no restoration and maintenance survived the earthquake in the heart of the damage district. However, modern steel frame buildings, contemporary adobe buildings with jack-arch roof (a composite steel-brick roofing system) as well as the earthen structures within the ancient Arg-e Bam, which are reconstructed or restored from 1950 onwards, collapsed or suffered very severe damage (3).

Adobe domes, in particular semi-spherical ones, with bi-directional load-bearing capacity present an acceptable seismic performance, because the horizontal earthquake loads do not create sufficient flexural stresses in the dome to result in a net tensile stress. As a result, domes are required to carry the load in compression. In general, adobe domes show better seismic performance than vaulted roofs (see Fig. 1). Post-earthquake survey indicated that flat adobe vaults collapse very easily during the earthquake, whereas the vaults with high rise to span ration like catenary vaults resist better against seismic actions (1, 4).

Figure 1. Interior of an adobe dome after the 2003 Bam earthquake, showing damage, but no collapse (3).

Earthquakes occurred in Peru also confirm the effect of architectural features on seismic performance of adobe buildings. Most modern vernacular adobe houses in Peru have been constructed without technical requirements, and thus with poor construction quality. Hence, they possess the architectural features detrimental to structural behavior such as several stories, thin walls, large openings, and irregular configurations. However, in the regions with the same seismicity, earthen buildings that have built using a vernacular earthquake-resistant construction system, called as Quincha (a type of wattle & daub technique), were safe without serious damage during past earthquakes (5).

The same is observed in the Latin American countries like El Salvador and Nicaragua in which a 3D timber frame (like a basket) filled with small stones or adobe and plastered by mud, called in Nicaragua as Taquezal and in El Salvador as Bahareque, is used. The construction system is a vernacular earthen technique with acceptable structural behavior during the 1931 and 1971 Nicaragua and the 1986 El Salvador earthquakes (see Fig. 2) (5).

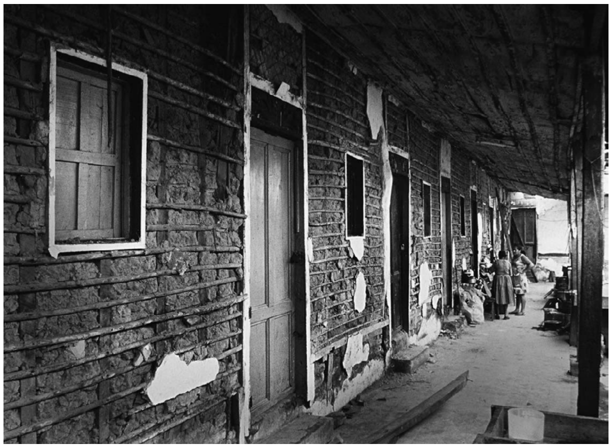

Figure 2. Bahareque building in El Salvador, after 1986 earthquake showing shedding of plaster from undamaged walls (6).

2.1 Element-based vernacular solutions

This section addresses different vernacular solutions, which are based on the use of some specific elements to improve the building seismic performance.

A construction system is used in the city of Lahijan, north of Iran, to build traditional adobe houses. In this system, pieces of wood are incorporated between the ground and the bearing walls of the houses. The construction system presented a good performance during the 1991 Manjil-Rudbar earthquake so that a permanent displacement of 15-20 cm almost without any damage was observed for some of the houses (see Fig. 3) (7).

Chinneh (a Persian word) is an earthen construction technique for erecting long, high and thick fence walls around the cities in ancient Iran. Chinneh walls, which were used in Iran until almost 100 years ago, are erected following a construction process very similar to the cob technique (without the use of formwork for built up). As shown in Fig. 3, one of the differences is that masons used bed joints made of clay brick (fired adobe) 3-4 times along the wall height. The bed joints act as tensile reinforcing elements to suffer tensile and shear stresses when the wall is subjected to the horizontal loads. This mechanism led to survive the walls, which had no maintenance in over 150 years, during the 2003 Bam earthquake (post-earthquake very little damage) (8). Based on the same mechanism, some of turrets were stable during that earthquake due to incorporating and extending timber reinforcing elements through their walls.

The use of wooden tie beams is another element-based vernacular solution, which is utilized in different countries to strength connection between structural components, as well as, to absorb earthquake-induced tensile forces. Different applications of wooden ties are presented in Fig. 4. The use of buttresses is very common in vernacular architecture of different regions of the world. Buttresses, as the architectural components of a building, prevent out-of-plane failure of masonry walls subjected to earthquake and subsequently the collapse of the entire building. Fig. 4 shows examples of buttress used in Iranian and Peruvian vernacular architecture.


Figure 3. Vernacular solutions: application of seismic base isolation in Lahijan, Iran (left image) (7); Chinneh wall after the Bam earthquake with slight damage (right image) (8).


Figure 4. Vernacular solutions: application of wooden tie beam in Yazd, Iran (left image) (1); application of buttresses in the Andean region (right image) (9).

3 SEISMIC RETROFITTING TECHNIQUES FOR VERNACULAR EARTHEN ARCHITECTURE

As stated before, improving local construction practices, vernacular earthquake-resistant solutions (seismic culture), play an important role to guarantee the safety of the vernacular earthen constructions against earthquake. However, in many cases, the large recurrence period of the earthquakes occurred, the economic limitations of habitants, and the poor state of conservation and maintenance of the buildings detract the important influence of these solutions.

On the other hand, even with good construction practices and incorporating above-mentioned solutions, the earthen constructions may present a poor behavior against strong earthquakes due to some features of these constructions, as a type of URM structures, such as high mass, irregular configuration, insufficient connection between structural elements, etc. Hence, according to the desired performance level as well as the seismic hazard considered (the conservation objective), the use of seismic retrofitting techniques within the conservation of earthen architecture sometimes becomes necessary. Inspired by the vernacular solutions described before, the retrofitting techniques should be effective on structural behavior as well as compatible with architectural requirements, earthen material and local climate and environment.

In the case of adobe buildings, as the most-used earthen technique, an extensive research performed at the Getty Seismic Adobe Project (GSAP) indicates two main groups for available retrofitting techniques, namely as strength-based and stability-based techniques. The former group, which addresses the elastic performance, aims to postpone the onset of cracks by increasing the elastic capacity of the entire building and/or the building components. Dealing with the post-elastic behavior of the adobe buildings, the stability-based retrofitting techniques aim to improve the structural ductility of the building after the elastic limit of material, which is more crucial than the structural behavior before formation of cracks. A wide range of available seismic retrofitting techniques of each mentioned group, applied in historical adobe buildings, have been reviewed by Michiels (9). These techniques are briefly introduced as follow.

1- Strength-based techniques such as cement renderings or shotcrete reinforced with steel wire, polymer fibers or glass fibers, grouting the existing small cracks and soft-stitching of the big cracks;
2 - Stability-based techniques:
a - Techniques to obtain overall stability such as timber or reinforced concrete bond beam, partial plywood diaphragm, steel or nylon rods and straps, center-core rods (steel, cane or wood), different types of meshes (steel welded wire or polymer) with earthen or lime rendering and boundary wooden elements (see e.g. Fig. 5).
b - Techniques to stabilize building elements such as horizontal elements that connect parallel walls like wooden tie beams or steel tie rods, connections between perpendicular walls, corner keys or braces (wooden element), connections between perpendicular walls and buttresses.

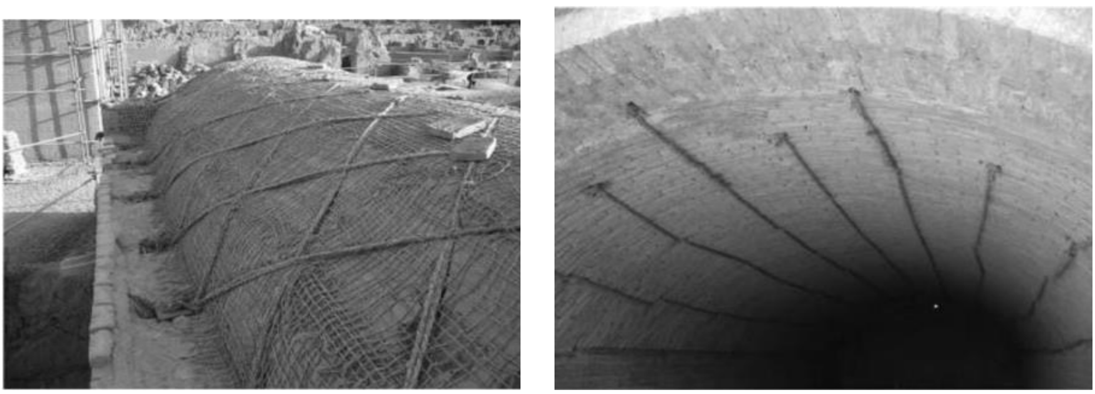

Figure 5. Strengthening a vaulted roof with mesh made from palm-fiber, Bam citadel, Iran (10).

4 FINAL REMARKS

In general, vernacular earthen constructions present poor performance during earthquakes due to the heavy weight of the constructions, their low strength, brittle behavior, and insufficient connections between structural elements. However, based on the post-earthquake observations, it can be claimed that there are some vernacular solutions in the regions affected by a number of small or moderate earthquakes, by which the seismic performance of earthen constructions has been improved.

Exploring and classifying such vernacular solutions help engineers to develop some effective retrofitting techniques, which are compatible with earthen material, architectural requirements and environment. These techniques can be used for strengthening of the vernacular earthen architecture, with a low-quality current state, and/or those located in the regions with high seismicity.

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Walls protection and consolidation of earth fronts of excavation in Pompeii

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ABSTRACT

The restoration and consolidation of the Chaste Lovers Insula, in Pompeii, involve, among different actions, a new cover, walls protection and consolidation of earth fronts of excavation. The aim is securing the archeological site, by better managing risks, also taking into account Earthquake Risk. The choices are made in order to reconcile the need for "conservation" and "structural safety", through reversible interventions, preserving the original structural role of the elements and using compatible materials.

The analysis of the structural behavior of the archeological walls involved historical knowledge, geometric survey, analysis of discontinuities, the evaluation of the causes of the disruption and the identification of the interventions. Each technical sheet has been structured by identifying the failure and the causes and providing intervention proposals in compliance with operational practices adopted in the Site, aimed at safeguarding the archaeological asset. The design also includes the work on re-profiling earth excavation fronts, excluding the archeological excavations envisaged.

The detailed survey gives the opportunity to establish a chart of risk, by considering different elements (geometries, presence of elements of values, structural problems). Some devices were adopted to improve the accessibility and the quality of the touristic visit in places considered "at risk" for accessibility. Fruition and valorization are conceived in a modern way: the places that cannot be visited by tourists can be seen from a suspended pathway, in order to allow visitors to understand more, and without any risk. A special attention has been given also to planned maintenance for the future.

Keywords: evaluation of risk, prevention techniques, Pompeii archeological heritage, earth front of excavation.

1 INTRODUCTION

In this paper we focus on a case study of managing Earthquake Risk on Archeological Structures through the idea that, in cases of particularly fragile and delicate environments and contexts, it is anyway possible to keep up with a "conservative" balance. An archeological site has plenty of fragilities: the case study deals with the Chaste Lovers insula in Pompeii, next to Naples, in the South of italy, with the aim to show- synthetically- the core of general and specific topics. The project is in the context of the Major Project Pompeii, MPP, a great collective commitment, and an example of good practices, good planning and high executive skills, by public administration and highly specialized professionals. Launched only few years ago, the program had a large coordination effort, and it lead soon to great results in restoration activities, in securing the site from many types of risks, and in increasing of the incoming of tourists.

2 THE CHASTE LOVERS INSULA

The so-called Chaste Lovers insula ("dei Casti Amanti", in italian) (IX 12) is located in the central district of the archeological site of Pompeii, represented by Regio IX, along the main decumans of Pompeii, *Via dell'Abbondanza* [Fig. 1]. The block extends over an area of approximately 4.000 square meters. This district is bordered to the north and south by the two parallel east-west routes of Via di Nola and Via dell'Abbondanza, and is crossed by an intermediate, partly excavated, partly documented axis. From geognostic investigations carried out on the *plateau* above it, the excavation of this area was interrupted towards the end of the nineteenth century, leaving a surface equal to about half of its planimetric development. The limits of this area coincide with the boundary of the excavation area, where still archaeological structures are buried underground.

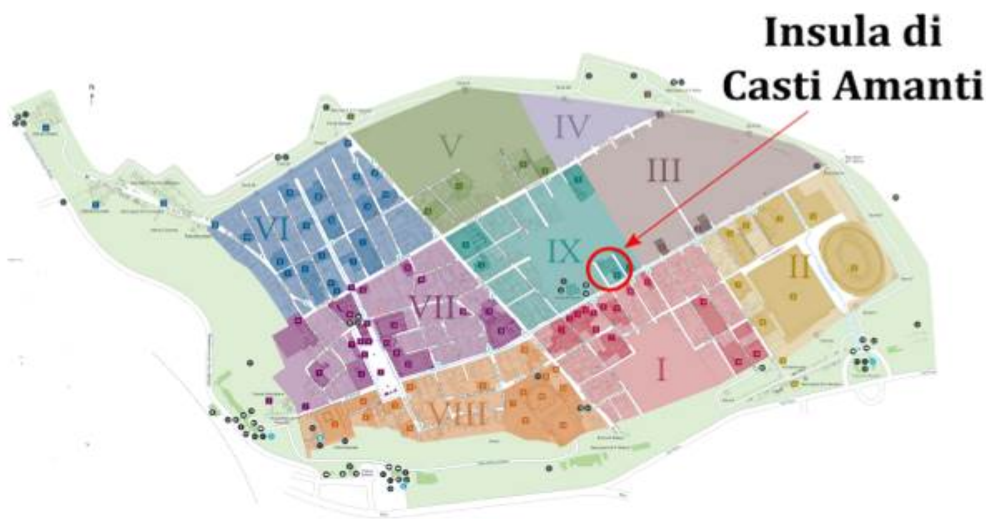


Figure 1. Framing of the Chaste Lovers' insula

The structuring of this road marked the phase of urbanization of the district, with relative delimitation of the blocks in the forms known to us, in a moment that can be archaeologically dated during the third century BC. The insula overlooks the north side of Via dell'Abbondanza: its first unveiling, essentially limited to that extreme front line, started at the beginning of the 1900s, with a modest ingression towards the interior, limited to almost 15 meters, at its southwest corner. The insula has come to light in the early 20th century and soon, in 1943 it has been bombed and partially destroyed by Allied Forces. It has been then restored and widely reconstructed.

Systematic investigations lasted for more than 20 years starting from the 80s of the last century. With these investigations it has come to highlight- net of irretrievable losses, suffered as a result of the aerial bombardments of 1943- what was recovered and restored on the margins of the first excavation, of a southern sector of about 1.600 sq. m. Excavations boundary were implemented and the area was protected with a provisional roofing systems, that nowadays still cover the entire surface.

At the current state of knowledge it would seem that it is possible to extrapolate four defined and distinct real estate units, all with access from the Via dell'Abbondanza [Fig. 2]. We can distinguish different units in the block. The first unit consists of the small building (m 6 X 10) located in the south-west corner with entrance at number n. 1, subjected to the so-called *First cenacle* (Primo Cenacolo). The second would be identifiable in the commercial plant at number n. 5, independent of the adjacent domus subjected to the so-called *Second cenacle* (Secondo Cenacolo). The third unit, with access from the civic n. 6, consists of the Casti Amanti bakery (Bottega dei Casti Amanti), inscribed in an almost exactly rectangular plant at the south-east corner of the block (m 17 X 24). The fourth unit would consist of the commercial plant (m 4 X 7) cut from the aforementioned bakery at the far corner of the insula, open on the street at street number n. 7.

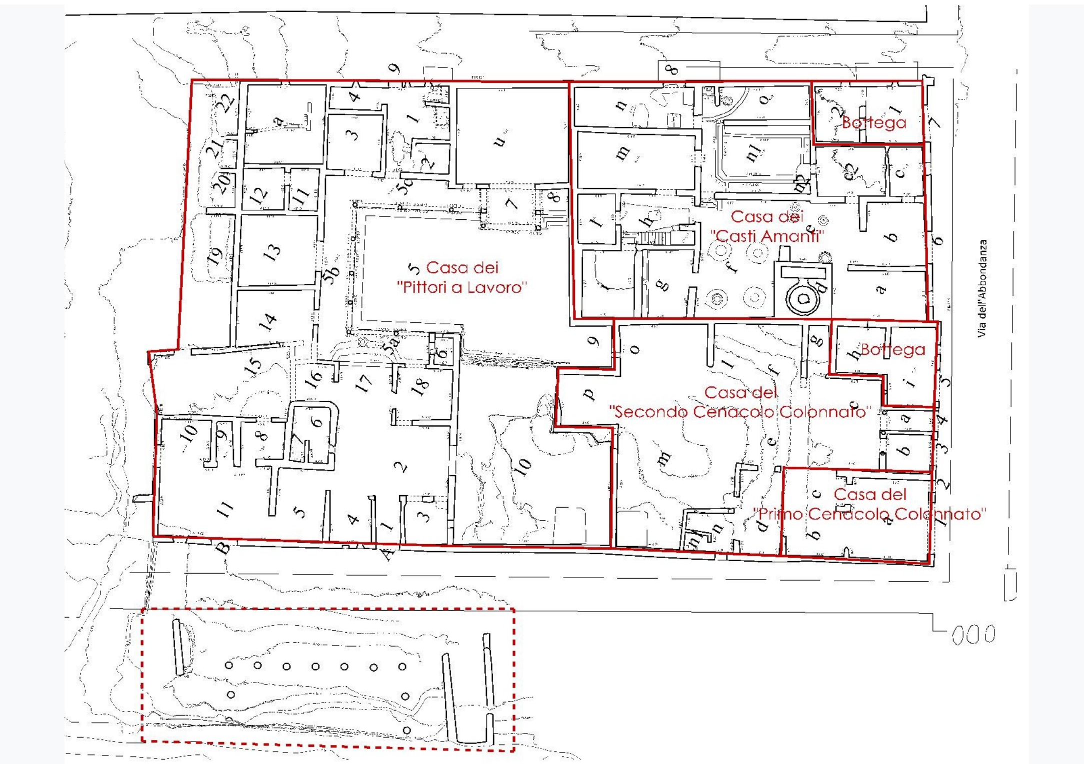


Figure 2. Plan with identification of the cadastral units

All the remaining built-up area, connected along the three side roads to entrances corresponding to the civic n. 3-4 (Via dell'Abbondanza), relating to the so-called House of the Second Upper Room with Workshop, n. 9 (eastern alley), relating to the posticum of the *House of the Painters at Work* (Casa dei Pittori al lavoro), A and B (western alley), relating to the most recently investigated structures in the north-west area, does not yet offer certain elements for the definition of the internal divisions connected to the different properties. The possibility of a total interpenetration of the inhabited spaces within a single large building unit is not excluded.

3 STATE OF CONSERVATION OF THE SITE

The archaeological structures extend over an area of approximately 4,000 sq. m. (120 x 32.5 m) oriented with the longitudinal axis in the N / O - S / E direction. The northern limit of the insula coincides with the border of the excavation area in the vicinity of which the high archaeological finds are buried below the plateau. The same situation is to be found on the west front which is almost entirely "excavated" also in the section of the alley that laps the insula and beyond which the excavation front begins to gain altitude to reach the level of the plateau; in the northern part of the front, on the left side of the alley there is a large area partially freed from the backfill that falls within the cadastral boundaries of the insula adjacent to that of the Chastes Lovers - IX 11 - and from which 11 columns emerge - of which almost entirely buried in the back front - in stone drums covered with plaster afferent to a peristyle of a domus to date still not excavated [Fig. 3].

Simultaneously with the excavations that brought to light the insula's internal environments, even with subsequent progressive additions, the area was gradually protected with a heterogeneous system of roofs that currently cover the insula. The main roof is made with a system of pipes and joints and corrugated sheets, with a deliberately provisional character, and which over time had also been supplemented with new portions on a multidirectional provisional structure and transparent plexiglass cover. Furthermore, new structures have been connected to these roof structures to support archaeological structures in precarious static conditions. The metal gangway is also partially connected to the roof, resting on the ground in some points, which was built at the "event site" held in 2010. During this period the insula could be visited by a contingent number of tourists, following a path that did not interfere with the archaeological excavation and restoration activities, at that time in progress, but rather facilitated its vision.

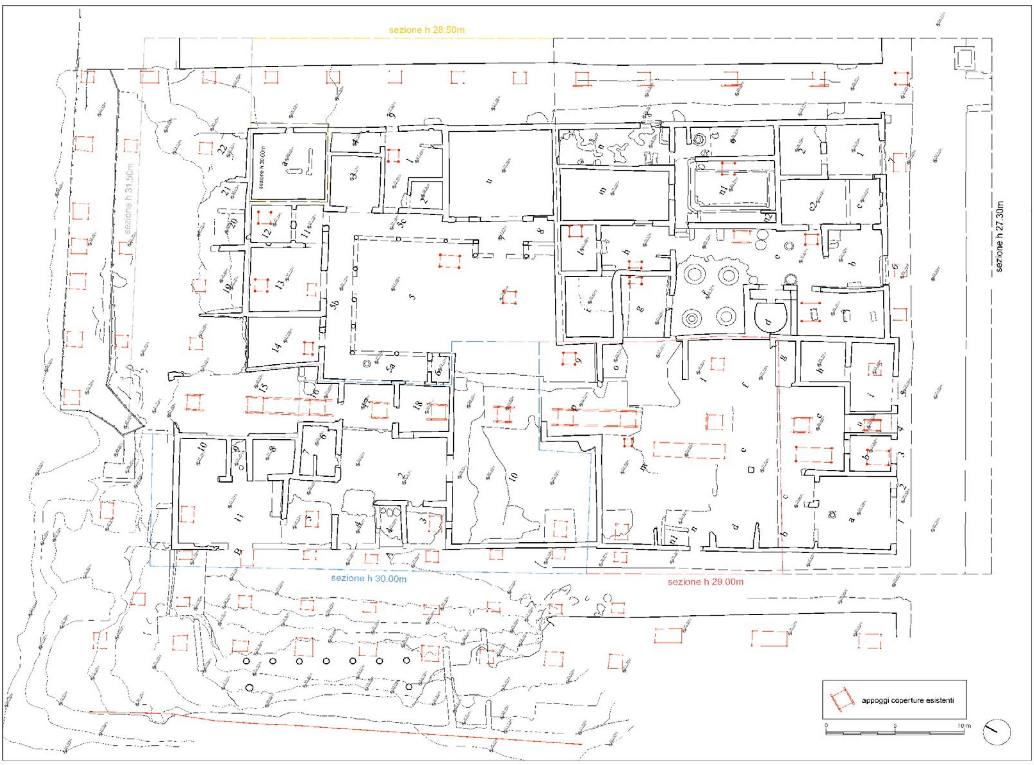


Figure 3. State of conservation of the site

Over time the roofing structures have carried out their primary task, namely that of repairing artifacts and archaeological structures, as well as the remains of *equidae* found in the stable of street number 9 from direct atmospheric agents. This function was carried out with complete satisfaction, since today it is possible to find a widespread discrete conservative state of matter. The cover also allowed the preservation of rare historical evidences in the Pompeian context, such as archaeological and geoarchaeological elements describing the eruptive dynamics of 79 AD, preserving in situ all the stratigraphy due to the dramatic intervening event.

Moreover, the evidence of human activity at that time, which specifically characterizes the Casti lovers' insula, is very well preserved, especially with regard to the restoration work in progress following the seismic event of 62 AD, of which are present sinopias in the so-called Casa dei Pittori a Lavoro, traces of lime that was prepared inside the millstones torn in the area of the pistrinum, in addition to the signs left in the ground by the vegetation of the garden of the triportico of civic 9 and of the bushes that encircled the small shrubs. Signs thanks to which it was possible, following the excavations, to carry out a work of archaeobotanical reconstruction that intended to reconstruct a verisimilar image of how the garden should appear in the past.

Naturally, since the roofing system was not designed to be permanent and, above all, due to the lack of continuous maintenance and monitoring, the structures have shown, over time, that they cannot guarantee an optimal state of preservation. if, in fact, overall the coverage has exercised a positive action of better protection and consequent conservation of the artifacts, in some cases the degradation of modern structures has rather increased some negative effects on the archaeological construction. This is the case, for example, of some dripping phenomena that occurred in correspondence with punctual infiltrations from the roof, in fact water penetrating through the sheets of the covering to the extrados of the covering structure penetrates through the constituent elements of the same transporting with it iron oxide so that in addition to the mechanical degradation due to the constant pressure of the drops of water on specific points of the underlying area, and to the degradation due to the growth of biodeteriogenic agents, the chemical effect of the iron oxide is added is found to cover elements or parts of the historicized material below the roof; this is the case of the mosaic tesserae in the "Painters at work" salon (environment u) in which there are at least four points of water fall that have ripped the mosaic tiles from their support, also covering them with iron oxide (analogous phenomena they can be found extensively below the coverage and the level of severity varies according to the artifacts they meet below, or even of episodes of excessive pressure of the metal devices on the walls or floors, such as for example in the environment 5 of civic A, or of localized degradation phenomena induced by a general absence of microclimatic monitoring in situ.

Moreover, since its assembly, the coverage is significantly invasive with a view to fruition- 54 supports with a footprint of 1 x 1m - and in many cases decidedly incompatible with the structures it intends to protect, due to the presence of supports that weigh on mosaic floors or due to thermo-hygrometric conditions that are often unsuitable, so much so as to cause, after 2010, the closure of the insula to the public.

4 THE INTERVENTION: ACTIONS AND CRITERIA

The project is based on the principles of minimal intervention, reversibility, control of impact, compatibility with the context and among materials, and "polite" possibility of distinguishing the intervention. It means, in some cases, to be able to assess, but also to surrender the fight against risks and sometimes accept to manage it also in a different but more conservative way.

The intervention and assessments can be divided and organized by themes, in order to sort out all the problems, summarized as follows:

- Design and verification of a new coverage;
- Consolidation of the boundaries of excavation;
- New archaeological excavations;
- Restoration of surfaces and walls securing;
- Accessibility and valorization of the site.

They are all closely connected to each other, not only in terms of restoration choices, but also of operational steps.

We will focus on at least three principal orders of questions linked to structural matters:

- the new construction of the roof cover and the evaluation of the impact of its structures in the archaeological site;
- the consolidation of the boundaries of excavation;
- the consolidation and the protection of the archeological walls in the site;

5 CONSIDERATIONS ON PRELIMINARY INVESTIGATION ACTIVITIES AND THE NEW ROOF COVER

Following assessments and analyses carried out on the existing roofing system (also through mechanical investigations on the pipes and joints) the criticalities of the structures that make it unsuitable to guarantee the maintenance of the conservation state balance were highlighted of archaeological artefacts. This led to the design of a new structure to replace the current coverage that will result in the positioning of n. 12 columns on plinths in c.a. of circular section in correspondence of the inner sidewalks of the two side alleys of the insula.

This is of particular relevance, as it involves archaeological strata that have never been investigated in order to define the positioning of the aforementioned plinths, and before that they perform the disassembly of the retaining elements and replace them with temporary structures that contain the archaeological structures and support the roof.

Following this choice, a diagnostic campaign was carried out in order to gain knowledge of the site according to the realization of these works.

The execution of geognostic investigations in the West Alley of the insula is conditioned by the presence of the garrison works (roof supports, contrasting props, etc.) which currently occupy, for the entire section, the first 20 meters of the alley from Via dell'Abbondanza, and that therefore should be previously disassembled also to make the transit of machinery possible for the execution of the necessary tests.

In light of this, and following the study of the construction site and the execution of the planned works it emerged that, given the specificity of the area, and the operations envisaged by the project (restoration of archaeological artefacts, re-profiling of excavation fronts and disassembly / assembly of the cover) are closely connected to each other for the following reasons:

• the consolidation and restoration of many high walls can be carried out only after the dismantling of the temporary support works;
• the elements of retention / control in many cases are connected to the existing roof structures and frequently fall on areas that are subject to archaeological excavation in the project;
• due to the peculiarity of the site it is necessary that the area is never exposed to atmospheric agents. This to safeguard different and particular presences: layers of ash and pumice as testimony of the eruptive dynamics of the event of 79 AD; the garden with the essences found in situ, to be re-proposed with an operation of archaeobotany; cover of the peristyle of number 9 with the original tiles found during excavation, subject to partial anastylosis; remains of equidae in the stable; decorated surfaces in good condition; etc.

All this does not allow that the dismantling of the supervision works for the execution of the investigations in the functional alleys to the positioning of the plinths can take place without taking into account the interconnection with these other project operations.

in fact, the specific project for the construction site had to consider these interferences, identifying phases and sub-phases of work.

Therefore, planning and design integration activities have been planned, preliminary to the execution of the works, necessary for the in-depth definition of the aspects linked to:
• the positioning of the supports of the new roof and the creation of the relative foundations;
• implementation of safety measures for archaeological structures that may have emerged following the archaeological excavation;
• restoration of surfaces and artifacts possibly emerging following the archaeological excavation;
• updating of the architectural survey and implementation of photographic documentation.

The new roof, with reduced covered surface, will be long lasting and it will help to keep the conservative balance of the site, meeting the needs of preservation and improving of the accessibility. The impact of the structure fit in harmony with the environment, in the landscape, in relationship with the neighboring buildings. The coverage is based on a metallic reticular spatial structure, with tubular rods in Steel with varied dimensions and spherical steel nodes. The geometry of the cover was designed according to the differences in heights of the site (9 meters), trying to minimize its impact. There are only 6 pillars per side, along the two streets that delimited the insula, every pillar is on a one stand round column 500 mm diameter (40 mm thickness). A capital with three arms on the top of each columns is linked to a seismic isolator (double pendulum type) which is important to dramatically reduce the seismic actions transmitted by the cover to the support and from them to the foundations which are on independent footings.

The design choices are motivated by the following advantages:
- Minimize the impact compared to columns with a rectangular section;
- Reduce the interferences with archeological structures;
- Get a better behavior in terms of absolutes and differential subsidences;
- Have a better distribution of radial tensions;
- Get a better interaction soil / foundation.

For the structural project and the design of the new roof geotechnical surveys were carried out in order to characterize the soil. These surveys included geoelectric, georadar and CPT trials.

According to italian technical norms (NTC 2008) the return period of the seismic action was defined by assuming that it is a strategic public structure in order to have the maximum of security. The cover could have a nominal life VN of more than 100 years and it has been estimated a coefficient CU = 2, that corresponds to a class of use IV. Different conditions of charges has been evaluated at the FEM by simulating the behavior of the structure. The specific model at the finite elements has been implemented in order to define the charges of the cover and dimensioning the columns and the foundations. The horizontal actions coming from earthquake are absorbed by seismic isolators (FP) double curved: this is the more rational and convenient solution considering the needing of having as less column as possible and the needing of reducing the maximum shearing and overturning moment stress from the soil to the foundations, in order to grant seismic security also in case of high medium magnitude events. The advantage is also to reduce thermal stresses on the cover The maximum stress values are not consequences of earthquake but of wind impact (pression and depression). The positioning of seismic isolator on the head of pillars has contributed to a significant reduction of the number and the size of pillars and the dimension of foundations. The punctual foundations were positioned in already existing cavities. Refined calculation permitted to limit their maximum dimensions.

The analysis of the structural behavior has been carried out by different steps concerning;
- Knowledge of the elements of the insula;
- Geometrical survey and analysis of the structural instabilities and disorders in situ with specific non invasive diagnostic;
- Evaluation of the causes of instability and study of the necessary and specific interventions to protect the elements;

The project maintains documentation of all phases of history and of the work. A complete survey has been done, keeping analytical accounts, stone by stone, and identifying tracks and materials, (architectural, archaeological and structural units with the team of technicians. Graphics and computer documentation base were used for locating analysis, project and restoration.

5 CONSOLIDATION OF THE BOUNDARIES OF EXCAVATION

5.2 The subsoil in the area

From a stratigraphic point of view, given the results of the surveys, it was possible to carry out a reconstruction of the subsoil in the Casti Amanti area, in particular, starting from the surface of the plains downwards:

• between the countryside level to a depth of 1-1.3 m: topsoil (TV);
• up to depths varying from 1.6 to 3.7 m from the ground, there are surge products from the Plinian event, consisting of thickened cinerites;
• this layer is limited inferiorly by a deposit of pumice (POMICI) constituting the pyroclastic fall of the Plinian eruption of 79 AD, and has variable power, between 4.70 and 7.20 m. The Pomici settled on the ancient city in the first phase of the Plinian eruption, so that under the Pumices in some verticals the paving of the road pavement was found, in others a level of paleosolus of strongly variable power (PAL), sometimes mixed with gravel sands in a cineritic matrix.

On the western front, in correspondence with the peristyle of the neighboring domus, partially discovered after the collapse of the cantonal border with the alley that separates the insulae XI and XII, the recognition of the materials on site is very easy, as is the identification of the stratigraphic passage from the Pomici to the closing surge.

The situation on the northern front is slightly different; the stratifications in the top part are visible following the very recent weeding operations (Riporti e Ceneri); the stratigraphic passage from the surge to the underlying Pomici is not always recognizable. These observations, together with the data obtained from the surveys carried out in 2002 made it possible to create two stratigraphic sections . [Figg. 6-7-8].

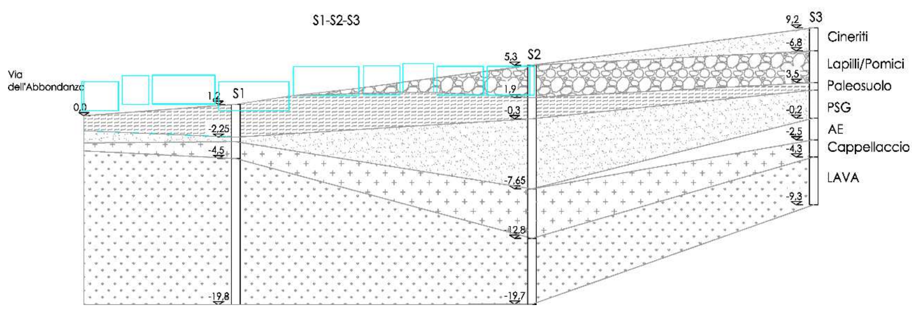


Figure 6. Stratigraphic section S1-S2-S3

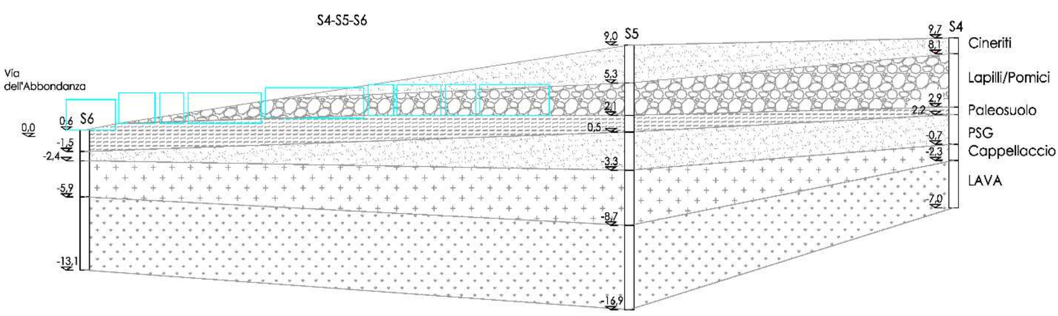


Figure 7. Stratigraphic section passing through the S4-S5-S6 surveys

Figure 8. Sections directions

5.2 Geomechanical characteristics of the land

The penetrometric tests carried out on the northern plateau in correspondence of the two avenues that delimit the insula made it possible to obtain two geomechanical profiles of the soils up to the lava bank which determined the instrumental rejection in both tests; these profiles allow to analyze the resistance to the penetration of the soils subjected to the repeated vertical pressure generated by a hammer that strikes iron rods, progressively infixed into the ground. The two geomechanical profiles have different lengths as a consequence of the different depth to which the lava is found; the comparison of the profiles with the stratigraphy deriving from the surveys carried out in 2002 and with what is visible in the sections exposed, highlighted, however, a good correlation.

5.3 Geotechnical characterization of the land involved

The geotechnical characterization of the significant volume was performed by referring to all the investigations carried out to date and the analyzes conducted in the geological and geotechnical study attached to the present project.

From the stratigraphic point of view, given the results of the surveys, we can say that the subsoil is so constituted:

• starting from the surface of the plains and up to a depth of 1.0-1.3 m, there is vegetable soil (TV);
• below, and up to depths varying from 1.6 to 3.7 m from the PC, there are surge products from the Plinian event, consisting of Ceneri (CENERI), sometimes interspersed with topsoil, so much so that not always the limit of separation between the two layers is identified; this layer is bounded inferiorly by a deposit of pumice (POMICI), constituting the pyroclastic fall of the Plinian eruption of 79 AD, and has variable power, with the height of the bed from the surface of the ground between 4.7 and 6.80 m.

The Pomici settled on the ancient city in the first phase of the Plinian eruption, so that under the Pumices in some verticals the pavement of the road pavement was found, in others a level of paleosolo of strongly variable power (PAL), sometimes mixed with gravel sands in a cineritic matrix. It should be noted in this regard that, in Regiones I and IV-V, the sequence just described is sometimes completely absent; in some survey verticals carried out in the aforementioned Regiones, in fact, up to the depth of the basalt of the ancient road axis there is a chaotic level of building materials, which includes strips of brick, masonry, and travertine, immersed in pyroclastic sands and pumiceous lapilli (Old RIP); the formation of this layer, with an absolutely chaotic structure, and mainly due to the collapses that occurred during the two phases of the Plinian event.

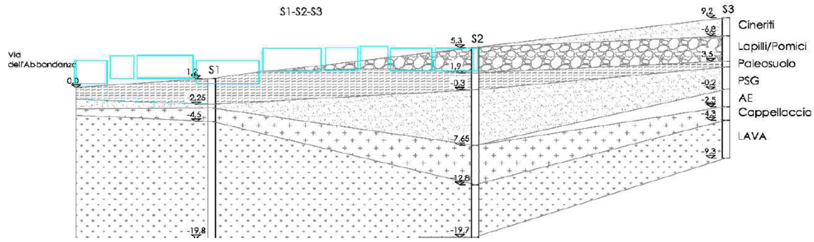


Figure 9. Stratigraphic section S1-S2-S3

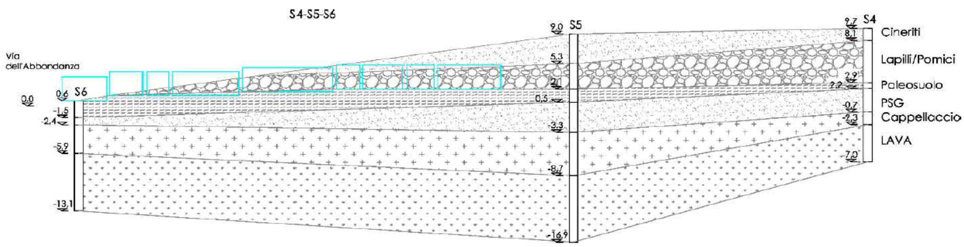


Figure 10. Stratigraphic section S4-S5-S6

The following table shows the properties of the soils deriving from laboratory tests only, integrating both the tests carried out in the Insula of the Loving Cases, and those performed in the Regiones I and IV-V:

Strato	Sigla	γ (kN/m³)	c' (kPa)	φ (°)
Terreno Vegetale	**TV**	13,6	0,0	30,0
CENERI	**CENERI**	13,2	3,5	34,0
POMICI	**POMICI**	9,0	0,0	34,1
PALEOSUOLO	**PAL**	13,1	0,0	30,0
PIROCLASTITI SG	**PSG**	14,8	1,2	32,5
CAPPELLACCIO	**Cappellaccio**	18,4	5,15	33,4
APPORTI ELUVIALI	**AE**	12,9	4,7	30,0
LAVA	**Lava**	-	-	-

Table 1. Stability analysis of excavation fronts

The methodological approach adopted in this phase is based on the assumption that in the Ashes the available cohesion is attributable, at least in part, to the phenomena of partial saturation of the slopes, and that is that is greater than the effective cohesion 'true', such as the cohesion that it can be derived from triaxial tests carried out under conditions of complete saturation.

On some samples taken from surveys carried out in the neighboring Regiones, direct cutting tests were carried out. It must be said, however, that direct cutting tests, if carried out at high speeds (in conditions, therefore, partially not drained), lead to an overestimation of the cohesive term and to an underestimation of the angle of cut resistance. There are no details on the direct cutting tests actually carried out, so it is not possible to infer in any way indications about the true cohesion of the ashes.

In any case, the cohesion (true and / or apparent) must be such as to guarantee the stability of the excavation fronts of the Regiones of the ancient city at least in the current configuration. This contribution, in part due, as mentioned, from suction, can be obtained in the case of the most unfavorable section by backward analysis, ie by varying the cohesion of the ashes until the safety coefficient of the aforementioned section is not unitary.

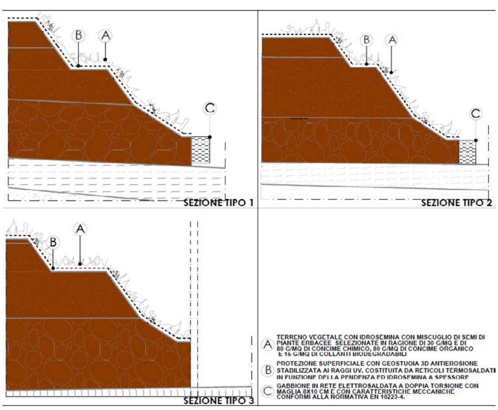
5.4 The reprofiling of the embankment

The reprofiling of the embankments was carried out taking into account first of all the heterogeneity of the subsoil constitution and, in particular, of the condition of partial saturation of the Ashes, whereby, an inclination angle of 34 ° was assumed in the stretches in which the front and consists of Pumices and 55 ° in the stretches in which the same front is formed by Ashes (or Ash / Lumps), so that the excavation volumes are reduced to a minimum.

The excavation front that currently surrounds the peristyle of the Domus belonging to Insula XI (section 2-2 'and F-F') has been opted for. This choice does not derive from stability problems of the excavation fronts, but from the desire to leave the columns of the peristyle outcropping, freeing another row, so as to provide a clear image of the peristyle of the adjacent insula and favor its visual usability beyond that improve the conservative conditions for now not controllable due to the presence of layers of incoherent layers in contact with the surface of the columns.

The need to reduce the pressure on the elevator walls on the northern and western front was also taken into account. To this end, in the case of the elevator wall present in the initial feel of the western front, which it has already suffered
a considerable downward rotation (section H-H '), the reduction of the holding height to 2.5 m was envisaged, the application of a minimum distance of 0.75 m between the internal face of the elevator wall and the edge of the slope and the re-profiling of the same slope, with a slope of 34 ° in the Pomici and of 55 ° in the Ashes.

Finally, in order to minimize the magnitude of the erosion phenomena, a row of gabions has been added at the foot of the slope; these elements, of very modest height, were positioned at a distance of 0.75 m from the edge of the escarpment and therefore do not pose executive difficulties, although their installation is expected in the Pomici.



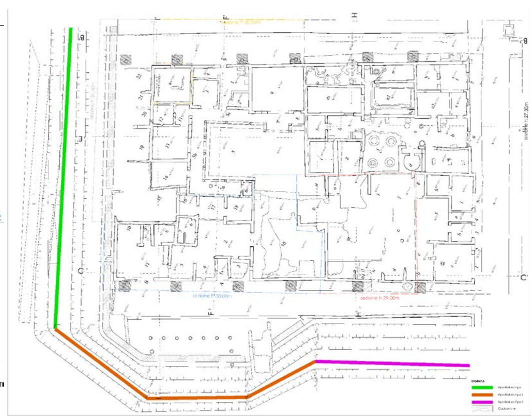


Figure 11. Design sections of the excavation fronts;
Figure 12. Plan with identification of reprofiling types

6 RESTORATION OF SURFACES AND WALLS SECURING

6.1 Analysis of the structural behavior of high walls and garrison structures

The analysis of the structural behavior of the high walls was carried out in successive phases which concerned:
- Knowledge of the building agglomeration constituting the insula;
- Geometric survey and analysis of landslides carried out with the help of specific in situ analyzes;
- Evaluation of the causes of the failure and identification of the interventions necessary for the protection of the elements;

The following pages describe the aforementioned phases, the analyzes carried out, the results obtained and the specific protection measures envisaged by the project. All the evaluations made during the analysis, as well as those that we will see later for the sizing of the protection elements where necessary, were carried out in the following fundamental hypotheses:
- The high walls no longer have a structural load-bearing function, if not that relating to stability with respect to their own weight, as they are no longer present "horizontal to bring";
- The new principals deemed necessary have been designed also in seismic conditions.

6.2 Specific surveys on walls

To acquire information also on the quality of the materials making up the high walls, a specific survey plan has been prepared with non-destructive tests:

ID TEST	DESCRIPTION	NUMBER
T	Sonic Tomography	20
S	Sonic investigation on masonry	60
PM	Penetration test on mortar	60
IQM	Wall quality index (IQM)	10
E	Endoscopy (provided only in pre-existing holes and lesions)	8
GPR-M	Georadar survey on walls, roofs and vaults	
Term	Diffused thermographic investigation	

Table 2. Tests: description and number

The sonic measurements are carried out using the direct transmission method which consists of the propagation of waves with appropriate frequency through the structure under examination. The calculated parameter is the speed of propagation of the same waves starting from the signal transit time along the path.

The sonic / ultrasonic tomography represents the natural evolution of the sonic investigation, as signals are emitted from multiple source points and acquired by multiple receiver points and arranged in such a way as to be able to carry out a high number of measurements of the transit time of the signals. In this way the tomography allows to determine the speed distribution on flat sections of the investigated object. The results obtained from the tomographic survey are returned in the form of sections in false colors representative of the variations in the speed of crossing the sound impulse. At lower velocity values (in the case, therefore, of the presence of defects or discontinuities) darker colors (dark red, brown and black) will correspond to the tomographic section; in the case of high speeds (therefore of homogeneous material) light colors (orange, yellow and white) will correspond.

The penetrometric test allows the determination of the mechanical characteristics of the mortars by reading the penetration of a steel point infixed into the mortar joint. The instrument used consists of a sclerometer to which is added on the percussion rod a steel cap capable of supporting a ferrule consisting of a steel rod with a circular section 2.5 mm in diameter with a total length of 50 mm, with a truncated cone tip at an angle of 35 °. The mechanical resistance (fc) of the mortar is determined in relation to the correspondence between the theoretical penetration resistance (fco), measured in ideal conditions with the infixion inside the mortar joint, and the average penetration value measured in situ.

The IQM is an indirect method for measuring the mechanical characteristics of the masonry, based on the analysis of the wall texture (survey of the geometrical, compositional and lithological characteristics of the masonry).

The wall quality index is distinguished according to the possible direction of the action soliciting the generic masonry panel. Therefore, for each typology there will be three wall quality indices: IQM for vertical actions, IQM for horizontal off-plane actions and IQM for horizontal actions in the plan. In the evaluation of the IQM some characteristic parameters of the correct and effective installation of the masonry come into play: the so-called parameters of the "rule of art". By observing the masonry the degree of compliance (Table 1) of each parameter of the rule of art is in fact evaluated based on some rules defined in the aforementioned literature.

EVALUATION OF THE PARAMETERS THAT DEFINE THE STATE OF THE ART	
NR	NON RESPECTED
PR	PARTIALLY RESPECTED
R	RESPECTED

Table 3. Degree of compliance with the parameters

The final result is thus made up of three values, variable between 0 and 10, associated with the type of wall and dependent on the direction of the soliciting action. Each of these values will then be associated with a "category" belonging to the masonry from A, B or C: to a category A masonry corresponds a good structural behavior; a category B masonry corresponds to a medium quality behavior; a masonry in category C shows an unsatisfactory behavior in front of the hypothesized stresses.

CATEGORIES	
A	GOOD BEHAVİOR OF THE MASONRY
B	MEDİUM QUALİTY MASONRY BEHAVİOR
C	INSUFFICIENT MASONRY BEHAVIOR

Table 4. Category of masonry

The endoscopic investigations are performed exclusively inside the existing masonry cavities to verify the homogeneity of the investigated structural element and to detect the possible presence of voids or discontinuities. The result is provided through a progressive composed of frames.

6.3 Relevant cards in the field

The knowledge phase is completed by geometric and visual surveys in the field for each of the high walls returned in the form of survey forms consisting of the following information:
• Wall identification code;
• Identification of the wall in plan
• Identification of the mechanisms of failure:
• Brief description of the wall and constituent elements (decorations, aids etc.):
• Crack pattern:

- Identification of existing props:
- Geometric survey of existing structures and graphic representation (detected crack pattern)

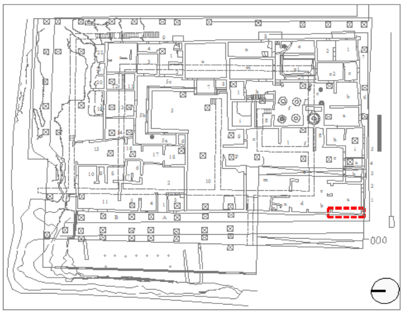


Figure 13. Wall identification

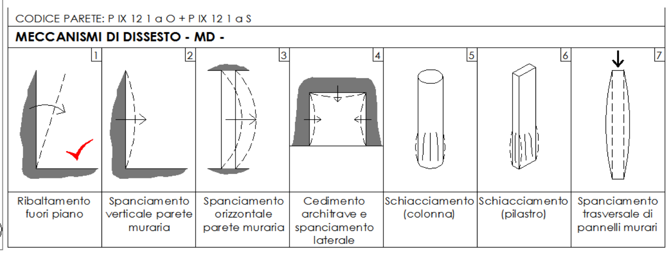


Figure 14. Mechanisms of instability

Breve descrizione: parete interessata da fenomeni di spanciamento verticale - orizzontale e ribaltamento fuori piano. Scavo per resti di equidi.	
Parete interessata da decorazioni pittoriche:	No
Ambiente interessato da pavimentazione di pregio:	No
Elemento con presidio esistente:	Si
Connesso alla copertura:	No

Figure 15. Wall description

QUADRO FESSURATIVO		
/	Lesione semplice:	Si
//	Lesione passante:	No
	Mancanza di ammorsatura:	No
C	Crollo:	No

Figure 16. Crack pattern

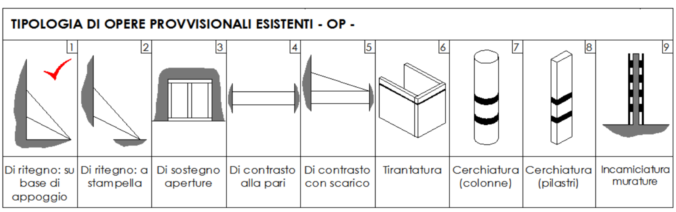
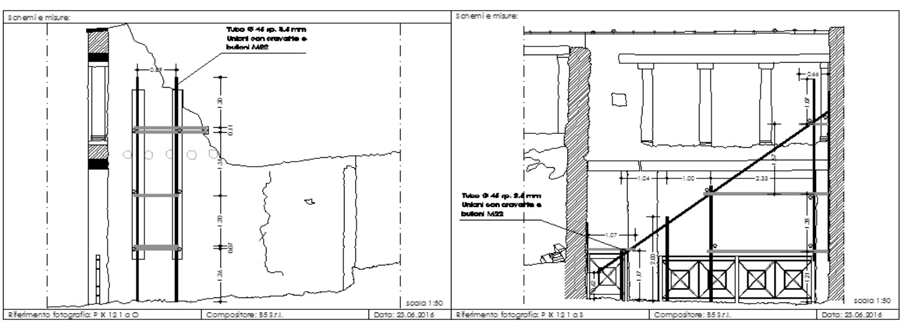


Figure 17. Tipology of exixting props



The boards so constructed were used, in one for the investigations, for the evaluation of the causes of the failure to define the safety measures.

6.4 Evaluation of the causes of the failure and identification of the interventions necessary for the protection of the elements

Once the phase of knowledge related to the present level of design was completed, the possible causes of instability were assessed and the preliminary measures were taken for the safety measures of the high walls visible to date.

From the analysis carried out, on the basis of the information known in this phase of the design, it was possible to note that the most burdensome conditions are connected to the high walls already shored up today, while, in the other cases visible to date, the analysis of the cracked pictures does not returns conditions of particular crisis.

The main causes of the failures detected are the following:
- Lack of clamping between walls and relative spines;
- Box operation not effective due to the lack of horizontal connection elements;
- "unusual" loading conditions due to the type of high walls: this condition is mainly due to the fact that, in many cases, the walls of the rooms are subject to horizontal loads due to the thrust of the "eruptive" material not yet excavated compared to to which they have a very low resistance capacity if not nothing.

The project solution must therefore resolve the aforementioned "static" criticalities but, at the same time, it must resolve other functional criticalities connected to the existing safeguards, that is:
- In many environments the existing temporary works, all in pipes and joints and wooden boards, completely invade the spaces, severely limiting their usability;
- From the analyzes carried out on the temporary works it was found that, in many cases, the bolts of the joints do not comply with the functionality checks (the tightening torques do not pass the verification). This condition is due to the fact that these temporary structures need continuous maintenance and control.

Given the peculiarity of the treated structures (archaeological site), to the considerations reported so far must be added the fundamental characteristic that the design solution must have, that is the very low impact. The implementation of an intervention that is not very invasive excludes direct operations on the high walls, especially on those already propped up that, due to the instability they present, would require important and certainly very invasive interventions. For what has been said, the design solution is oriented to a security by means of new devices that have the following characteristics:

- Low visual impact;
- Limited extension to guarantee the usability of the environments in which they are installed;
- They must consist of elements of high durability and minimize the need for maintenance.

6.5 Preliminary sizing of protection works

On the basis of the information gathered during the knowledge phase, the high walls that were the subject of the intervention were identified, among those visible today as they are not buried. In particular, it is specified that the high object of intervention are all those that already present crisis conditions (all the high walls already manned) and those for which the need to intervene according to the information gathered was assessed.

6.6 Dimensioning of the protection works in principle

The conditions most frequently detected in terms of instability are the following:
- Tilting out of plan;
- Vertical bulging of the part;
- Horizontal bulging;
- Some passing injuries and / or lack of clamping.

As for the principals, the most recurrent types can be summarized as follows:
- Shore supports with crutches resting on the ground;
- Contrasting shoring on the roof supports;
- Shoring connected to the roof.

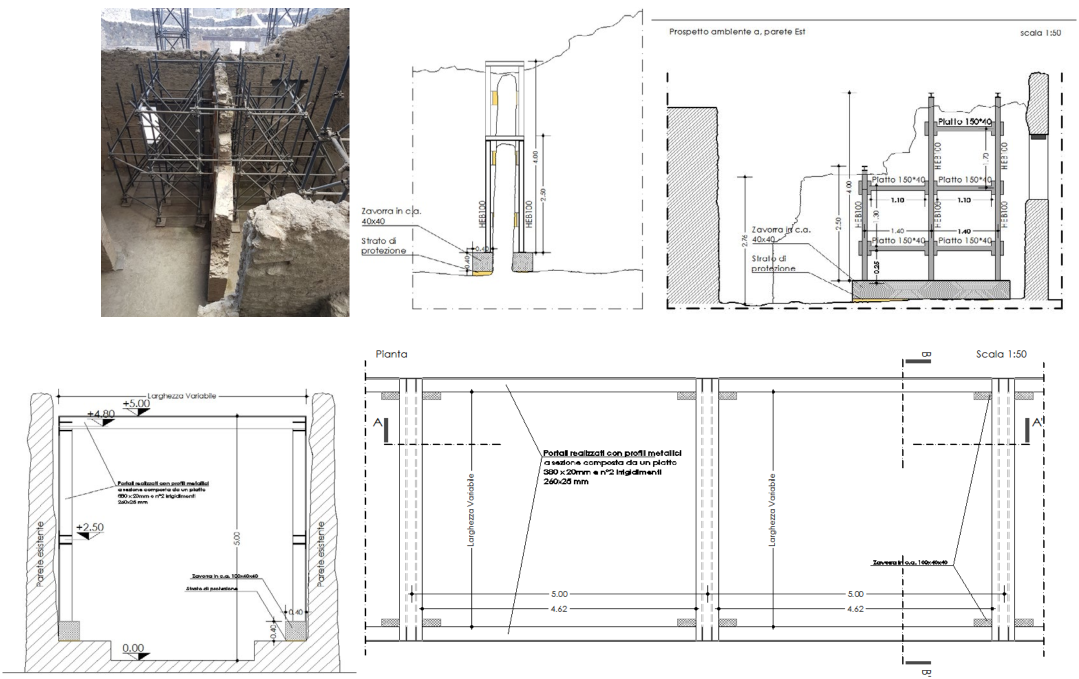
The definition of the interventions to protect the situations surrounding the high walls as well as the other interventions planned in the project.

The most common conditions are as follows:
1. High walls with non-dug eruptive material behind. Two cases fall into this category:

a. Elevated walls downstream of the excavation fronts, or areas where excavation is not foreseen (environment 10), to the rear of which only reprofiling is planned and which, therefore, in the final condition, will still have to sustain a residual thrust;
b. Elevated walls inside the rooms where the archaeological excavation is expected and that therefore, downstream of the excavation, will no longer be loaded by the push;

2. High walls affected by pictorial decorations or placed in environments with valuable flooring;
3. High walls with deformations and / or advanced instability not due to the thrust of the ground. The design solution, in addition to the characteristics already described, also takes into account the aforementioned boundary conditions and, moreover, treats the high walls as "no more structural" elements in the sense that, at present, they no longer have a structural function as they are not called to bear vertical loads in fact, in almost all of the insula, there are no horizontal elements.

Therefore the elevated are treated as elements to be supported and all the actions are transferred to the new principals that will be of No. 2 types:
- Steel frame with trestle;
- Contrast steel frame.



7 CONCLUSION

This can be considered as a scientific and cultural example on how we can try to manage with earthquake risk, or at least to keep up with it, by using different strategies and adopting all the efforts. The detailed survey gives the opportunity also to establish a chart of risk room by room, by considering different elements such as the geometries, the presence of elements of values, the structural problems. some devices were therefore adopted to improve the accessibility and the quality of the touristic visit in rooms and places that where considered "at risk" for accessibility.

Fruition and valorization are conceived in a modern way: the rooms that cannot be visited by tourists in order to prevent their destruction and to make tourists safe in case of earthquake can be

seen from a suspended pathway. The visit of the archaeological heritage allows visitors to understand more, and without any risk. The two ways are complementary. Both paths are opened to people with disabilities. A special attention has been given also to planned maintenance for the future. A 'conservation planning' corresponds to the current state of theoretic and methodological reflection: prevention and maintenance are the most effective way to transmit heritage to the future. Tangible results can be shared among international scientific communities.
it is not yet a true "risk management program":
1) trying to understand the current level of risk exposure;
2) assessing the acceptability of this risk;
3) evaluating alternative risk mitigation approaches;
4) selecting an appropriate approach;
5) implementing the approach.
We preserve and keep in order to transferring cultural contents, layers of history, structures and materials. We are conscious of being able to just slow down the relentless degradation, but not to grant an impossible- but anyway always pursued - immortality.

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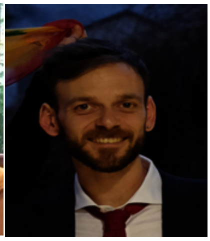
Lessons from Van Territory (step 2) Qualitative Results: Constructive Technics

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ABSTRACT

The paper will focus on the features of the vernacular architecture surveyed in Van Region (Turkey), hit by a significant earthquake in 2011. The paper aims to move further on the discussion about strategies for future interventions, arguing that some of them could be deduced from vernacular architecture lessons.

This second step of the research will describe the qualitative results of the research, carried through the tools explained in the 'kerpic '16' conference; the objective of the field research was, primarily, to verify the effective persistence of a multiplicity of earthen building traces that testify nowadays the spread presence of technological knowledge suitable to answer to the housing needs of the population.

The survey and the description of 50 houses, is functional to the comprehension of proper building technologies aiming to their operative re-proposition and, at the same time, to the transmission of the regional constructive culture, tangible expression of the memory of this territory.

Thanks to the interview carried to the inhabitants and builders, it has been possible to gather information about the mixture for blocks and its process of aging, the quality of the mortar, the foundations building method and all of the expedients in the construction process.

The information collected during the field research allowed to provide a comprehensive catalogue where it is possible to systematically identify specific features and recognize recurrences and similarities between the buildings. According to this observation, different Abacus for the structural elements has been elaborated and reported in the research results.

Keywords: Adobe; Van; Technics; Vernacular Architecture; Classification;

1 INTRODUCTION

In the last two decades vernacular architecture became an important field of research in order to recognize settlements constructive rules and to develop strategies in order to deal with the contemporary issues on building environments.

The meaning of "vernacular architecture" is "buildings in indigenous styles constructed from locally available materials following traditional building practices and patterns and not architect designed". It is developed by the stratification of transformations along the history, in order to answer to different and changeable community needs [1]. This stratification still enriches the identity of territory because it represents a whole of processes that brought humanity to develop knowledge through virtuous practices. Indeed, this stratification is part of the memory of the territory [2], especially concerning its material and tangible heritage.

In this framework, the paper will focus on the features of the vernacular architecture surveyed in a specific territory, Van Region (Turkey), hit by a significant earthquake in 2011 and characterized by the presence of an evident majority of Kurdish population. The paper aims to move further on the discussion about strategies for future interventions, supposing and arguing that some of them could be deduced from vernacular architecture lessons. In fact the resilient character of vernacular architecture, later described, can suggests interesting ideas in order approach to the reconstruction process during and after an emergency state, as the occurrence of an earthquake. In Italy, for example, it is interesting to highlight the experience of Ced. Terra in the Chieti province after the Abruzzo earthquake.

The research has started with the analyses of many reports and studies carried out in Van region, in Turkey, by different research groups after the last destructive earthquake. Most of them were related to the description of unreinforced masonry buildings behaviour during the Van earthquake in 2011: the high level damages occurred on masonry building induced many survey campaigns especially in the most wounded Erciş, Muradiye provinces and in the city of Van [3]. After the reports analyses, the research proceed with a month of field research (August 2016) in order to verify the effective persistence of a multiplicity of earthen building traces that testifies nowadays the spread presence of a technological knowledge suitable to answer the population's housing needs. The survey was carried on 50 houses and it represents an essential step for the comprehension of proper building technologies aiming to their operative re-proposition and, at the same time, to the transmission of the regional constructive culture, tangible expression of the building identity of this territory.

The research also aims to classify an adequate number of buildings in order to develop some considerations about building typologies and regional housing culture. The availability of the inhabitants, the hospitality, rarely neglected to the authors, allows describing the internal distribution of the spaces, to observe the uses of internal, bordering and external spaces, to compare aesthetic and functional recurring characteristic and to collect tales and knowledge.

The paper will then debate about the Eastern Anatolian region as a case study, methods and tools used to carry out the field research and with the report of the different results: structural and technological features of the surveyed buildings and some considerations about the regional housing culture. The paper highlights the technologies that behaved better and considers the structures that survived to the test of time as a clear sign of 'rules of thumb' and well done structures.

2 FIELD RESEARCH

The field research is a cognitive practice of places direct experience, based on observation and interviews. Concerning rural and urban settlements, as material expression of relationships in between men and with the surroundings environment, the direct experience of places provides essential data for an aware territorial framework and social-cultural context.

The observations of existing structures, of their damages due to the passing of time, to the abandonment or to extraordinary traumatic events as the recurring earthquakes, from whom the region is interested, provides many extremely important technological informations.

At the same time, interviews to inhabitants and builders represent a direct testimony about technological characteristics and functions of the buildings. Every meeting, tale or explication is part of the oral history of a place and contributes to the development of a more conscious point of view, necessary to advance hypothesis and to imagine coherent answers. The research has been implemented walking, crossing places and sharing time with their inhabitants.

2.1 Methods and tools

As the research was particularly focused in surveys of constructions technologies and analyses of the housing culture, has been necessary to provide a support that allows to systemically organize a large number of information related to every analyzed building. For this reason a specific form has been elaborated in order to collect and synthesize the data that could have been significant for the aim: the definition of the "rules-of-tombs" from the structural and architectural point of view that characterize the vernacular architecture of Van Region.

The form, was based on the model of the AeDES one [4], elaborated by Italian Civil Protection in order to carry the first level emergency assessment of damages due to earthquakes events and adapted to the expected results of the research.

The form consists in different parts: first, the general identification of the building, its surroundings and the urban contest, then, the building would be describe in its structural and no-structural parts, with a specific focus on those features that reduce the seismic vulnerability as the anti-seismic presides or the building characteristics of regularity in plan, elevation and others. The form is adoptable for the survey of any kind of masonry building according to the masonry types (cooked bricks, adobe, concrete block) and function (dwellings, schools, commercial buildings, monuments...) and, thanks to some additional spaces, it is possible to take notes concerning unpredictable information, to draw particular details or schematic sketches of unusual technologies (this matter refers and it is deeply explained in the paper 'Lessons from Van territory: step 1')[5]

To complete the form is recommended to carry up interviews to inhabitants in order to obtain information which are not directly obtainable through observation such as the construction year, internal stratification of constructive elements, maintenance and transformation interventions, but also the internal distribution of rooms and the function of different spaces.

All of the considerations gathered thanks to the surveys of the 50 buildings and the interviews, has been organized in 50 schedules divided in three columns 'Fig.1':
- the left one concern the geographical identification and the general description of the building. Then, the structure is analyzed providing specific descriptions of macro-elements characteristics (foundation, masonry, floors, roof), specific considerations about the regularity features, and the presence of the anti-seismic presides;
- in the right column, is provided a general descriptive picture of the building in order to represent the aesthetical features of the building and its plan, useful to describe the different functions of the building spaces. The different colors of the walls, reported in the plan, explain also the different building material (stones, mud bricks, concrete blocks);
- the central column is more specific and different for each building: concerning all the data collected through the interviews and the impressions due to the direct observation of the element's qualities and the ir state of maintenance, are here reported particular transformations, specific structural problems like cracks, failing of material or disconnections, and the particular finishing details, plasters and decorations.

3 APPLICATION AND RESULTS IN THE CONSTRUCTIVE TECHNOLOGY

According to the 3.3 paragraph, Van region is one of the most dangerous zones according to the earthquake risks (fig.11) and it is now important to underline that the surveyed houses present an average age around 50 years old. This means that most of them, have been hit and resisted at least to three or four important seismic events and to dozens of smaller activities. It is also important to remember that these 50 houses are just a small part of the existing adobe buildings that the authors

saw during the field research, and really few examples in respect to all the adobe buildings present in the region.
Thanks to the interview carried to the inhabitants and builders, it has been possible to gather informations about the mixture for blocks and its process of aging, the quality of the mortar, the foundations building method, all of the expedients in the construction process, until the waterproofing of the roof and the disposition of the channels.

N° form 29 Data 03.09.2016

Collected data		State and maintenance
Identification		
Region	Van	
Province	Gevaş	
Locality	Selimiye Mh.	
Description		
Position	isolated	
N° of storeys	2	
N° of basements	1	
Average storey h	3 m	The building is abbandonaed since 2013.
Average storey m²	121 m²	
Age of building	> 50 years	
Use	residential	
Foundations		
Site morphology	mild slope	Regular stone foundations, generally in good conditions.
Structural material	stone	
Typology	countinuous	
Masonry		
Structural material	adobe/stone	Mansonry seems to have been disposed in different periods. Generally is not in good condition. It present some vertical cracks on the south facade and some widespred falling of material just under the roof level.
Average thickness	~60 cm	
Typology	type I	
Floors		
Structural material	wood	
Typology	no survey	
Roof		
Structural material	wood	In bad condition with widespread vegetation on all his surface. and some out of his plane behaviour because of the falling material of walls.
Typology	type I	
Regularity		
Plane	no	
Elevation	no	
Openings	yes	
Anti-seismic presides		
Floor-wall link	yes	Existing but bad floor-wall connections. Is possible to see some s.r. but they are not continuous, is not possible to uderstand if they are efficent.
Structural rings	no	

Plan and picture

Figure 1. Resume schedule, provided on for each house

The information collected during the field research allowed to provide a comprehensive catalogue where it is possible to systematically identify specific features and recognize recurrences and similarities between the buildings. Along the research has been recognized the repetition of similar constructive choices regarding the masonry disposition, the floors and the roof technologies. According to this observations, different Abacus for the structural elements has been elaborated and reported in the research results.

Concerning the vertical structural elements, it has been recognize a general recurrence of 60 cm thickness for the wall sections (just few cases are 50 cm) reached through the combination of 3 different types of mud-bricks sizes and arrangement. These combinations are reported in the Masonry Abacus 'Fig.2' with the dimensions of the blocks, the plan and section disposition drawings. The 60 cm thickness is suitable to guarantee an internal climatic comfort both in the hot and in the cold period thanks to the excellent thermal-mass property of such a thick earthen wall. Is important to notice that most of the masonry walls that were surveyed presented good connections between the bricks.

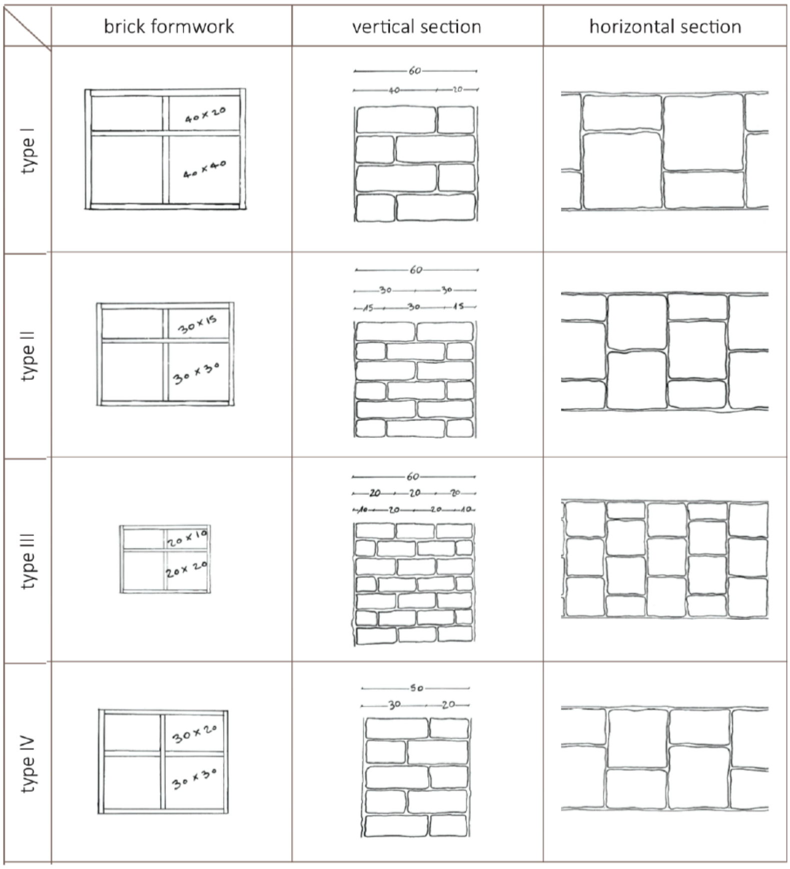

Figure 2. Masonry abacus

The 'Floors Abacus' contains three kinds of constructive technologies. All of them are structurally made by wooden beams and they differ according to the secondary spanning choices. All of them are here analyzed in their different layers and considering the opportunity to provide different finishing touches. Beams and also the other wooden layers are made using the popular tree (kavak), largely widespread in the region, in the places where there is not an evident deforestation process. The floor types are 'Fig.3':

- Type I: it is composed of a primary layer of circular wooden beams, with a interaxel spacing between 50 and 70 cm. The diameter of each beam was observed between 12 and 25 cm. The secondary layer is composed by wooden boards, which cover totally the area over the beams. It is a really regular spanning, the usual dimension of the boards is 200x30x5 cm. The third level is the finishing touch, which can be done with a mixture of humid earth posed on a layer of canniccio and pressed with a stone ruller. The thickness is around 5 cm. It is also possible to find cement finishing touch, 2-3 cm thick, or without a finishing touch;
- Type II: the primary spanning is the same of the first type, the secondary spanning is composed by irregular wooden boards. It covers totally the area over the beams. The wider dimension of the slices can vary between 25 and 10 cm instead the thickness can change between 3 and 5 cm, Sometimes it can be disposed even on two levels. The finishing touch is the same of the first type.

Type III: the primary spanning is composed by wooden beams with an interaxel between 60 and 80 cm, as the two other typologies the diameters of each beam it can change between 12 and 25 cm. The secondary spanning is composed by wooden branches. They cover totally the area over the beams. It is an irregular spanning, the diameter of each element is not less then 3 cm, sometimes disposed on two levels. The finishing touch can be similar to the other typologies, but is also possible to find cement finishing touch, 2-3 cm thick

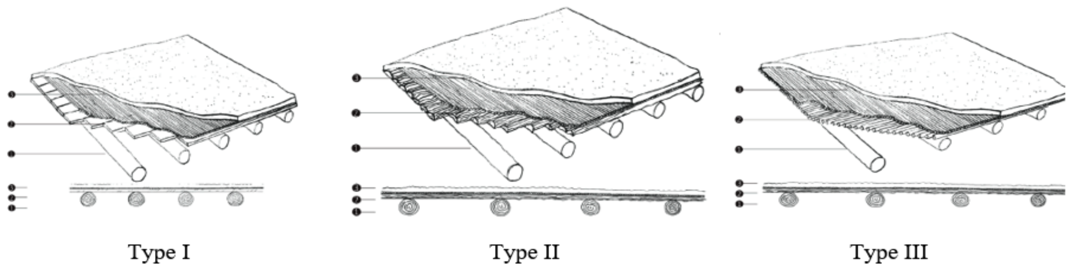

Figure 3. Floor abacus

Concerning roofs, it is firstly important to report that most of the buildings, quite all of them, presented the traditional flat roof (type I) until 10-15 years ago. Then, because of the maintenance process that these kinds of roofs require and because of the snow in winter, many surveyed buildings now present metal sheet, shaped differently according to the plan dimensions and the inhabitant personal choices. All of them are reported in the Roof Abacus 'Fig.4' with some indications and it is interesting to highlight that, also if metal sheet is later added, the earthen finishing (at least of 5-10 cm) disposes over the last floor, is continuing to provide the thermal comfort expected by the people used to the 20-25 cm traditional heavy roof.

- Type I: The primary and secondary spanning of this typology of roof can be either the same of the I, II or III type of floor. Finishing touch instead is composed by a layer of canniccio covered with 20-30 cm of humid mixture. The mixture includes earth and straw. Is also possible to find some small rocks in the mixture and usually last layer is mixed even with salt. Is pressed with stone ruler and drainpipes are disposed following water groove after the first raining day.
- Type II (one slope): the primary spanning is sustained from supports, one side by a wall in adobe or piriket masonry, on the other side is connected to a structural ring disposed over the last floor level In between of them wooden columns are disposed every 60-100 cm in the direction of primary spanning. The primary spanning is composed by wooden beams lying down on walls wood sustains If one or more extra sustain lines are placed in between the two edges, the p.s. is also placed on them. Beams can have the natural circular shape,10-15 cm of diameter, or rectangular shape in between 10x10 and 20x20 cm. Their interaxle is approximately 2-3 m. The secondary spanning is composed by wooden beams, disposed perpendicularly to the primary one. Beams can have the natural circular shape, 7-10 cm of diameter, or rectangular shape in between 5x10 and 10x15 cm. The interaxle between them is approximately 60-100 cm. The third spanning is composed by wooden beams, disposed perpendicularly to the secondary one. Beams can have the natural circular shape, 4-7 cm of diameter, or rectangular shape in between 5x5 and 5x10 cm. the interaxle between them is approximately 50-80 cm. The finishing touch: the covering layer is an undulating metal sheet. All the connections are guarantee by nails.
- Type III (two slopes): the supports are wooden columns, they are disposed along the central axel of the house every 60- 100 cm. They sustain the primary spanning giving the inclination to the roof. If the span between the edges is more then 5-6 m is necessary to add other lines of supports. The primary, secondary, third and final spanning are really similar to the type II roof form.
- Type IV (four slopes):The supports are wooden column and they sustain the primary spanning every 60-100 cm. The primary spanning is composed by wooden beams, disposed in

concentric rings and on the diagonals of the roof. The number of rings it depend on the area of the roof, the distance between them is approximately 1.5-2 m, with different height to give inclination to the roof. Diagonal beams are connected to the rings from the centre to the edges of the roof. Beams can have the natural circular shape,10-15 cm of diameter, or rectangular shape in between 10x10 and 20x20 cm. Concerning the second, thirth and the final spanning, they are similar to the type II or III.

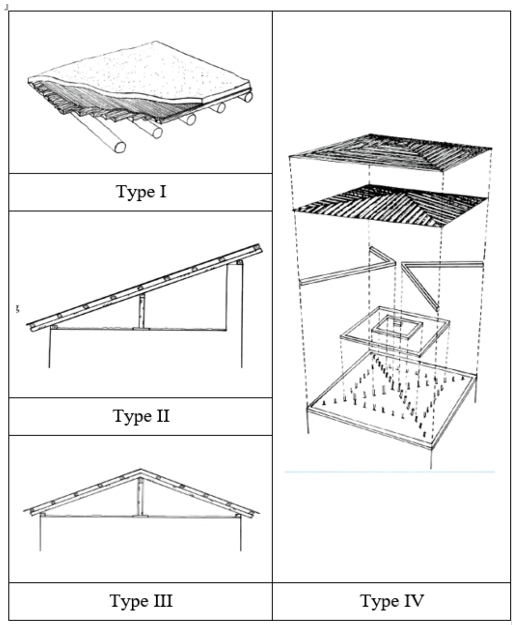

Figure 4. Roof abacus

Concerning the anti-seismic presides, it was possible to observe different types of connections between bricks (ammorsamento), often well done. One of the most interesting technological element observed during the field research are the wooden ring beams (hattıl) largely widespread all around the region as an important seismic preside. The element, made by two small (5x5 – 10x10) wooden beams, follows the plan section all around the building walls. The two parts are connected each other by wooden sticks placed every 40-50 cm.

The empty parts are filled with the same earthen mixture used for the blocks, until to reach the wood level in order to continue the blocks courses 'Fig.5'.

These wooden ring beams are always placed at the floor levels and they work also as connection between the wall and the beams of the floor, through nails and wire (fig.15). This element performs as contribution to the structural box behavior of the building, a very important characteristic for the masonry buildings stressed by seismic events, allowing to avoid out-of.plane response of the wall that cause sudden collapses of walls.
Often, the hattıl are also placed over and under the windows level in order to avoid structural problems like walls spanciamento and bad performances of walls connections during the earthquakes.

During the field research it has been observed an interesting case in which, together with the wooden beams, over them is placed a thick layer of stones (fig.16).

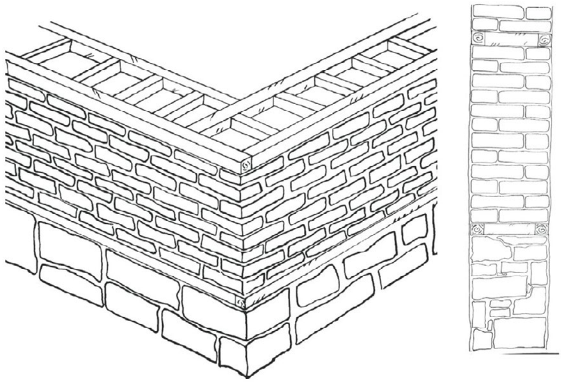

Figure 5. Wooden beams, seismic preside

4 CONCLUSIONS

Exclusively thanks to the direct places experience, it has been possible to acquire essential information in order to frame the socio-political contest and a constructive culture reach of interesting project sparks. The survey of the 50 buildings allowed to deeply investigate the adobe technologies features, largely widespread and still used in the Upper Mesopotamian region to answer the natural housing needs of the people.

The observation of existing structures and their damages due to the passing of time, abandonment or traumatic events which interest the area, such as the recurring earthquakes, is extremely important for technical information. The results reported in the technological abacus, allow recognizing particular constructive techniques, strongly connected to the locally available materials, and their specific features according to the seismic character of the region.
Every meeting, tale or explication is part of the oral history of a place and contributes to the development of a more conscious point of view, necessary to advance hypothesis and to imagine coherent answers for people settling needs.

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Adobe Houses, Fethiye Application of Wood Bagdadi Technique and Adobe Structure

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ABSTRACT

Boredom of people's urban lifestyle and reinforced concrete structures leads them to spend their holiday time at least in rural areas by experiencing the rural lifestyle relatively. The desire of the visitors participating in tourism to have a different experience than usual, to discover new things and to see the different one increases the importance given to rural tourism types and ecological life experiences. In nature, instead of reinforced concrete, nature-friendly materials such as adobe, stone and wood are known to be healthier. Staying in accommodation units made of environmentally friendly materials, which are known to be healthier, may be the reason of choice. The Adobe Houses, which were studied within the scope of this study, were built in the rural area of Yanıklar Village of Fethiye District, in the middle of agricultural lands. It is an ideal example that tourism can be done without disturbing the nature. Earthen architecture is a cost-effective, environmentally friendly alternative to modern building materials and all related methods, techniques and applications in general. In the Adobe Houses, the earthen architecture was built with a system called “kerpicarme” by the architect, inspired by the traditional hımıs-bagdadi technique and by pouring adobe into the wooden frame and bagdadi technique built structure. The aim is to propose a timber frame, hımıs-bagdadi technique wood and adobe system that can be implemented in rural Turkey which can be produced with local wood material, local soil, sand, straw, clay and simple craftsmanship at a low cost. And no need for a high-quality adobe.

Keywords: Rural Tourism Accomodation Units, Adobe House, Hımıs-Bagdadi technique

1 INTRODUCTION

Boredom of people's urban lifestyle and reinforced concrete structures leads them to spend their holiday time at least in rural areas by experiencing the rural lifestyle relatively. The desire of the visitors participating in tourism to have a different experience than usual, to discover new things and to see the different one increases the importance given to rural tourism types and ecological life experiences. In nature, instead of reinforced concrete, nature-friendly materials such as adobe, stone and wood are known to be healthier. Staying in accommodation units made of environmentally friendly materials, which are known to be healthier, may be the reason of choice. Today, rapidly developing rural tourism; It creates a new opportunity for tourists who want to escape from crowded tourism centers and relax by seeing the historical, cultural and natural beauties of the rural areas, as well as a new strategy for strengthening the economic structure in rural areas. In a world where heating / cooling based on fossil fuels has become the norm and where locally sourced natural materials are neglected, the desire to stay in natural structures is a health conscious and environmentalist approach. In the service phase of tourism architecture, it is necessary to consider these facts. Fethiye is a district of Muğla Province in the Aegean Region. It is a destination that is attracted by both foreign tourists and local tourists. The economy of Fethiye is basically based on two main sectors. These are tourism, agriculture and animal husbandry sectors respectively.

Fethiye, 166.100 hectares of forest area is a district where natural attractions are preserved. The fact that it is not completely dependent on tourism compared to other destinations allows local people to engage in their own business (greenhouse, agriculture, animal husbandry) as well as tourism. This aspect of Fethiye allows the application of different types of tourism than the types of tourism that are commonly seen in many destinations (URL[1]). The Adobe Houses, which were discussed in this study, were built in the middle of the agricultural lands in Yanıklar Village of Fethiye District. It is an ideal example that tourism can be done without disturbing the nature. It is located 15 km away from Fethiye city center, in only two places in the world, in the southwest Aegean and Canada, in an area where natural healing air conditioning trees, frankincense (sıgla) trees are distributed. It is located in a quiet area covered with pine forests on one side and citrus groves on the other. In the vicinity, there are opportunities for underwater diving, para sailing, rowing, canoeing, rafting, horseback hiking, and nature sports such as trekking on the ancient Lycian Way of Fethiye (URL[2]).

Earthen architecture, which has also been utilized in these Adobe Houses, is an alternative, cost-effective, environmentally friendly method to modern building materials and all related methods, techniques and applications in general. Earthen architecture is seen today as an alternative construction method that includes modernized designs and various materials inspired by modern techniques and technologies and traditional systems [12]. For various reasons, their use is limited to certain building types, sizes and geographical areas in our country. In addition, a fact that should not be ignored and which should be taken into consideration in all building construction processes is that according to the "Earthquake Zones Map prepared in 1996, Muğla Province is located in the first degree in a large area and in the second degree in a very small area [14].

2 MATERIALS AND METHODS

The scope of this study consists of Adobe Houses accommodation facility which has 10 rooms and a restaurant in 6 blocks in Fethiye Yanıklar Village rural area, which is inspired by the traditional Hımıs-Bagdadi technique and is built with pouring adobe into the wooden structure system in place. This construction system has been named "Kerpicarme" by its architect Ahmet Kizen, who has many years of experience in construction with natural building materials. In the research, a two-stage method consisting of literature and field research was designed. In the literature research stage of the method; the concepts of rural tourism and rural areas have been researched and the use of wood and earth as a building material, wooden structure carrier systems, rustic (hımıs) construction techniques and bagdadi plaster technique have been examined. Architect Ahmet Kizen photograph archive was examined and visual information about the construction phase of the buildings was obtained. For the current situation, the adobe houses website was used. In the field research section of the study, accommodation units were examined on-site and a detailed interview was made with architect Ahmet Kizen. According to the findings, the construction of the Adobe Houses with wooden construction system which is experienced in earthquake resistance in Fethiye, which is the first degree earthquake zone, is tried to be explained. The aim is to propose a timber frame, rustic-bagdadi technique wood and adobe system that can be implemented in rural Turkey which can be produced with local wood material, local soil, sand, straw, clay and simple craftsmanship at a low cost. And no need for a high quality adobe.

3 RURAL TOURISM

Particularly, the desire to escape from the monotonous working environment and the increased leisure time have led people who are overwhelmed by the boringness and stress of urban life to move away from their lifestyles [5][15]. As a temporary alternative to standardized lifestyles, rural tourism, which is one of the most important tourism types addressing these needs of people, has become more prominent today. The concept of rural area, which is defined as the main field used in the realization of rural tourism, is stated in the SPO Ninth Development Plan Rural Development Report; life and economic activities depend to a great extent on the use and utilization of natural resources, economic, social and cultural development processes are progressing slowly, traditional values are effective in shaping life, face-to-face relationships remain important, technological developments take a longer time to reflect on life and production, socio-economic characteristics are defined as spaces outside urban areas [5][8].

Rural tourism is a type of tourism that is intertwined with rural settlements and based on natural resources. Rural tourism, as well as adopting the protection of both nature and local culture, it has the characteristics of contributing to rural development, providing additional income to local people, preventing internal migration and supporting the survival of cultural heritage [7]. It is possible to provide an additional income and increase their welfare by using the natural, socio-cultural and historical values of the region for tourism purposes without leaving the agriculture, which is the main occupation of the farmers, especially in areas where agricultural activities are intense [5].

Kerpicevler (Adobe Houses), which is our subject, is accomodation facilities that serves in rral tourism in the rural area of Yanıklar village in Fethiye. In the vicinity, there are opportunities for underwater diving, para sailing, rowing, canoeing, rafting, horseback hiking, and nature sports such as trekking on the ancient Lycian Way of Fethiye. It is also preferred for Yoga and Meditation camps.

4 TRADITIONAL WOODEN STRUCTURE

Adobe Houses (Kerpicevler) accommodation facility buildings architecture, inspired by the traditional Hımıs-Bagdadi technique, built with pouring adobe into the wooden structure system in place.

Wood is one of the oldest building materials in the world and its applications have continued until today. Although consistently applied in developed countries, the implementation of these structures in Turkey, there has been an interruption in nearly forty years. However, in our country where almost all of its lands are earthquake zones, it is very important for our people's life safety and national economy to re-evaluate the wooden structures in terms of architecture and carrier system and to present them as an option [10].

Traditional wood frame construction technique, Turkey's earthquake risk is concentrated in the northern and western Anatolia, have been widely applied in Marmara Region and the northern part of Central Anatolia. These structures, which are formed by filling or covering the gaps between the wooden frame (skeleton) and the posts and beams forming it, are classified as hımıs, bagdadi and wood veneer. Structures formed by filling adobe or bricks between the wooden skeleton built on a stone foundation; "hımıs", the wooden skeleton was plastered with a 2-3 cm wide slat and the plasters were "bagdadi" [11], structures that are formed by covering the skeleton with wood from the outside and plastering over the inner bagdadi and left empty between the inner and outer coating are also defined as "wood coated" systems [1].

The earliest examples of residential structures with timber-framed construction technique in Turkey dates back to the seventeenth century. The construction of the wooden-framed housing continued extensively until the first quarter of the twentieth century. After the 1940s, this tradition continued to be limited in rural areas [1].

In some studies, wood carcass systems are also classified according to skeletal system types;
The Figure 1. shows the wooden frame types [2][3].

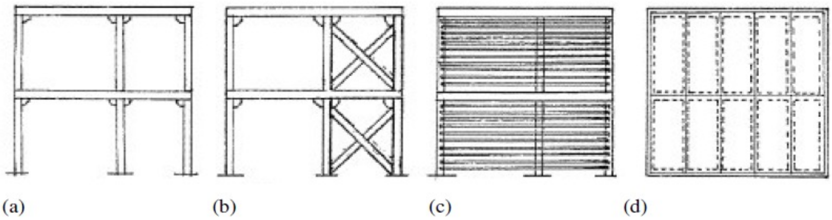

Figure 1. Wooden Structure Systems [2][3].

a) Traditional wooden carcass carrying only vertical load
b) Traditional wooden carcass reinforced with diagonals against horizontal earthquake loads
c) Traditional wood reinforced with frequent wooden slats against horizontal earthquake loads
d) Frequent spacers and plywood coated surfaces - American timber carcass

Different types of structural systems have been applied depending on the conditions of the region and the knowledge and skills of the masters, especially in traditionally constructed wooden structures. Therefore, it is possible to classify them in different ways in terms of architecture and bearing. Here, wooden structures are classified as follows, depending on the load bearing systems used in the walls and how they work under the influence of load:

• Wooden structures consisting of structural system logs,
• Wooden structures without curved elements in the carrier system,
• Wooden structures with inclined elements in the carrier system,
• Wooden structures reinforced with horizontal slats (bagdadi),
• Wooden structures with panel walls in the carrier system [10].

4.1 Hımıs Building
The Hımıs Building, which occupies an important place in our cultural building stock, is the structure consisting of the placing of various materials as fillers in wooden carcass structures. The carrier system material is wood. Different materials were used as filling materials, and these different materials revealed different types of rustic (hımıs) structures [2][9].

Branch and Mud Filled Hımıs Structures: In this system, tree branches are knitted in the form of basket weave between vertical carcass elements. The two sides are then plastered with mud. It is widely used in creek and river valleys.
Stone Filled Hımıs Structures: It is formed by hand filling the stone between the wooden frame. Usually sludge is used as binder.
Brick Filled Hımıs Structures: It is formed by placing bricks obliquely or straight into the wooden frame. Especially in the Marmara region, North Anatolia and Black Sea regions and rarely in Central Anatolia around Ankara.
Adobe Filled Hımıs Structures: These are the structures formed by using adobe blocks as filling material inside the wooden frame [2][9].

It was observed that the hımıs structures which were formed by filling the wooden skeleton in compliance with the construction rules, survived in 1999 Adapazarı and Düzce earthquakes due to the ductility of the wooden skeleton and the good energy dissipation and the energy absorption feature brought to the system by the adobe blocks used as filling [3].

The main subject of this study is the Fethiye Adobe Houses, which are built with pouring adobe into the wooden structures reinforced with horizontal slats (bagdadi), inspired by traditional bagdadi technique.

4.2 Timber Frame (Bagdadi) Building

It is a type of wood carcass structure consisting of walls made of filled brick, tile or mud mortar between the frame system formed by carrier wood, columns and beams and covered with wooden slats from inside and outside (URL[3]). On existing or new constructions, 20 * 20 mm or 25 * 15 mm cross-sectioned slats are punched and the plasters made on these slatted parts are called bagdadi plastering. Such plasters are known as masonry construction wall mortar and plaster of the old Seljuk period. It is a plaster made by adding clay, water, sand, lime, grass, garbage, straw, brick crumbs and egg whites in certain proportions [9]. By the slats on the wooden posts, it is ensured that the filler and frame move together.

At the Kocaeli Earthquake Symposium in 2005, after the 1970 Gediz-Kütahya earthquake, the hımıs and bagdadi structures in the region were generally seen as good behaviors during the earthquake damage. It was stated that these structures, which were formed by filling mudbricks and bricks, survived the earthquake with less damage compared to other structures by the energy absorption feature [10]. It has been reported that many houses built in bagdadi were found to have suffered the earthquake with little damage [10]. Although the hımıs structures are heavier than those of the bagdadi type structures, they eliminate these disadvantages by the rigidity of the filling applied into the frame. Particularly under the effect of earthquake, the frame system moves with the filled wall, as a result of which the bearing strength and stiffness is much more negligible than the empty frame.

5 ADOBE CONSTRUCTION SYSTEMS IN OUR COUNTRY

In our country, adobe building systems are generally divided into two types: solid adobe building systems and light adobe building systems [2][6].

5.1 Solid Adobe Building System

• **Construction system with adobe blocks;** It is the system where the dried adobe blocks prepared at the building site form the building walls, the walls serve as carriers, and these walls are connected to each other with wooden beams at certain intervals.
• **Forging adobe constructing system;** Mostly used in the construction of garden walls, temporary bag houses, mudbrick sludge prepared in certain sizes, the system formed by pouring between the molds to form the wall.
• **Masonry mudbrick construction system;** It is a system used in the construction of simple garden walls and sets rather than housing construction, consisting of overlapping the clusters taken from a vague heap.
• **Mixed adobe construction system;** Although not very common, it is a system that is used as a mixture of all other systems, used in the construction of temporary settlements and its sample is not very common today [2][6].

5.2 Lightweight Adobe Construction System (Hımıs Construction)

• **Adobe block filled construction system;** It is a construction system where the gaps formed after wood carcass are filled with adobe blocks formed separately.
• **Construction system with cast adobe filling**; It is a system in which the carcass spaces are attached to vertical wooden elements connected from the top and bottom, the cages are formed horizontally with the branches between these elements and the intervals of the carcass which is a surface cage are filled by adobe [2][6].

The main subject of this study is the construction of Fethiye Adobe Houses, which are built inspired by traditional hımıs-bagdadi technique and pouring adobe inside this wooden structure.

6 ADOBE HOUSES (KERPICEVLER)

Our subject Kerpicevler is in Fethiye Yanıklar Village rural area, all 20 acres of agricultural land on the 2800 m2 shares, 6 blocks with 10 accommodation units and restaurant serves as a pension business. In the vicinity, there are opportunities for underwater diving, para sailing, rowing, canoeing, rafting, horseback hiking, and nature sports such as trekking on the ancient Lycian Way of Fethiye. It is also preferred for Yoga and Meditation camps. On the land of frankincense (sıgla) trees, in 5 building, family rooms with 40 m2 usage area, standard room with 40 m2 usage area, economic double room with 25 m2 usage area, single room with 20 m2 usage area, swimming pool in the middle and restaurant building. There is a multi-purpose hall made of wood in citrus trees in a separate corner in the agricultural land.

Ahmet Kizen, the architect of Kerpicevler, has gained many years of construction experience with natural building materials in Fethiye, and is the owner and operator of the 'Pastoral Valley Ecological Life Farm Towards a Sustainable Living' in Yanıklar village. Inspired by the traditional hımıs and bagdadi technique, he named the system as "Kerpicarme". The system in which the structure made of wooden columns and frames reinforced with horizontal bagdadi slats, was filled with adobe by casting in site. This construction system will be summarized in steps below.

Figure 2-3. Kerpicevler Entrance Door and a General View from Interior Garden

6.1 Kerpicevler Materials and Construction Techniques

In the Adobe Houses, 50 cm. height of the base is manufactured by local stones. On the base, two-sided, 5 x 10 cm wooden pillows were placed under the walls. The wooden system is made of thin wood, as opposed to wooden structured, hımıs systems in Anatolia. The system is mainly composed of 30 cm. x 30 cm. columns in the corners and wooden panels between two columns in both sides of the wall. The wall panels between the columns were removed after being formed on the floor. The wooden frame system is combined with parapet and lintel high wooden beams. The 1.5 cm x 3 cm bagdadi slats were nailed in place with a pressure nail gun, facing the interior and exterior panels into the wall. The inner cavity of the wall was filled from above with adobe material mixed with straw, gravel and sand by a shovel. The soil test, by leaving mud balls from a height of about 80 cm to the ground has been reported to have been made [13]. The adobe material works together with frequent wooden slats as mentioned in Figure 1-c. Compression is provided by the own weight of adobe may be a kind of 'rammed earth' in literature [13]. Architect Ahmet Kizen thought that thin wood was used to replace iron and adobe was used to replace concrete. This system is called "Kerpicarme" in order to express the meaning of reinforced adobe. Since the completion of the accommodation units in 2010, it has been reported that there have been 2 earthquakes in magnitude 6 but no slight capillary cracks have occurred. Some researchers suggest that a structure can be considered earthquake resistant if it survived the earthquake without damage or structural damage other than some inevitable small cracks in the construction system [4].

Figure 3-4. Corner Wooden Column (30 cm x30 cm.) Wooden Panels and Bagdadi Slats View

Figure 5- 6. Preparation of Bagdadi Slats and Nailing with Pressure Nail Gun in Place

Figure 7-8. The adobe, which is not considered to be of high quality, was placed on the top with a shovel and compression provided by its own weight was ensured.

Figure 9-10. The gap formed on the surface of bagdadi slats is filled with the same material. All adobe surfaces and shrinkage cracks, except the wooden frame surrounding the panels, were plastered with earthen plaster.

Figure 11. Wall Cross Section View **Figure 12.** Wall Exterior View

In the wooden system, it is stated that pine or eucalyptus, which are the trees of the region, can be used and pine timber is used in these houses. The wooden frame, the bagdadi slats and the adobe filler move together. The adobe filler adds rigidity to the empty wooden frame.

Figure 13-14. Wooden Roof Over The Upper Wooden Beams Surrounding the Building.

Figure 15-16. Water-based Paint on The Facade

Figure 17-18. Interior View

Architect Ahmet Kizen recommended the use of natural root paint and linseed oil on the facade, but water-based paint was preferred by the owner. Among these concerns, this paint forms a film layer on the surface. The remaining space on the adobe wall and the wooden ceiling were covered with wooden paneling. Rabits wire and hard and rough cement mortar on the wooden construction in wet spaces are coated with ceramic material.


Figure 19. Wet Spaces Coated with Ceramic Material.
Figure 20. The gable Roof Cover Over the Plain Building.

The roof cover is saddle-ridge roof [11]. Since the plans of the buildings are plain, the roof forms are simple. The wooden eaves of the roof partially protects the building from rain.

7 CONCLUSION AND RECOMMENDATIONS

The desire of the visitors participating in tourism to have a different experience than usual, to discover new things and to see the different one increases the importance given to rural tourism types and ecological life experiences in rural areas. In rural areas, buildings made of natural materials such as adobe, stone and wood instead of reinforced concrete are known to be healthier. Staying in accommodation units manufactured with environmentally friendly materials may be the reason of choice. In a world where heating / cooling based on fossil fuels has become the norm and where locally sourced natural materials are neglected, the desire to stay in natural structures is a health conscious and environmentalist approach.

Fethiye Kerpicevler is thought to be a good example of accomodation units in rural areas serving tourism without disturbing the nature. Earthen architecture used here is a cost-effective, environmentally friendly alternative to modern building materials. Being able to stay in rooms without opening the air conditioner in hot weather provides an advantage in terms of facility operating costs and environmental management.

This wooden-adobe construction system may be suitable for earthquake zones. This system can be constructed with lower costs by using local wood material, local soil, sand, straw, clay and very simple workmanship. And also there is no need for high quality adobe. This system can be improved and can be subject to the necessary tests in university laboratories. This system can be considered for use in Turkey's rural areas. Our main aim is to contribute to the researches about adobe building systems that can be applied in rural areas. In terms of its environmental approach, it can be a contribution to rural tourism. Another purpose of this study is to make the Ministry of Environment and Urbanization aware of this system and to provide an alternative building system with local construction techniques and economic solutions if deemed appropriate by the universities.

8 ACKNOWLEDGEMENTS

Thanks to Ahmet Kizen, the architect of Kerpicevler. He is also the owner and operator of the "Pastoral Valley Ecological Life Farm Towards a Sustainable Living" in Yanıklar village.

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Natural Building Materials and Systems; Eco-farms

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ABSTRACT

The state of dissatisfaction created by the city life and the desire to get away from this environment has led some groups living in our big cities to seek a healthier, more peaceful and humble lifestyle. Thus ecovillage in Turkey, it has emerged as an alternative model of residential life and raising efforts in line with the ecological needs of life. The overall objective is to create a small-scale settlement in which a planned society that values both individual development and common life will live. Turkey had ecovillages are mostly rural / semi-rural areas, is planned as a low-density settlements. In terms of sustainability, it is aimed to have an economically self-sufficient cycle system. The main sources of income are ecological agriculture, educational activities and eco-agro tourism. In addition, respect to local culture and the traditional architectural features of the region comes to the fore. In this context, unlike contemporary building materials and systems, local, natural and recyclable materials such as wood, stone, mudbrick and straw bales are preferred in the buildings. The sampled eco-farms of this study are members of TaTuTa, the name of the project on "Eco-Agro Tourism and Voluntary Knowledge and Skills Exchange on Organic Farms", organized by Bugday Association for Supporting Ecological Living. With TaTuTa, Buğday Association is the official member of ECEAT- European Centre for Ecological and Agricultural Tourism- for Turkey, the national WWOOF organization of Turkey. WWOOF is a worldwide movement linking volunteers with organic farmers and growers to promote cultural and educational experiences based on trust and nonmonetary exchanges helping to build a sustainable global community. Contrary to contemporary, the buildings of these farms are natural buildings a cleaner, healthier and more personnal approach to housing constructed by "Kolûba" collective and volunteers. Natural building materials and systems used and the participants involved at the construction of one of these farms will be examined in this paper. Thus, this paper aims to attract attention to natural buildings and materials at rural areas and to show a way to build by a collective and volunteering process including craftsmanship with local and natural materials, by more professional standarts.

Keywords: Natural Building Materials, Eco-farm, Eco-agro Tourism, , TaTuTa, Bugday Association for Supporting Ecological Living.

1 INTRODUCTION

The state of dissatisfaction created by the city life and the desire to get away from this environment caused some groups living in our big cities to seek a healthy, peaceful and humble lifestyle. Thus, Turkey's ecovillages have emerged as an alternative model of residential life and raising efforts in line with the ecological needs of life. The overall objective is to create a small-scale settlement in which a planned society that values both individual development and common life will live.

After the Habitat-II- United Nations (UN) Human Settlements conference that took place in Istanbul in 1996, the themes of the conference were "habitable environment", "locality" and "participation". Turkey's accepted by the Local Agenda 21 activities "Think globally, act locally" principle formed the conference agenda and in our architectural practice, by initiating the questioning process on two issues related to the environment, awareness has been provided: Settlement problems can only be solved by the local actors and non-governmental organizations and individual initiative. Alternative/environmentally sensitive lifestyles and their positive role in creating settlements were addressed. Eko-villages are one of the main groups in many studies on sustainable architecture and settlements. Although diverse qualities that make sustainable/ecological structures, each sample to Turkey is a local-specific solutions.. Instead of comparing samples with similar success abroad in terms of structural, primarily it is stated that taking into consideration Turkey's urban and rural development policies and popular environmental approaches would be more correct. [2].

It was also found that eco-village and farm initiatives are more concentrated in the southern and western regions of Turkey [7]. Eco-villages are planned as low-density settlements in rural / semi-rural areas. It is aimed to have an economically self-sufficient loop system. The main sources of income are ecological agriculture, educational activities and eco-agro tourism. In addition, respect to local culture and the traditional architectural features of the region comes to the fore. In this context, unlike contemporary building materials and systems, local, natural and recycled materials such as wood, stone, adobe and straw bales are preferred in the buildings [2].

In a world where fossil fuels-based heating/cooling has become the norm, where local-sourced natural materials are neglected and where quality workmanship gives way to cheap prefabricated structures, alternative/natural building is a cleaner, healthier and more personal approach to housing. As the negative impact of the modern construction materials has without doubt many dimensions, by criticizing modern architecture in all aspects, numerous problems can be seen quite diverse of nature, theoretical, technical, social, economic, scientific and environmentally. Modern times construction materials are unsustainable, and so are most of the techniques involved. It would be very important to understand that environmental damages are not caused only in the building phase, and that the use of modern construction materials causes a troublesome amount of pollution in both, the pre-building and the post-building phases. Contrary to this for example, earthen architecture is a feasible, affordable, durable, cost-effective, environmentally-friendly, alternative to modern time's construction materials and to all the related methods, techniques and practices. Earthen architecture is nowadays viewed as an alternative construction method that involves diverse materials and incorporates a wide range of modern techniques and technologies [8]. For a variety of reasons, their use is limited to specific building types, sizes and geographical regions in our country.

1.1 Purpose

Thus, this paper aims to attract attention to natural buildings and materials at rural areas and to show a way to build by a collective and volunteering process including craftsmanship with local and natural materials, by more professional standarts

1.2 Methods

For this study, ecological architecture, natural building materials and systems, eco-agro tourism documents were scanned and "Kolûba Collective" projects were analyzed as case study. Data needed for the research is obtained through interview with "Kolûba Collective" team and also through "Kolûba Collective" and eco-farms web page.

2 NATURAL BUILDING MATERIALS AND SYSTEMS OVERVIEW

Natural building materials and systems have their roots in pre-industrial indigenous building techniques. About two-thirds of the world's population lives in buildings made with non-industrial materials such as earth and bamboo. For a variety of reasons, their use is limited to specific building types, sizes and geographical regions. Some examples of natural building materials with structural uses are straw bale, bamboo, wood and multiple techniques using earth. Other related uses are earthen finishes, tree house designs and thatched roofs. There are also hybrid construction techniques that combine natural and modern materials such as steel reinforcing in earthen structures or portland cement used in earthen or bamboo/earthen hybrid buildings. Timber construction is also considered a natural building material [5]

The amount of information and testing available on natural building techniques is varied, but generally not extensive when compared to modern indusrtial materials. With the exception of timber construction, there is little industry involvement with these materials so standards for design and quality assurance and sources of funding for research are not easily found. Still much is known based upon historic empirical knowledge and modern innovations bu various organizations, non-profits, and universities. Locating the most relevant information can be a challenge [5].

2.1 Earthen Structures
Earthen structures have seen pervasive use as human shelter on many continents, with the oldest excavated site dating to 8,300 B.C. [6][5]. There are very types and variations of earthen structures: adobe, rammed earth, stabilized rammed earth, gunearth, fired ceramic, cob, erathbag and underground structures. Well designed and maintained earthen structures have endured the test of time, but there are durability concerns in wet regions and safety issues to be aware of in seismicallyactive areas. The environmental advantages of earthen materials are compelling. Earthen structures create a natural, non toxic, indoor environment. Little energy is typically required extract, process and fabricate the material, with the largest energy input usually being human labor. The use of natural materials precludes adverse end-of-life issues. Due to their large mass, earthen buildings are beneficial for passive solar design and have low sound transmission. They also naturally regulate indoor humidity and comfort [3][5]. Depending upon local soils and the desired mixture of clay, sand, silts and gravel, importing of earthen material may be necessary. But typically, earthen construction materials are locally sourced which means low embodied transportation energy.

2.2 Straw Bale
Straw bale construction dates back to the late 1800s in the Midwest, where straw bale buildings were built in agricultural communities. Straw buildings have proven to be quite durable when detailed properly [5][9]. The advent of modern agriculture has brought about straw baling equipment. After the grain is harvested, the straw stalks that remain in the field are cut and tightly bundled into bales by machine. There are two basic structural systems that use straw bales. In post and beam construction, straw bales are used as non structural infill between the posts and beams, with timber framing supporting gravity loads. In the other type of structural system, the bales themselves are used as load bearing elements; both gravity and lateral loads are resisted by the straw bale walls. The bales are usually placed in a running bond. Adjacent walls are inter-connected at corners by continuing the running bond from one Wall into another. At openings, however, partial length bales are needed, and these have to be made by cutting and restringing the bales. Conventional roof framing systems are often used.

Slip straw, also known as light straw or clay straw, is mixture of clay and straw, compacted into forms until it is tight and strong and stable. Slip straw comes in somewhere between cob, which is mostly clay with chopped straw as a stabilizer, and strawbale, which is mostly straw with clay (or other stucco) as a covering. The finished wall of compacted straw, glued together with clay, before it is plastered over.

2.3 Slip Straw (Light Straw Clay)
Straw clay is highly compatible with framed wall systems because it is a non-load bearing material. Light straw clay can be infilled in nearly every wall framing system, be it timber framing, pole framing, conventional lumber framing, or framing specifically designed for straw clay infill. LSC is also excellent retrofit insulation because preexisting walls can be furred out to any thickness. Furring out a wall simply involves adding stud material to the desired depth of wall. This can be

done to the interior of a building or to the exterior. Using staggered studs or Larsen trusses also improves the insulation's performance because it allows the creation of a continuous thermal envelope, doing away with the thermal bridging that occurs in a conventionally framed building (where solid studs create breaks between insulated stud cavities). Interior walls can be infilled with straw clay in buildings that have exterior wall systems of other materials. Interior walls can benefit from the soundproofing that straw clay provides, and they provide a seamless look because they take plaster as well as other natural wall systems. If done with good and consistent formwork and with attention to detail, the walls can be very flat, lending themselves to very smooth finish plaster, which leads to less "dusting" through the life of the wall.

LSC's compatibility with conventional framing systems makes it easier to find contractors who can provide straightforward estimates for a project (URL[2]).

2.4. Plaster

Plaster applied to the bales plays an important role in conferring strength and stiffness to the bale walls, and helps integrate the somewhat irregular surfaces resulting from stacking bales into a more monolithic wall assembly. A variety of materials are used to create different types of plasters, and these are often reinforced with chopped straw fibers or plastic or still wire meshes. The tensile reinforcement confers some degree of tensile strength and ductility to the plaster and prevents the development of large, unsightly, cracks in the plaster as it cures. A wide range of plasters are used in straw bale construction. The plasters function to fill in the irregular surface of the bale wall, integrate the bales into a coherent mass, and provide a smooth finish surface.

The plaster also protects the bales from fire, insects and rodents. The plaster must retard the entry of moisture into the wall during rainstorms, while allowing moisture generated inside the building to pass through the plaster rather than condensing inside the bale wall; this requires that the plaster act as a vapor-permeable membrane while having low liquid permeability. In load-bearing construction, the plaster is part of the load path, and also supports and protects any mesh reinforcement that may be provided for tension and shear.
The primary binders used in straw bale plasters include clay, lime and cement. Other constituents include an inorganic filler such as sand, water and possibly chopped straw or other fibers. Earthen plasters rely on clay binders, sometimes supplemented by lime, cement or even manure. Lime plasters use one of the various forms of lime, preferably a hydrated or slaked lime, and sand. Cement-based plasters are made using sand and portland cement, and may also include lime or pozzolonic admixtures such as fly ash. [5].

These natural materials are only overviewed, code considerations, structural performances, specifications, rating systems such as LEED, sustainability impacts, reuse and disposal, not deemed necessary..

3 BUGDAY ASSOCIATION FOR SUPPORTING ECOLOGICAL LIVING

Since 1990, they have been carrying out activities leading to people who adopt a life that respects nature. However, in 2002, these activities were gathered under an association and transformed into an institutional structure. The purpose of the Buğday Association is defined as to create the awareness and sensitivity of ecological life in individuals and society, and to support lifestyles compatible with nature in order not to disturb the ecological balances. In order to fulfill this aim, the Buğday Association is trying to contribute to the continuation of agricultural production as in traditional villages, to the spreading of sustainable agricultural methods that do not harm the environment and human health, and to redefine human needs in harmony with ecosystem cycles (URL [1]). In addition to supporting ecological settlements, the Buğday Association actively plays an important role in raising awareness of eco-village entrepreneurs on organic farming activities.

One of the most effective applications of the Bugday Association is the TaTuTa project. It was established in order to incite ecological agriculture by providing information support or volunteer labor to family farmers in Turkey. TaTuTa allows people who are interested in ecological agriculture or who want to learn about such issues, individual farms or eco-village formations established in many different regions, to gain experience for a fee. The main activity of the TaTuTa project is to design long-term or short-term visits to the farm. In the context of visits, people are called "volunteers" and "guests (URL [1]). Volunteer visitors are people working on the farm providing labor, information and / or experience support. The volunteer's accommodation and food needs are met by the owners. Guests are required to provide financial support to stay on the farm and do not have to work on the farm. (URL [1]).

The sampled eco-farms of this study are members of TaTuTa, the name of the project on "Eco-Agro Tourism and Voluntary Knowledge and Skills Exchange on Organic Farms", organized by "Bugday Association for Supporting Ecological Living". With TaTuTa, Buğday Association is the official member of ECEAT for Turkey, the national WWOOF organization of Turkey and an accredited EVS organization.. WWOOF is a worldwide movement linking volunteers with organic farmers and growers to promote cultural and educational experiences based on trust and nonmonetary exchanges helping to build a sustainable global community. Contrary to contemporary, the buildings of these sampled farms are natural buildings a cleaner, healthier and more personnal approach to housing constructed by "Kolûba Collective" and volunteers. Natural building materials and systems used and the participants involved at these farms will be examined in this paper.

4 THE TEAM AND VOLUNTEERS

"Kolûba Collective" is a platform, thinking, working and designing about alternative building systems. The team includes self-taught builders as well as architects, engineers and designers who understand the value of quality workmanship. With different backgrounds and fields of expertise each member of the Kolûba Collective contributes in his or her way to the building process. Volunteering approach at these projects goes beyond having people working for them for free. Volunteers are desired to be passionate people who really want to learn the skills and perhaps get seriously into alternative building. Each member of the Kolûba team had started off as a volunteer and gradually earned experience this way. Volunteering is seen as a form of aprenticeship.

5 TEZEKEVLERİ / TEKIRDAG

As part of a project, at Gundogan Dairy Farm, Tezekevleri was designed to demonstrate the possibilities of natural materials. Three small houses and a bathroom started to be built in 2016; 100 m2 total surface; 10 months work, 80 volunteers involved. 500 earthbags, 300 strawbales, 3000 mudbricks are used. Adobe house, slipstraw house, load bearing strawbale house, wood/earthbag/slipstraw bathroom are built. Bathroom Building is the first building is a 30 m2 with four showers and four dry toilets. Exterior walls are made of earthbags topped with cob bottle walls, and interior walls are wood construction filled with slipstraw. Its roof has the particularity of sloping inwards, directing the rain water to its center which is then stored in tanks. All showers are plastered with a colorful shiny tadelakt lime plaster.

Figure 1. (a) Bathroom building exterior walls made of earthbags,
(b) Bathroom building exterior (URL[3]).

Figure 2. (a) Exterior walls are made of earthbags topped with cob bottle walls
(b) Showers plastered with a colorful shiny tadelakt lime plaster (URL[3]).

The three small houses (17m2) had been designed to demonstrate the possibilities of natural materials. They are based on the same plan, only exterior walls' materials change. They all have gravel bags foundations, an adobe (mud brick) interior wall supporting a mezzanine, and a strawbale insulated roof. Their large opening to the south and their heavy energy storing interior wall make them very warm on sunny winter days. (URL[4]) The meaning of Tezekevleri is dung's house. Very few of dung had been used especially in earth plaster and earth bricks (URL[4]). However, the name had come from the project main purpose, using local and natural materials in a durable and easy way, preventing soil degradation and resources over usage. In this way, dung, associated to earth and straw, is a good material as it stabilizes the plasters and the bricks, but also enriches the soil is the buildings are abandoned and let to decomposed(URL[4])

5.1 The strawbale house

The strawbale house is load bearing, meaning that the walls do not contain columns supporting the roof. The weight is carried by the straw itself. Most of its structure was executed during a workshop in 2016

Figure 3. Strawbale House (URL [4]).

5.2 Slipstraw House

The slipstraw technique consists in mixing loose straw with a small amount of liquid clay and compress it within boards to fill walls of any thickness. Its insulation level can be as high as that of strawbales. The surface is then plastered with a rough coat earth/sand/straw mix and finished with a fine coat of water resistant earth/cow manure mix.

Figure 4. Slipstraw House (URL [4]).

5.3 Mud Brick house

Adobe or mud brick building is one of the most common earthen building technique in the world. These bricks have a high compression strength but a low insulative value. Their production is also very labour-intensive but reduces the need for wood as load-bearing support.

Figure 5. Mud Brick house

5.4 The materials and techniques used for the construction of the buildings

Several construction techniques were chosen according to the design of the building, the properties of the materials and the function of the building elements. Several mixed techniques in each building were also used as it is more efficient to use materials and techniques according to their properties. As foundation, gravel bags, polypropylene bags fulfilled with gravels were used and then stamped into trenches. As walls, straw-bales (load-bearing technique), slip-straw (light straw-clay) inside a wooden frame and also as external wrapped insulation, mud-bricks (load-bearing technique with main and half bricks), earth-bags (load-bearing technique) were used. As structural elements, wooden frame or straw-bales, mud bricks or earth bags were used. As roof heat insulation, straw-bales or slip-straw were used. As plasters and finishes, earth plasters reinforced with cow-dung, casein, linseed oil, egg white; lime plasters, tadelakt, clay paints, burned clay plasters were used. As floors, earth floors (rammed earth floors and adobe earth floor) protected by linseed oil or tempera (linseed oil, pigment and yolk) were used.. Where insulation was needed straw-bale or loose straw and very light slip-straw as they are good insulation materials (λ<0.7W/Km²) were used. Where high thermal storage materials were needed, mud-bricks, heavy slip-straw or earth-bags were used. Earth plasters and earthen walls were also used to regulate the humidity level in the buildings. Straw-bales were also used for sound insulation. Cob, a plastic earth material was used for decoration and aesthetic purposes. As plaster, earth plasters stabilized with flour paste in the interior were used and different techniques for the exterior plasters to lessen the yearly maintenance were attempted. Where waterproof plaster where needed tadelakt (a

Moroccan lime based plasters) and lime plaster while burned plasters and oiled clay paints were used for water resistant surfaces (URL [4]).

5.5 The Buildings resistance to weather conditions

The ownwer tells that after 3 winters, their buildings are resistant to normal rains and snow as well as heavy sun and droughts especially by the large roof eaves and drainage in the foundation. However, as the winds are very heavy in the area, earth plasters are not fully appropriate and they are experimenting every year a new technique to stabilize the plasters and protect the walls. But no walls had fallen of nor any water entered the buildings.

5.6 The Buildings resistance to earthquake

As the buildings are made with not conventional materials and technique, no regulation in Turkey deals with and even few international regulations are taking it in account. However, while building it, they were following the ICC-IRC 2015 – Appendix S and R (International Residential Code for USA) for straw-bale and slip-straw and the NZS 4298 and NZS 4299 (New-Zealand Standards) for earth construction. So, they say their buildings are resistant to "normal" earthquakes as any other modern buildings. Moreover, they say all the materials used can be used as infill materials inside a structural wooden or steel frame which would make the building compliant to earthquake codes. The main advantage of using these materials is that even after an earthquake, the house can be repaired or rebuild easily, using the same materials whereas a concrete house will need to be put down.

5.7 The Buildings resistance to fire

Most of the materials used are not flammable materials or materials that burn with difficulty. As straw-bales are very compact, it is difficult to burn and then also protected with an earthen plaster. Other materials are made with earth, making them very difficult to burn as earth is not a flammable material. The timber used in the construction for structure and surface is the only flammable material that can be easily accessed and then again, it is not easy to start a fire and it is burning slowly enough for the inhabitant to be safe out of the building. As very few plastics are used, fire would not spread fast and no toxic smoke will be released.

5.9 About the comfort of the buildings

To make the building more comfortable and energy efficient, it is designed according to bioclimatic principles. But the physical comfort (heat/cold, humidity level, noise, smell…) is mostly depending of the materials used as is the "healthiness" of the buildings. As no chemical materials are used (paints, plastics and PVC, glues…) very few VOC (Volatile Organic Compounds) and formaldehyde are released in the air, limiting the impact on the health of users. Moreover, "breathing" materials are used such as earth plasters, straw-bales or earth construction techniques, the humidity level in the building is regulated through humidity circulation through the walls and humidity storage in the plasters which makes the building more comfortable. As they used heavy materials, they also managed to put a very high thermal mass in the building which regulate the temperature both in summer and winter, preventing overheating and overcooling (URL[4]).

6 CONCLUSION

In general, it is seen that in Turkey, also affected by development policies and economic problems, there is not much progress in practice in rural areas in the areas of sustainable settlements and ecological buildings.

As mentioned at the Local Agenda 21 activities "Think globally, act locally" principle, Buğday Association is trying to create the awareness and sensitivity of ecological life in individuals and society, and giving support to lifestyles compatible with nature in order not to disturb the ecological balances. The Buğday Association is trying to contribute to the continuation of agricultural production as in traditional villages, to the spreading of sustainable agricultural methods that do not harm the environment and human health, and to redefine human needs in harmony with ecosystem cycles.

In addition to supporting ecological settlements, the Buğday Association actively plays an important role in raising awareness of eco-village entrepreneurs on organic farming activities including the natural buildings with modernised designs inspired by traditional systems, building by unconventional and greener ways, mostly with earth, straw and wood, to create healthy living spaces. This process is made possible by the TaTuTa, the name of the project on "Eco-Agro Tourism and Voluntary Knowledge and Skills Exchange on Organic Farms".

By being members of this project, both as an eco- farm or a volunteer, an enjoying process is made possible. Volunteering is seen as a form of aprenticeship. Volunteers are desired to be passionate people who really want to learn the skills and perhaps get seriously into alternative building.

By collective groups and works, platforms for example like "Kolûba Collective", thinking, working and designing about alternative building systems is made possible.. Earth, straw and wood can combine in the farm buildings to move beyond shelter and reconnect with what houses should be a refuge where one may find peace and comfort.

As a conclusion, this paper aims to attract attention to natural buildings and materials at rural areas and to show a way to build by a collective and volunteering process including craftsmanship with local and natural materials, by more professional standarts.

"Without craftsmanship, inspiration is a mere reed shaken in the wind."
Johannes Brahms

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Managing The Complexities of Heritage Sites: A Tale of Three Cities

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ABSTRACT

Heritage resource managament planning is both a multi-layered and complex process that requires a multi-disciplinary approach. The main objective of this paper would be to capture this complex process through the lens of multiple Indian cities. The authors of this paper have been part of the process of three cities in the country namely Bhubaneswar, Hubli-Dharwad and Bengaluru in different capacities. The paper would aim to compare and contrast the different case examples through both primary and secondary data points in order to summarise the entire process. The cities would be studied based on first hand experience:

- Bhubaneswar – The approach to heritage under the Smart Cities initiative
- Hubli Dharwad – The approach to heritage keeping in mind the Transit Oriented Development that links the twin cities of Hubli and Dharwad
- Bengaluru – The review of the Masterplan 2031(Chapter pertaining to heritage) for the city of Bengaluru

The cities will be studied using various tools and benchmarks already established both internationally and nationally namely:

- The value based approach of Heritage Conservation and Management set by UNESCO manual on Managing Cultural World Heritage
- The HRIDAY cities initiative by the Ministry of Housing and Urban Affairs, Government of India
- The Historic Urban Landscape or the HUL approach

Finding the answer to the perfect framework for a Heritage Management Plan may not be ideal as each context calls for a specific approach. However, what this paper would aim at developing is a sound process flow accompanied by a checklist that could act as a guiding document for any Heritage Professional.

Keywords: Heritage Resource Management planning, Urban Heritage, Urban Planning, Legislation and Policy, Stakeholder Participation

1 INTRODUCTION

There has been a substantial shift in the understanding of 'heritage' since its definition at the first World Heritage Convention in 1972. The expanding scope of the term can be perceived by looking at the changing definitions in important manuals and toolkits over time. Initial endeavours strived to delineate cultural and natural heritage of outstanding universal value [1] in isolation. A study of the *Burra Charter (2013)* reveals a stark contrast in approach with the emphasis being on 'place' and 'cultural significance.' The past decade has seen an inclusive approach towards heritage along with a concerted effort at promoting intangible heritage. At present, the chief focus is on 'urban living heritage' of a city. India is a repository of an astounding wealth of living patterns and modes of heritage. As Amartya Sen succinctly said, the culture of modern India is a complex blend of its historical traditions, influences from the effects of colonialism over centuries and current Western culture - both collaterally and dialectically.[2] Unfortunately, this living heritage is facing a serious threat from escalating development, especially in an urban context. While urbanisation in India is less than 30% of the population, it has been characterised by an unusually large concentration in a small number of highly populated cities.[3] With international conventions, charters and declarations stressing on the need for urban cultural heritage to be better integrated into planning and management practices, it is essential for a country like India to create a similar framework that suits its context. This paper aims to address this need by not only looking at existing policies but also looking at international trends. We do go in with an understanding that not all the trends or policies on an international scale can be directly applied to every site, but the effort here is to try to draw relevance from each and have a holistic approach.

2 A REVIEW OF EXISTING NATIONAL POLICIES

A logical start point would be to look at what is the existing framework in the country before proceeding to further section of the paper. The protection of heritage requires relevant legislation that is backed by ample funding. As discussed in the introductory section, there is an urgent requirement for comprehensive legislation at every level of governance.

2.1 Understanding The Context And Overview Of Policy Evolution

To understand this section, it is necessary to understand the mechanism that under which the country works. Table 1 explains the skeletal framework under which the government of India works and the various planning and implementation bodies associated with each level [4].

Table 1: Various government organisations associated with heritage regulations at various levels

National	State	City
• Central Planning Commission • Ministry of Urban Development (MoUD); Commission and Ministry of Housing and Urban Poverty Alleviation (MHUPA) • Town and Country Planning Organization (TCPO) • Building, Land Policy, Urbanization, Urban Reforms etc. • Housing and Urban Development Corporation (HUDCO) • National Institute of Urban Affairs (NIUA)	• Town and Country Planning Organization • Development Authorities / Improvement Trusts / Special Planning Authorities • Water Boards and Sanitation Boards; Public Works Department • Education and Health Departments	• Municipalities, also called Urban Local Bodies

The above mentioned categories simplifies the otherwise complicated system under which the government functions. For the scope of this paper this overall framework will suffice to appreciate the driving theme which is to develop a heritage management matrix. One could argue that the 74th Amendment Act of the Indian Constitution in 1992 was a crucial turning point to the way the legislative framework in the country functions. This was essentially done to bring about a decentralised approach and bridge the gap between the government and the governed.
As a ripple effect of this several things came into play. Let us look into some of those effects and its impact on heritage briefly [5]:

- Urban and Regional Development Plans Formulation and Implementation [URDPFI] Guidelines: Heritage has a sizable mention in this document as part of both Macro and Micro level planning policy from perspective plan to regional plan to local area plans. It also calling out to master plans to include heritage in their sector specific planning
- Model Regional & Town Planning Development law: The Model building bye laws for heritage was incorporated in 2010 and this needed to be taken up by state level agencies in their Town and Country Planning Acts
- Jawaharlal Nehru National Urban Renewal Mission Schemes – Heritage toolkit was developed by UNESCO & Indian Heritage Cities Network Foundation act as a guideline for heritage conservation on a macro level
- 13th Finance commission – Separate funding was allocated for heritage at Urban Local Body level
- 18 functions were to ULBs by the state governments where function 12 is about promoting culture

Having discussed the overall working, the following sections will touch upon some of the national level legislations in place as State and city specific legislations will be specific to those regions only.

2.1.1 The Ancient Monuments and Archaeological [Sites and Remains] Act, 1958

The Ancient Monuments and Archaeological [Sites and Remains] Act regulates and protects monuments under the purview of the Archaeological Survey of India [ASI]. Historically the Act enabled the protection of historical monuments and precincts but did not provide for the protection of wider heritage zones, intangible and material heritage within. [6] A slew of recent amendments has attempted to bring it in line with international guidelines. The Amendment and Validation Act of 2010 created a prohibition zone of 100m around the monument and a regulatory zone of 200m while the Amendment Bill of 2017 declared that public infrastructure sanctioned, financed and carried out by departments/offices of the government can be executed in the prohibition zone. While both amendments carry a set of pros and cons, it is not within the scope of this paper to analyse them.

2.1.2 The Antiquities and Art Treasures Act, 1972

The Antiquities and Art Treasures Act of 1972 regulates the export trade in antiquities and art treasures to prevent the smuggling of, and fraudulent dealings in antiquities. [7] It also provides for the compulsory acquisition of antiquities and art treasures for preservation in public spaces.

2.1.3 The Environment Protection Act, 1986

The Environment Protection Act addresses the indiscriminate exploitation of our natural resources and has enabled the integration of environmental concerns with development projects, for the protection and improvement of the environment and matters related to it. [8] This act regulates developmental projects in close proximity to ecologically sensitive zones and is a useful tool when world heritage sites are spread over larges areas [Hampi, Karnataka]

2.2 Analysis and Conclusions

Over the years, it is clear that the scope of heritage has been slowly expanding in India as well. However domestic structures, which form the largest percentage of heritage buildings in the country, and are disappearing at an alarming rate do not fall under the realm of protection. The other challenge lies in the fact that all these major legislations operate independent of each other. Apart from a slew of amendments in recent years to the existing framework, there hasn't been a comprehensive guideline that addresses the increasing threat to the country's heritage. Figure 1 shows that a vast volume of our heritage structures fall under the privately owned category which further drives home the need to approach heritage management on policy from a multi thronged approach which will be discussed in the following sections.

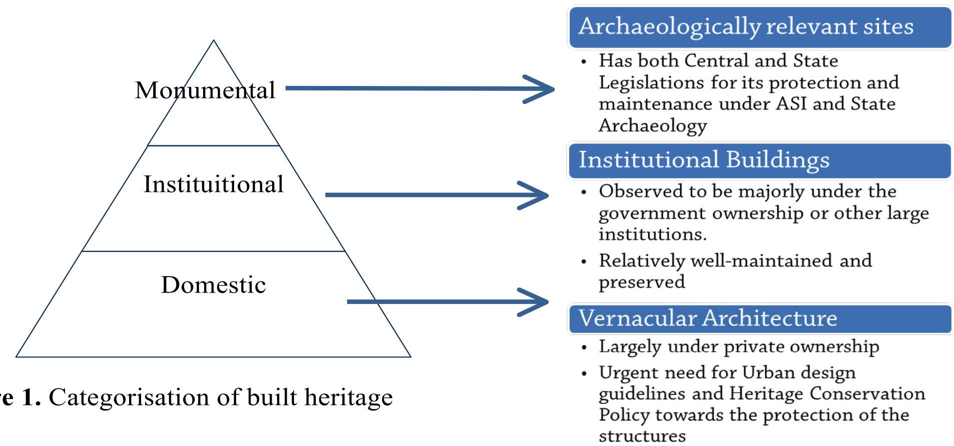

Figure 1. Categorisation of built heritage

3 NATIONAL AND INTERNATIONAL TOOLS AND GUIDELINES

Before creating a checklist and guide for a heritage management plan in the Indian context, it is important to study existing tools and benchmarks and understand the process involved. This will later be used to establish the guiding principles for a similar document that can be utilised in capacity-building by anyone working in heritage conservation.

3.1 UNESCO Manual – Managing Cultural World Heritage

The expansion of the concept of heritage has meant in turn an increase in the number and type of structures and places that are treated as heritage. This widens the range and complexity of skills required to manage it and also greatly multiplies the adverse impacts. The manual recognises that the dynamic nature requires a fluidity in management approach that has to be adopted. It is imperative that the driving forces behind decision making are not static.

3.1.1 Values led approach to heritage management

The values led approach is a response to the increasing complexity of heritage. This approach is based on the premise that people in society associate different values to heritage. [9] It is borne out of the need for a holistic management of heritage and the need to invest in the relationship between heritage and society. The significance of a heritage property is first established in a participatory approach by involving all of its stakeholders. Having established a statement of significance, this becomes a basic framework for developing conservation policy and strategy whilst taking into account the condition of the property, rules and regulations, requirements of the community and so forth. While the manual also provides a template followed by English Heritage in its Guidance on Conservation Plans [10], this paper aims to understand the principle behind the approach and outline a plan of action specific to the Indian context.

3.2 Historic Urban Landscape [HUL] Approach

The Recommendation on the Historic Urban Landscape was adopted in 2011 by the 36th session of UNESCO's General Conference. UNESCO's approach to managing historic urban landscapes is holistic; it integrates the goals of urban heritage conservation and those of social and economic development. It moves beyond preservation of the physical environment and focuses on the entire human environment with all of its tangible and intangible qualities. [11] Heritage, Environmental, Economic and Socio-cultural aspects are viewed as complementary fields that are vital to the long-term and holistic development of a city.

3.3 Heritage City Development and Augmentation Yojana [HRIDAY Initiative]

HRIDAY was a national scheme introduced by the Government of India in 2015 to facilitate the holistic development of 12 heritage cities in India. The scheme supported the development of core heritage infrastructure projects with a special focus on the creation of urban infrastructure like sanitation, drainage, waste management, approach roads, footpaths, street lights and so on. Currently under implementation, the scheme was introduced in a 'mission mode.' Like most other initiatives, HRIDAY has committees at national and city level to ensure a transparent and efficient implementation process. An interesting aspect is that it is also ensuring professional photo and video documentation to generate greater awareness of the cities' historic landscapes on a national as well as international level[12].

3.4 Analysis and Conclusions

The values-led approach and the *HUL* approach are essential to the framework of a heritage management plan in the present context. However, it is clear that in a developing country like India, the existing approach marginally differs from the manuals and toolkits established worldwide. The focus is on the creation of infrastructure and amenities for a population of 1.37 population while remaining sensitive to the immense cultural and historic landscape. Establishing a guideline/ checklist to heritage management plans in India would require an integration of both approaches.

Table 2: Summary of all the 3 approaches

UNESCO Manual – Managing World Heritage	**Historic Urban Landscape Approach**	**HRIDAY Initiative – Infrastructure Centric Approach**
Values led approach	Holistic approach that integrates heritage with economic, environmental and socio-cultural aspects	Infrastructure driven approach while retaining the city's cultural heritage identity
Emphasis on Management systems	Emphasis on Management systems	Emphasis on fast-tracked execution of approved projects
1. Summary of main conclusion of conservation plan 2. Introduction with scope, limitations & stakeholders 3. Understanding the site 4. Assessment of significance 5. Issues/Vulnerability 6. Conservation Policy 7. Implementation & Review	1. Assessment of city's natural, human and cultural resources 2. Participatory planning and stakeholder consultations to decide aims and policy 3. Vulnerability assessment 4. Integrate urban heritage values into city development framework 5. Prioritize policies for conservation and development 6. Establish appropriate public-private partnerships 7. Develop mechanisms to coordinate the various activities	

4 CASE STUDIES – 3 CITIES

4.1 Bhubaneswar – Heritage Management under Smart Cities Approach

Bhubaneswar holds a unique position among the cities of India. A city in the foothills of eastern Ghats and on the banks of river Mahanadi, the city prides itself with its temples, ancient ruins, ponds and its wealth of monuments that is testament to an ancient continuous heritage covering over 2,000 years. With Puri and Konark it forms the *Swarna Tribhuja* ("Golden Triangle"), one of eastern India's most visited destinations.

The Bhubaneswar Urban Knowledge Center is a one stop technical city resource center that is parked under the Smart city initiative to offer consistent and cohesive technical and analytical inputs to city agencies. Under this, there are 5 main domains:

- Child friendly Smart City Center
- Urban Transportation and Complete Street Cell
- Smart Growth Programme
- Place making, Open space Heritage Preservation Program
- Communications Outread and Knowledge Management

4.2 Hubli Dharwad – Heritage and Transit

Hubli-Dharwad is home to a rich historic and cultural heritage, evident in the surviving monuments, natural sites and other remains. The history of the twin cities reaches as far back as the rule of the Rashtrakutas i.e. 800 AD. Since then the two cities have together as well as independently come under the rule and influence of several different dynasties, which continue to shape the cultural diversity evident in the region.

4.3 Bangalore – Master plan Review

Bangalore is a perfect example of a multiple cities with one large metropolis. It has a long history and the birth of Bengaluru is dated back to the 16th century AD. Its long and continuous history has left the city very rich and diverse in terms of its cultural heritage. In 2018, the city released its Revised Master Plan 2031 that featured Heritage Conservation and Preservation as a chapter 14 in its main document. A group of conservation architects, lawyers and journalists came together to review this document and submitted suggestions to be taken into consideration to make it more comprehensive.

Table 3: Summary of all the 3 Case Studies

Management Plan Location	Bhubaneswar	Huli-Dharwad	Bengaluru
Duration of engagement	3 years	6 months	2 months
Approach	Developing Comprehensive Heritage Management Plan	Developing Framework for Management	Developing Recommendation and review
Steps			
1	Gathering Data – Deskbased Assessments	Gathering Data – Deskbased Assessments	Gathering Data - Reviewing already prepared Master plan
2	Cultural asset – Understanding analysing appraisal based on Deskbased Data collated	Cultural asset – Understanding analysing appraisal based on Deskbased Data collated	Round table discussions with other professionals
3	Field Visits and Surveys – Multiple visits – both individually and with	Field Visits and Surveys – with local expert to expedite understanding	Providing recommendations and suggestions – based on

	local experts/guides	due to short duration of engagement	discussions
4	Identifying and collaborating eith with local NGOS and other stakeholders	Clustering of Tangible Assets based on location	Collation of data
5	Reassessing Data and archiving with the identified Stakeholders	Identifying possible collaborations	Making a case to the government
6	Cultural asset – Understanding analysing appraisal – with stakeholder Input	Developing Macro & Micro Level Plans – as Inception reports	
7	SWOT with Stakeholders	Developing Initiatives & Tool Kits	
8	Developing Macro & Micro Level Plans – based on SWOT		
9	Developing Initiatives & Tool Kits		
10	Move onto Implementation & add monitoring standard operating procedures		

5 CONCLUSIONS AND MATRIX

From having studied the theories through the mentioned manuals and having corroborated the three case studies, there are certain main sub heads under which the entire process can be summed up. Figure 2 below attempts to create a flow chart of essential steps when one has to approach the arduous task of developing a management plan. This may be seen as the over simplification of the process, but it could be taken as a start point. The task of creating a Heritage Management plan can be daunting, but if broken down into smaller units it can be managed more effectively.

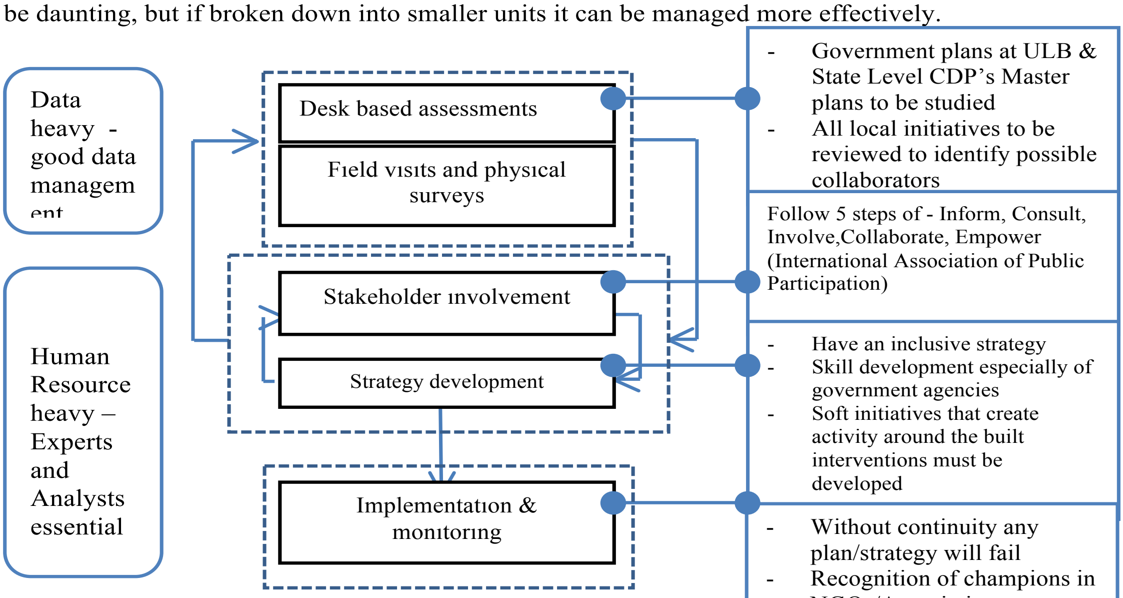

Figure 2. Heritage Management Plan – Process flow Matrix

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A Vernacular Technique for Earth Stabilization

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ABSTRACT

The considerable interest in modern unfired earth-based building materials has led to the increase and development of new types of products such as precast earth walls, prefabricated earth panels and boards, compressed earth bricks etc. on the market. However, the major drawbacks of these products such as low water stability and moderate strength result in cement stabilization, which as a consequence reduce their environmental advantage. As known the earth stabilization is being applied since the ancient time. This paper deals with a vernacular technique of producing water insoluble compounds for development of a new stabilized earth-mixture. The first laboratory analyses on this mix-design have proven a significant water-resistance and a remarkable increase in compressive strength. Furthermore, the characterization of the stabilization effect has been performed through X-ray powder diffraction patterns (XRD) and clearly identify the production of ettringite using very low CO_2 intensive raw materials. Finally, these results open a new avenue for earth stabilization and secure the implementation of this material in the conventional construction industry.

Keywords: Stabilized earth, precast earth, XRD, earth-based building materials, pozzolan

1 INTRODUCTION

Construction with earth has a long tradition; however, currently it is replaced with concrete and modern materials, which brings along many environmental issues. Earth provides many environmental and social benefits if employed in an adequate way. At present, there are a few countries, where environmentally friendly architecture is getting more and more popular. This popularity is due to a recently growing construction sector, which offers contemporary earthen products and completion methods to the planners and costumers [1]. However, since the beginning of the industrial revolution, the diversity of construction materials has increased rapidly, due to the development of the construction industry. Via the global market the use of concrete, produced with cement and cement additives as a binding material. As a consequence, cement is being commonly used to stabilize the earth material in contemporary earthen architecture. An environmental friendly strategy to substitute cement with other additives is needed. For this purpose, a variety of alternative materials with lower environmental impacts can be used. Their use is based on the importance of minimizing CO_2 emissions, as well as increasing interest in the production of cementitious materials that develop good mechanical properties and good stability in corrosive environments [2]. This paper discusses an alternative solution, consisting in combining trass, gypsum, and lime to replace the use of cement in a vernacular way.

1.1 Earth Stabilization

Soil stabilization is known as the process that enables the control of dimensional changes that clays suffer when they are exposed to water [3]. However, stabilization is not only a water related issue. Rudolf Vincent Matalucci [4] distinguished it in terms of construction procedures. According to him, the stabilization clarified as compaction, waterproofing, dilution, cementation and chemical stabilization. In countries like the USA, France, Australia, and Spain it is an important research subject, succeeded in testing earthen constructions as a significant alternative against highly energy consuming new products. Stabilization is an old tradition, however, it was only in 1920 that a scientific approach could be developed [5]. Since ancient times, small proportions of lime [3], pozzolan and gypsum were used in combination with earth. Murthy et al. [6] classified the stabilizing agents as traditional and non-traditional. According to this classification gypsum, lime and pozzolans are traditional agents. Trass is rich in acid reactive components such as SiO_2 and Al_2O_3, it shows a very high pozzolanicity in a highly alkaline environment. Lime alone has several effects on stabilization. It provides an environment with a high pH, which accelerates the pozzolanic reactivity. It extends the rapid hardening of gypsum and makes it possible to gain about extra 20 min of working time [7][8]. Also, lime reacts with the clay minerals of the soil, or with any other fine, pozzolanic components such as hydrous silica, to form a tough water-insoluble gel of calcium silicate, which cements the soil particles [9]. The interaction between clay particles and lime is, however, a long-term process. Diamond et al. [10] reports this stage as an accumulation of soil-lime reaction products, causing a slow development of strength. The addition of gypsum supplies mainly sulphate to the mixture, which forms, together with the trass minerals, the ettringite.

Several studies have tried to explain the effects of gypsum, lime, and pozzolan stabilization. In 2007, Vroomen [11] researched the properties of cast gypsum-stabilized earth. According to this study, a great advantage of gypsum over cement is that it can be produced locally by small-scale enterprises and it demands a low amount of energy in production as it can be calcined at approx. 125°C instead of 1100°C. In 2011, Lopez et al. [12] studied the chemical reaction between soil, fly ash (15%), gypsum (10%), lime (2%). They stated, when fly ash and lime are mixed with water, there is no chemical reaction in the initial phase. However, with increasing curing time a pozzolanic reaction begins between the fly ash and the gypsum. In 2011 Isık [13] and in 2012, Pekmezci et al. [14] published a paper showing the performance of earth structure by using lime (2,5-5%) and gypsum (8-10%) addition. According to these researches, gypsum-lime stabilization improves the water resistance of earth.

In this study, however, the fly ash, which is a by-product and classified as an artificial pozzolan, is being substituted with a natural pozzolan called trass. This is due to several drawbacks: its production is seasonally limited and its usage encourages the sectors producing by-products of burning processes and therefore, contributes to environmental impacts. Jackson et al. [15] reports, with the current decline in coal-fired energy, fly ash is now becoming technically and/or economically unfeasible for use in concrete. Furthermore, artificial pozzolans result from chemical and/or structural modifications of original material, which may have weak pozzolanic characteristics, or not. On the contrary, natural pozzolans do not require any treatment before their use [12].

2 METHODS

2.1 Materials

The earth used for the preparation of stabilized earth specimens consists of 30% commercially available mineral earth material for plastering (Stroba Naturbaustoffe Ag, Switzerland) and of 70% standard sand CEN EN 196-1. The XRD technique revealed, that the main mineralogical components are muscovite/illite (24.8wt%), quartz (21.3wt%), kaolinite (21.3wt%), smectite (16.6wt%) and goethite (9.1 wt%). On the other hand, small amounts of rutile, chlorite, microcline, and albite were found.

Three different additives (trass, gypsum and lime) were used in combination to stabilize the earth material. The trass (Tubag, Germany) was used as pozzolanic additive. It is also known as "rheinischer Trass". Its chemical composition, obtained through X-ray fluorescence spectrometry (XRF), is given in Table 1. Trass is a natural pozzolanic material, which can be found in various regions of the earth. The mineral composition of trass is mainly volcanic glass, zeolitized to a different extent (clinoptilolite), and secondary components from cyrstaloclasts of magnetite, zircron, apatite, biotite, quarz, sanidine, plagioclase [16]. XRD pattern of the trass is given in Fig. 1. Commercially available hemihydrate gypsum ($CaSO_4 \cdot 1/2H_2O$) was used. Moreover, a hydrated lime ($Ca(OH)_2$) was used as an additive.

Table 1. Chemical composition of the trass studied by X-ray fluorescence analysis. Values are given in mass % [17].

Component,(%)	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	Mn_2O_3	P_2O_5	CaO	SO_3	K2O	Na_2O
	56.90	18.50	1.10	6.30	2.20	0.2	0.2	5.20	0.20	5.70	3.50

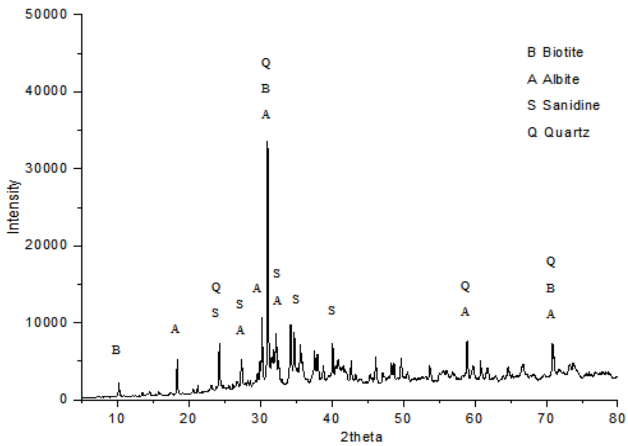


Figure 1. X-ray diffraction spectrum of the trass used in this study.

2.2 Sample preparation

Three different stabilized earth samples were produced by using different proportion of trass, gypsum, and lime as additives to determine their efficiency on water resistance and on the strength of earth materials. The mass of lime was kept constant at 2.5 wt% in all series: only the proportion of trass and gypsum was varied form one sample to the other. For all samples, the water to binder ratio was determined as 0.4 allowing to obtain a pourable material. The mix samples were poured into standard steel moulds (4cm x 4cm x 16cm). The mixture proportions and labelling of the stabilized earth samples are given in Table 2. After the addition of water, the mixing and the casting of specimens were no longer than 10 minutes. The mixing of the material was done manually. Samples were stored at 23°C and 50% relative humidity.

Moreover, to identify the pozzolanic reaction products, XRD analyses were performed on mix-designs mentioned in Table 2. The samples for the XRD analyses were prepared without earth. Therefore, the chemical interaction between additives and clay was not investigated in this study. XRD samples were cured for 7 days at 23°C and 50% relative humidity.

Table 2. The labelling and mixture proportions of the specimens

Labelling	PE	T10G8	T14G4	T16G2
description	Plain earth with 30% terrasol and 70% standard sand	Earth with 10wt% trass, 8wt% of gypsum and 2.5wt% of lime	Earth with 14wt% trass, 4wt% of gypsum and 2.5wt% of lime	Earth with 16wt% trass, 2wt% of gypsum and 2.5wt% of lime

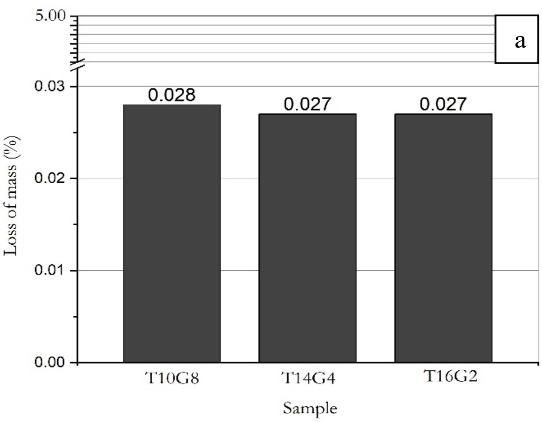
2.3 Procedures

The pozzolanic activity can be determined by physical, chemical, or mechanical means. In this research, together with the water insertion test, the compressive strength (mechanical method) and XRD analysis (physical method) have been conducted to determine the pozzolanicity of the proposed mix-design. To determine the water resistance of stabilized and non-stabilized earth specimens, water insertion test was done. The water insertion was carried out according to the standard DIN 18945. The specimens were cured at 23°C and 50% relative humidity for 14 days. The loss of material was determined by filtering the residue in the dip tank. 7 and 28-day compressive strength tests were carried out on prismatic specimens with the dimensions of 40 x 40 x 160 mm. Mineralogy of the samples is determined on randomly oriented powder specimens with X-ray diffraction analysis [18]. X-ray diffraction measurements were made using a Bragg-Brentano X-ray diffractometer (D8 Advance, Bruker AXS, Germany) using CoKα radiation. The qualitative phase analysis was carried out with the software package DIFFRACplus (Bruker AXS) [19].

3 RESULTS AND DISCUSSIONS

3.1 Water Contact Tests

Once plain earth gets contact with water, it swells, and the dissolution and erosion are inevitable. This weakness can be overcome with the help of stabilization of earth. The loss of mass of the stabilized earth specimens and plain earth after the water insertion test is presented in Fig. 2a. DIN 18945 reports that, the loss of mass has to be less than 5% of the total mass to be considered as acceptable. As described in DIN, after 10 min. of water insertion, the loss of mass of the plain earth samples was determined as 38.406% of the total mass. Fig. 2b shows the final situation after 10 min. of insertion. As can be seen in Figure 2a, all stabilized earth samples have shown similar behaviour and the loss of mass of all stabilized series is between 0.02-0.03 percent of total mass, which is significantly lower than the limit value. Moreover, no cracks were observed due to swelling: the proposed combination of additives significantly improved the water stability of the earth specimens. However, it can be observed that the change in trass/gypsum ratio does not influence the water resistance of the stabilized earth specimens.



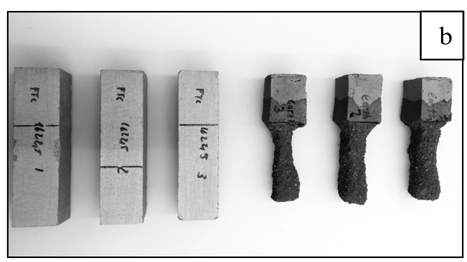


Figure 2. (a) Loss of mass of stabilized earth samples after water insertion test, (b) samples after ten minutes of insertion

3.2 Compressive strength:

The compressive strength values of 7 and 28-day cured stabilized samples are shown in Fig. 3. The maximum compressive strength is obtained for T16G2 samples containing 16wt% of trass and 2wt% of gypsum. While T10G8 containing the highest amount of gypsum does not show an increase in compressive strength from 7 to 28 days, the samples prepared with a higher amount of trass progressively gain strength from 7 to 28 days. Samples containing 14 and 16wt% of trass show a similar parallel behaviour of strength improvement from 7 to 28 days. Using higher content of trass allows improving the compressive strength of stabilized earth materials. These results show that the compressive strength of the earth material can be significantly improved with the proposed mix design of additives.

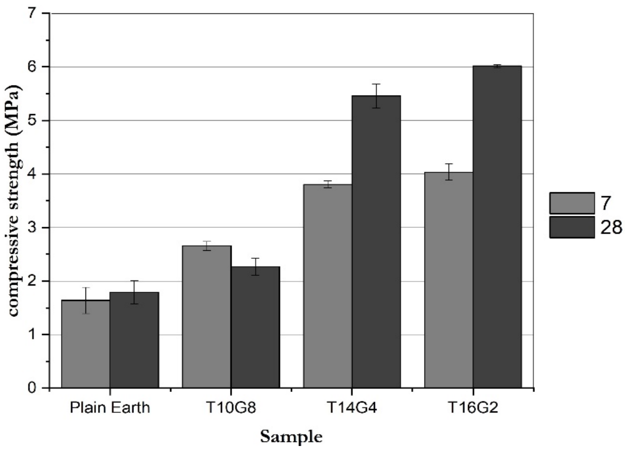


Figure 3. Compressive strength of the specimens after 7 and 28days of curing.

3.3 XRD Analyses

The mechanism of stabilization is based on pozzolanic activity. Therefore, the durability effect caused by pozzolanic activity is an environmentally friendly application. To better understand this mechanism and to identify the products of pozzolanic reactions, the mineralogical composition of the mix-designs were analysed with the help of XRD analyses. The results of 7day-cured mix-designs can be seen in Fig. 4. According to XRD pattern, the sample with 10 wt% of trass and 8 wt% of gypsum (T10G8) displays high amounts of gypsum. As expected, increasing the amount of trass is reducing the intensity of gypsum peaks. Very weak peaks of ettringite can be observed in T10G8. However, it can be noted that, with the increasing amount of trass in samples, the intensity of the ettringite peak is getting higher. The reason for this behaviour is assumed to be the pozzolanic effect of trass. The additives react with particles of trass to produce hydration products such as ettringite ($Ca_6A_{12}(SO_4)_3(OH)_{12}{\cdot}26H_2O$). A part of Aluminium is being consumed by the formation of ettringite. However, a notable amount of analcime ($NaAlSi_2O_6{\cdot}H_2O$), was observed in all samples, which probably consumes a part of aluminium in trass. Moreover, a great amount of calcite and muscovite was observed in all series.

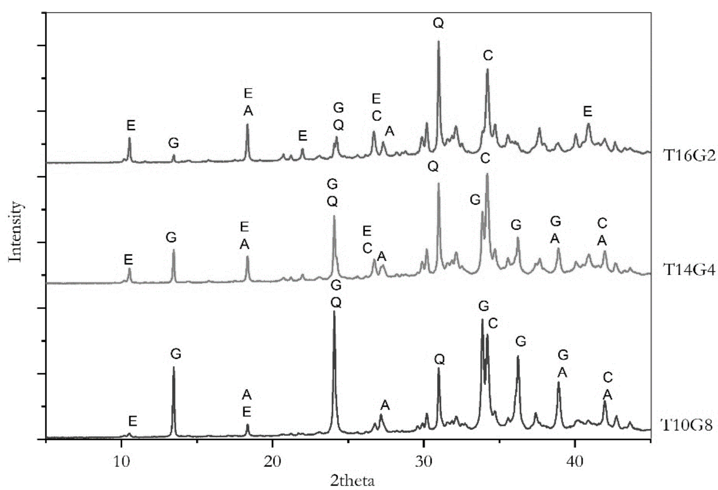


Figure 4. XRD pattern of the studied mixes of additives (without earth). (E; Ettringite, G; Gypsum, A; Analcime, Q;Quartz, C;Calcite)

4 CONCLUSIONS

In this study, it was aimed to produce water insoluble reaction products with the help of proposed additives to develop an earth-mix with a higher and durable strength. The results obtained from this study can be summarized as follow:

1. The water-resistance and the compressive strength of the plain earth were improved by the presence of trass, gypsum, and lime.
2. Ettringite, which is typical hydration product of Portland cement, could be produced with the proposed mix design.
3. With the increasing amount of trass, the precipitation of ettringite was increased. This provokes the progressively improvement of compressive strength of the stabilized earth.
4. The samples containing the highest amount of gypsum showed in early age higher stability than plain earth samples. However, the strength improvement of these samples was mainly limited with the setting of gypsum alone.

5 ACKNOWLEDGMENT

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Studying the Use of Mudbrick from the Past to The Present and Its Behavior in Earthquakes


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ABSTRACT

Sun dried mudbrick has been one of the most important building materials in the history of civilization. The Assyrians built masonry structures in Mesopotamia using mudbrick approximately 6000 years ago. Mudbrick has been extensively applied in regions and countries where there are few trees and stone is not easy to find. Mudbrick ensures the opportunity to benefit from the amply resources in the country in building structures, housing, businesses and service buildings at the easiest and most advanced level, the opportunity to assess the traditions and customs of the local people, saving energy efficiently, to reduce the use of resources necessary for development in the building sector to the lowest possible level, to provide its user with most suitable conditions inside the building in all seasons, as well as to ensure the application of all types of building materials in the structure befitting modern-day society. Due to these reasons, mudbrick structures bear the quality of the contemporary building material of today. Despite its many positive features, the use of soil as a building material also has its drawbacks. Earthen structures need to be protected from water-moisture and precipitation. Because adobe is one of the weakest of all building materials against moisture and water. They require constant maintenance. As the inner surfaces of the walls in the soil structure retain dust and dirt, a suitable cladding is required. In order to minimize these negative parameters, cement, lime, gypsum and vegetable fibers are added to the adobe structure, thus increasing their use in contemporary architecture.

The use of adobe structures throughout history has been emphasized in this study. The behavior of mudbrick structures in earthquakes has been scrutinized. Having gone beyond being just a material in underdeveloped or non-developed societies today, mudbrick has become a contemporary building material used in highly industrialized economically powerful nations for reasons such as not having negative effects on those dwelling in the structures.

Keywords: Mudbrick structures, use of mudbrick, earthquake damage, mudbrick in the past, mudbrick today

1.INTRODUCTION

Specimens of single or two storey structures constructed of adobe material in rural architecture are frequently encountered (Table 1). The destruction of adobe structure today is due in part to the master/apprentice relationship which has passed down their historical accumulation. Constituting an important building material for Turkish architecture, adobe is found in almost every region, whereas adobe architecture in our country differs from region to region (Fig 1-2-3-4).

Table 1. Adobe's Historical Progress (Gül, 2011; Altun, 2008)

Years	***Building Material***
4500-1500 B.C.	*Adobe brick*
4th cent. BC - 3rd cent. AD	*Adobe and brick*
600-965	*Wooden and sometimes adobe walls*
500-700	*Adobe brick, cut stone and wooden columns*
969-1187	*Foundation brick, rarely adobe, brick walls, reinforced with adobe*
840-1211	*Adobe structure*
1040-1157	*Deep foundation adobe and brick walls, wooden beams*
1000-1100	*Sloped rising walls and two-storey adobe walls reminiscent of stepped pyramids.*
1400-1500	*Thick adobe walls*
≥1500	*Stone, wood, adobe*
1700	*Wooden framework is widespread, with occasional stone and adobe structures*

Fig 1. Hacı İmam Villa, Gümüşhane (Gül, 2011)

Fig 2. Acıkuyu Village Home, Ankara (Gül, 2011)

Fig 3. Sansarak Village, İznik (Kıvrak, 2007)

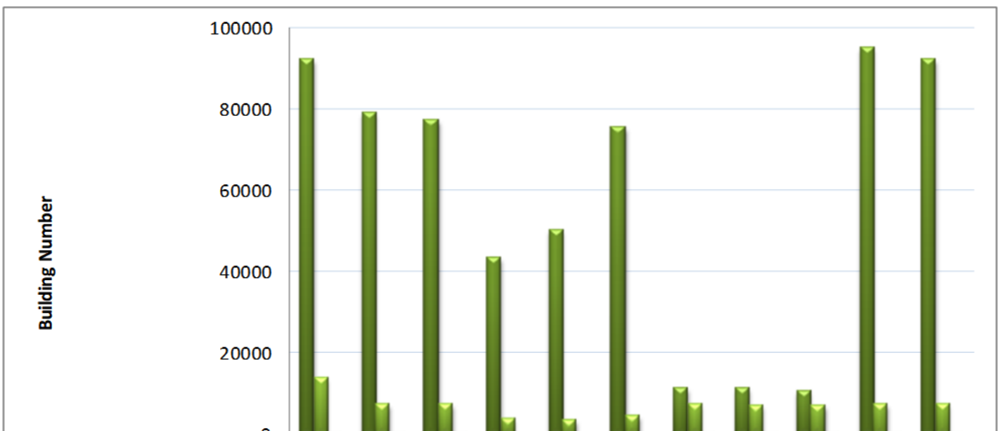
Fig 4. Village house built in 1935, Bursa (Gül, 2011)

The use of adobe bricks in Anatolia has progressed tremendously throughout history. While adobe bricks at Çatalhöyük, one of the oldest settlements in Anatolia, were as large as 80-90 cm. long and had to be carried and positioned by two people, those at Aşıklıhöyük measured 40x40 cm. In the Troya'daki Boğazköy, mudbricks in size were used. Adobe bricks measuring 43-48x48x10cm were used at Boğazköy as well as those measuring 40 x 60 cm. were utilized at Troy. Situated in Central Anatolia, the capital city of the Hittites, Hattusha was established in the 13th – 14th centuries B.C.E. and was protected by adobe brick walls measuring 9 km-long and 7-8 m. high. While most of the walls have survived to this day, a portion was reconstructed in 2005. The adobe bricks used in the Wall measure 45x45x10 cm. and weigh approximately 34 kg. (Bektaş, 2005).

2. EARTHQUAKE BEHAVIOR OF ADOBE BUILDING

Improved mudbrick is a suitable building material in our country conditions for single- or two-storey buildings. Mudbrick construction which incorporates engineering properties does not pose earthquake-related problems. In addition, adobe is the most suitable building material for our country in order to reduce the aforementioned CO_2 emission and energy consumption. 36% of our population living in rural communities experience a housing shortage (Alkaya, 2005). In light of all this, adobe is an alternative building material for our country, offering cheap, expedient and comfortable housing. Nevertheless, in a survey conducted by TUIK and entitled 'The Number of Additional Structures,' it is seen that adobe structures have practically disappeared. While 17.28% of newly constructed buildings were made of mudbrick in 1954, only two of the 92,342 buildings constructed in 2009 were of adobe material (TUIK, 2010; Figure 5). Over the last decade an average of only 8% of the buildings receiving building permits were for masonry structures in our country. While all of these could have been adobe structures, the number of recently built adobe structures is practically negligible. That said, the most popular masonry systems are brick, briquette and stone, respectively.

Table 1. Total number of buildings between 1999 - 2009, the number of masonry buildings and number of adobe buildings



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Number Of Buildings	92469	79140	77430	43430	50140	75495	11425	11420	10665	95193	92342
Number Of Masonry	13848	7282	7468	3762	3499	4458	7166	6809	6921	7296	7334
Number Of Adobe Masonry	14	6	7	0	0	0	40	5	3	3	2

That adobe has taken the blame for the loss of life caused by earthquakes in our country is unfortunate. From reports prepared as a result of earthquakes, it is seen this is nothing more than prejudice. Assessments pertaining to adobe structures from reports of recent earthquakes are provided below. Most structures found in villages around Çankırı that were damaged in an earthquake that hit the region on 6 June, 2000 had mud mortar/rubble and mudbrick walls. Almost all of these structures were comprised of barns and haylofts. Economic conditions and the necessities of rural life force the region's inhabitants to live in structures that are not earthquake resistant. For example, it was seen that the adobe structures destroyed during the earthquake were built directly with adobe without using stone foundations.

A 6.0 earthquake struck Sultandağ on 3 February 2002. The reasons why adobe structures were destroyed during the earthquake (Alkaya, 2005);

- ✓ Because the structures were very old (Yardımlı and Dal, 2016; Dal, 2018a),
- ✓ Because most of the structures were adobe masonry supported by non-earthquake-proof wooden frameworks,
- ✓ The impact the rainy season had on the adobe. (Dal, 2016; Dal, 2018b)

The adobe was seen to have crumbled in a pre-investigation report prepared by Sadık and colleagues (Bakır, 2010) regarding an adobe structure damaged during an earthquake that struck Elazıg on 8 March, 2010. As straw was seen in the mudbrick blocks, it was ascertained that they were not mixed properly and that there was no mortar applied between the mudbrick blocks. In the same report, it was also noted that girders and lintels were not found in all of the structures. The conclusion part of the report stated there was no engineering value of the collapsed or damaged buildings. Nazım and Zerrin (Koçu and Korkmaz, 2007) investigated the effect of the Afyon-Aksehir earthquake on adobe structures in the province of Konya. Mudbrick material was used in 27% of the houses built around Konya. It was found that the structures that sustained earthquake damage had no girders, poor corner connections and heavy earthen roofs. The fact that structures produced with mudbrick material that was not earthquake resistant was not only due to material error, but rather to a lack of attention to details, insufficient water and moisture insulation, and most importantly, the report stated that the structure collapse was caused by problems related to the placement of the support walls (Ergin, 2005; et al., 2018). In the end, the study stated that mudbrick structures that were not built according to construction rules were unable to withstand the destructive effects of earthquakes. What all reports had in common was the statement that adobe structures which had collapsed bore no engineering value. It also stated that neither the soil and straw mixture ratios were considered proper nor was the soil used to make the adobe of a suitable quality.

3. DISCUSSION and CONCLUSIONS

In drawing a conclusion, the principle reason for the damage of mudbrick structures sustained during earthquakes is that individuals who built a structure in rural architecture ends up repeating the same engineering errors over and over again. The structure sustains earthquake damage, not because of the adobe, but rather because of problems caused by constructions technique. Lessons should be learned from structural damage after earthquakes, and deficiencies that have been identified should be added to the engineering standards. This will make mudbrick structures more earthquake resilient, thus the structures will remain intact for much longer periods. Within the scope of sustainable ecological structure in rural architecture, adobe structures should be made more popular in our day and age by garnering the engineering and architectural importance they deserve. Adobe structures built according to engineering and building codes are earthquake resistant. Interest in these structures is bound to increase as long as there is an effort to promote masonry structures. Thus, the housing shortage in our country's rural communities can be solved once and for all.

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Alterations Seen in Adobe Structures

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ABSTRACT

There is a lot of structural damage in architectural structures in our country caused by water-humidity problems. There are mudbrick structures built in accordance with technical specifications are still intact. Due to the fact that mudbrick structures are soil-based, mudbrick structural elements showing a homogenous cross-section and features can be adequately protected from the detrimental effects of rain and frost. There are aspects to consider while erecting adobe structures. The life of the structure will be extended and it is possible for them to be more sturdy than others as long as these aspects are complied with. First of all, the structure's foundation must be made of stone using concrete mortar. The use of mud mortar instead of concrete mortar will cause water and moisture to wreak greater damage to the foundation and shorten the life of the building. The mudbrick material to be used after emerging from the foundation must comply with standards. The soil used must feature high binding properties and should not contain very large aggregates. Grouts should be cut straight and beams should be placed intervally between them. Water-moisture insulation should be applied on the structure's outer surface to avoid the impact of water and moisture. If the insulation is done correctly and according to standards, structural resistance concerns will be eliminated to a major extent.

It has been observed that water-moisture tops the list of causes for mudbrick structure damage. As a result of the study, it was determined that damage to mudbrick structures was caused by precipitation, groundwater, water flowing from the roof gutters, lack of care, apathy and bad use. Particularly, it is seen that the impact of rainfall on the outer surfaces was caused by water splashing off the roof or the effect of the wind. In comparing facades getting the brunt of the wind with those that do not get any wind, it was observed that the outer plaster flaked off by the effect of the wind along with the rain. It was seen that no such situation existed for the non-wind facade and that the plaster was as good as new. Therefore, it is quite clear that water-moisture insulation is bound to eliminate many problems.

Keywords: Mudbrick Structures, Usage of Mudbrick, Damage of Adobe Building, Water-Moisture Damage

1. INTRODUCTION

Adobe is a building material obtained by adding fibrous additives such as hay to sandy soils containing clay of a proportion that binds particles to each other, forming a mortar by adding water, pouring and shaping the mixture into simple wooden molds, then drying it in the sun. Adobe structures provide the opportunity to take advantage of the abundant resources in our country at the easiest and most advanced level, while enabling communities to assess the traditions and customs of the people. Efficient energy conservation aims to minimize the use of resources required for development in the building sector. It provides the user with the most convenient seasonal living conditions in the building, making the best use of solar energy with the easiest methods, and the application of all kinds of fixtures deemed necessary by society in today's structure.

As one of the oldest and most common building materials which emerged and developed in various regions throughout the world and used in many different building cultures, soil is one of the most easily available materials which, according to climatic conditions and usage area, can be used in different ways. It is an economical material that can be utilized both as a support or plastering material, the binder of which is clay soil obtained from nature. It is an indispensable material particularly for rural areas, whose usage has stretched from the earliest ages to the present day, the cost is dirt cheap, the production does not require setting up a production facility, while it is a building material with high thermal insulation value. It provides the most comfortable comfort conditions for the building user during every season. It also has important advantages, such as the ease of adobe production using simple tools, no need for energy in its making, and no emission of harmful gases such as CO_2 into the atmosphere. Adobe does not accumulate any waste during its production. Rubble generated when adobe structures are demolished are highly compatible with the environment. Many researchers have undertaken studies in order to improve the properties of adobe in recent years. The results obtained have indicated that traditional cement material can be used as a contemporary building material.

2. HOW ADOBE DEFORMATION OCCURS

Deformation that appears in mudbricks is directly related to the structure of the materials generally used in the production stage, construction techniques and environmental conditions they are found in. In order to understand the factors causing deformation, the types of deformation and the factors causing the deformation need to be investigated. The factors causing the decomposition of historical works are classified under three headings; physical, chemical and biological. The main cause of decomposition in mudbricks is generally water in its gaseous (humidity) and liquid forms. In addition, there is the freeze-melt cycle of wet mudbricks, erosion, the use of incorrect materials during renovation work, deformation caused by people and biological deformation types.

2.1. Physical Deformation

This type of deformation occurs through the accumulation of precipitation in the form of rain and snow that builds up at the foot of adobe structures, rivers or ponds located in the vicinity of the structures, improper drainage systems and increased groundwater levels. Water that accumulates around the structure joins the contents of the walls due to rising capillarity moisture, causing them to get as wet as much as the drying level. If the mudbrick becomes excessively wet or saturated due to this water, there will be deformation in these areas. Consequently, the most visible damage is in the form of flaking off (erosion) from the surface in spots close to the ground and the thinning out of lower wall sections (Dehkordi, 2008).

Rainwater penetrates directly into the adobe structures from top to bottom whenever it rains. Consequently, both the impact force and the accumulation of excess water causes the adobe to wear down. The rate and amount of wear is directly proportional to the speed and amount of rainfall. Mudbricks in the upper part of the wetted walls will be the first to be come waterlogged and begin to disintegrate. As a result of this flow, channels open from top to bottom on the wall surfaces and these channels begin to become thinner. The reason for the thinning of the formed channels is that the dry parts of the wall absorb and swell up in the water. As a result of this swelling, the existing pores in the material begin to close up, stopping water from moving to the lower parts, result in deformation occurring at the top of the walls (Staff, 2006).

The presence of high amounts of water-soluble salts in soils used in the construction of adobe also leads to structural problems (Von konow, 2002). Even if there are low precipitation levels, such soil begins to be affected and disperses rapidly whenever it comes into contact with rainwater. Starting from the grouts and thin channels, the decomposition of adobe bricks increases with the flow of water. Such decomposition is greater if the soil used has more non-binding silt in the soil than deemed necessary. Damage which is seen in this decomposition is in the form of deep crevices and channels on the wall surface.

Wind swept rainfall causes water drops to strike the wall surface quickly. While fragments break off with the impact of water droplets striking the wall surface, the soil is also washed at the same time. A rough, irregular surface is formed on the wall surface as a result of these pieces breaking off. Such decomposition usually occurs during the seasons with prevalent stormy weather (Feilden, 2004).

Direct contact with rainwater in some parts of the structure, water that doesn't evaporate at the bottom of walls, as well as shade covering these sections throughout the day all lead to moisture that is constantly trapped inside. The continuously high level of moisture leads to the salt dissolving in the soil and cause an ion exchange of the clayey minerals. This in turn causes structural decomposition and deformation of the adobe. The constantly moist surface leads to very deep crevices in the adobe and larger fragments to break off from the surface (Toracca, et al., 1972).

The presence of excessive amounts of non-binding minerals such as quartz and feldspar in the soil used in mudbrick causes cracks to form during the drying process due to diminished binding properties. On the other hand, a high amount of montmorillonite in the clay used in mudbrick construction (due to the excessive water retention) will cause excessive shrinkage during the drying process and thus lead to cracks forming in the mudbricks. Due to the different clays used in the mortar, cracks and crevices form due to the drying speed which is not equal on all sides of the structure. Mortar prepared during the construction of adobe needs to settle for a certain amount of time and kneaded properly. The clay minerals become completely water saturated, forming a homogeneous structure as a result of this rest and kneading. Failure to make produce the adobe properly causes the mudbricks used in the building to be affected and expanded from outside moisture. Consequently, cracks and crevices of different sizes form due to the pressure created by the increased volume (Warren, 1999; Dehkordi, 2008).

2.2. Chemical Deformation

Chemical decomposition occurs as a result of reactions of materials containing high amounts of calcium carbonate ($CaCO_3$) with acids, which end in the formation of gypsum or limestone. However, as it is known, because of low amount of lime ($CaCO_3$) in adobe, this sort of decomposition is rather insignificant.

2.3. Biodecomposition

Biological factors generally encompass all living organisms that form the living part of the soil and live in the soil. Straw and similar plant life used in the making of mudbricks are a source of nutrition for ants and many similar living entities. Reptiles, rodents, insects, bacteria, fungi and plant species that survive in the soil can directly or indirectly affect the decomposition of adobe structures. The nests and channels they create in the soil cause structural decomposition in the adobe. The nesting of some bird species inside mudbrick walls or feeding their offspring insects and similar organisms causes the destruction in mudbrick structures (Dede, 1997).

Plants constitute another group of life forms. Some plant species that have the opportunity to thrive on the surface of mudbrick walls may directly or indirectly cause the decomposition of these building elements. For instance, the volume of plant roots reached during their growth and development inside the adobe also means the formation of a channel as great as this volume. This volume expansion caused by plant roots can weaken the adobe soil, causing it to disintegrate more quickly. On the other hand, it is possible to mention the damage caused by living entities that provide nutrients from the roots or leaves of these plants. For instance, living entities that feed from the roots of these plants, as well as the channels opened in the soil to reach these roots may weaken the structure of the adobe soil, causing disintegration, and indirectly playing an active role in its decomposition (Gayurfar, 2009).

2.4. Damage Occurring as a Result of Erroneous Intervention

Portland cement-binding mortar, plaster and filler materials have been ascetained to cause significant damage in mudbrick restorations because of their high soluble salt content, brittle structure and different thermal expansion coefficients. These types of repair materials are going to lead to all moisture-related problems because they cause humidity and salinity as well as condensation in the structure, thereby cause damage to the wall (Staff, 2006).

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Use Palm Leaves Added to Adobe for Applications in The Restoration Process

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ABSTRACT

This paper discusses two points of Adobe buildings: The first point is to save that large heritage of earth architecture and Adobe buildings around the world, by restoring and repairing the damages of those buildings Sec. point is to find an alternative material to rice straw to be used for making Adobe brick, Provided that availability the same quality of rice straw.

Egypt is considered one of the oldest and famous for Adobe construction and it appears in Siwa Oasis and in Upper Egypt like the new Qurna village which is one of Hassan Fathy's works. The village because of the neglecting for years needs a lot of restoration work, so the paper will show some of the reasons and types of Adobe damages, and the techniques of repairing and restoring Adobe, As it known, water is the enemy of Adobe buildings, so we will focus on an absorbing water test, testing the palm leaves as an alternative material to rice straw, and comparing between them first as a raw materials in absorbing water, sec. after using them in producing the bricks, the samples made of palm leaves and the samples made of rice straw in absorbing water.

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

1 INTRODUCTION

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

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

When we mention about Adobe buildings, the historical and heritage buildings come to our minds first, and how to save and survive it again, it can be done by repairing and restoring it with a materials work out in a high quality as the original materials of the building, also guaranteed to remain for a long time, and as it known, water is the first enemy of Adobe buildings, from this point, Both rice straw and palm leaves were subjected to water absorption tests, before mixing with the soil (as raw materials) and after mixing with the

soil (as a brick), we observed that the reaction of palm leaf with water was always slow and little while the reaction of rice straw was active with water and fast.
For example, the brick made of palm leaves was absorbing the water slowly to reach 7 cm after 5 hours while the brick made of rice straw absorbed over 11 cm after 5 h. and totally collapsed after 10 h.

2 QURNA VILLAGE (HASSAN FATHY)

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

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

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

Figure 1. The market place in Qurna village – Hassan Fathi - Luxor – Egypt, Author

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

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

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

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

Although some of the buildings were undergoing restoration processes. The last was carried out in March 2019 under the supervision of UNESCO, but the restoration is not enough to cover the entire village, as the restoration of mud buildings "adobe buildings" is considering each building a special independent case upon the style and time required for restoration. (URL 13)

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

3 THE RESTORATION OF ADOBE

- **Adobe Restoration process**

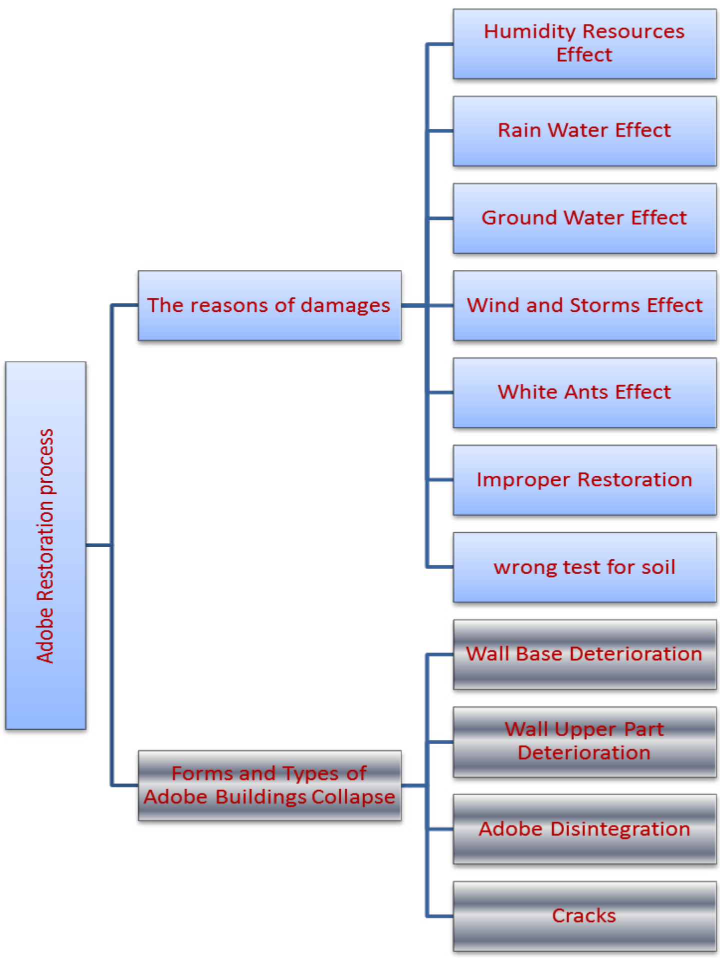


Diagram 1. The Diagram shows the Restoration process, the reasons of damage and types of collapse, by researcher

- **Techniques Used in the Adobe Restoration**

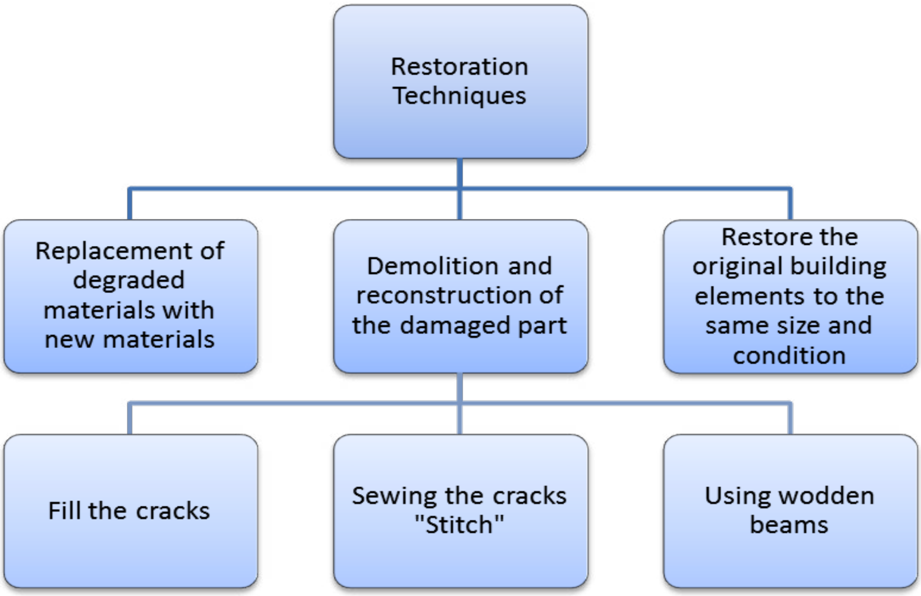


Diagram 2. The Diagram shows the Restoration Techniques, Author

- **Maintenance and Preservation**

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

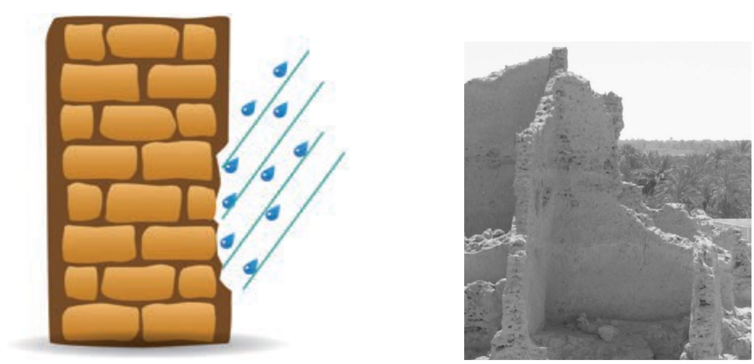


Figure 5. Rainwater impact on adobe walls

Figure 6. The wind affection on an Adobe wall, Siwa, Egypt,

The ground water affection starts to cover the Adobe wall

Figure 7. The ground water affection on an Adobe wall

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

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

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

Figure 11. Installation of timber beams for the treatment of a vertical discontinuity
Figure 12. Timber beams at the corner of adobe walls

4 THE ADOBE BRICK AND ITS COMPONENTS

In Egypt:
2 Soil (2clay + 1sand) + 1 straw + water = the mixture
2 : 1
70% : 30% : as the mixture needs
Mix all components together and leave it to ferment well for 8 to 40 h; cover the mixture by plastic cover. Fermentation produces lactic acid because of the Lactose in the straw. After fermentation process, we start to put the mixture in the brick form (25*15*5 cm), and then we leave it under sun to dry well for 3-6 days. We found that the brick made of pure soil shrank 37% after the drying process. Adding straw has two advantages: First, it works as a fabric for the mud that makes bricks coherent and secondly, it reduces the shrinkage rate of bricks.

Figure 13. the mixing process

Figure 14. the framing process

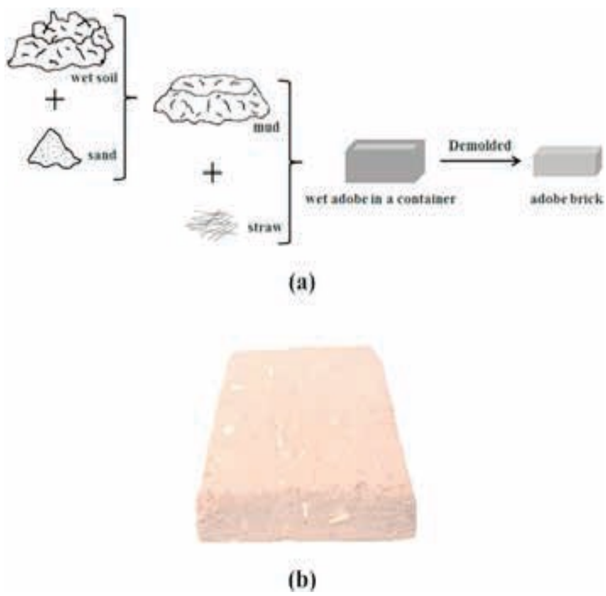


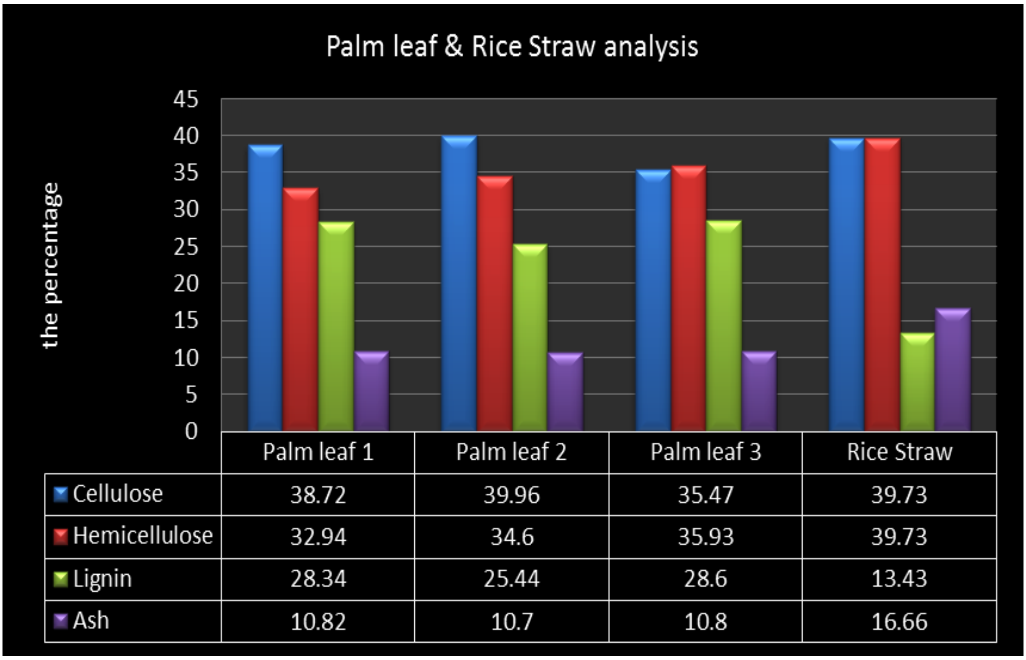
Figure 15. Showing the components of Adobe brick and how to get the brick

4.1 The Rice Straw and Palm Leaves

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

1- The result was almost as close between rice straw and palm leaves samples as for Cellulose.

2- The result was higher in rice straw than in palm leaves samples as for Hymselolose.



Charts 1. Comparison between the results of rice straw and palm leaves sugar percentage: the researcher

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

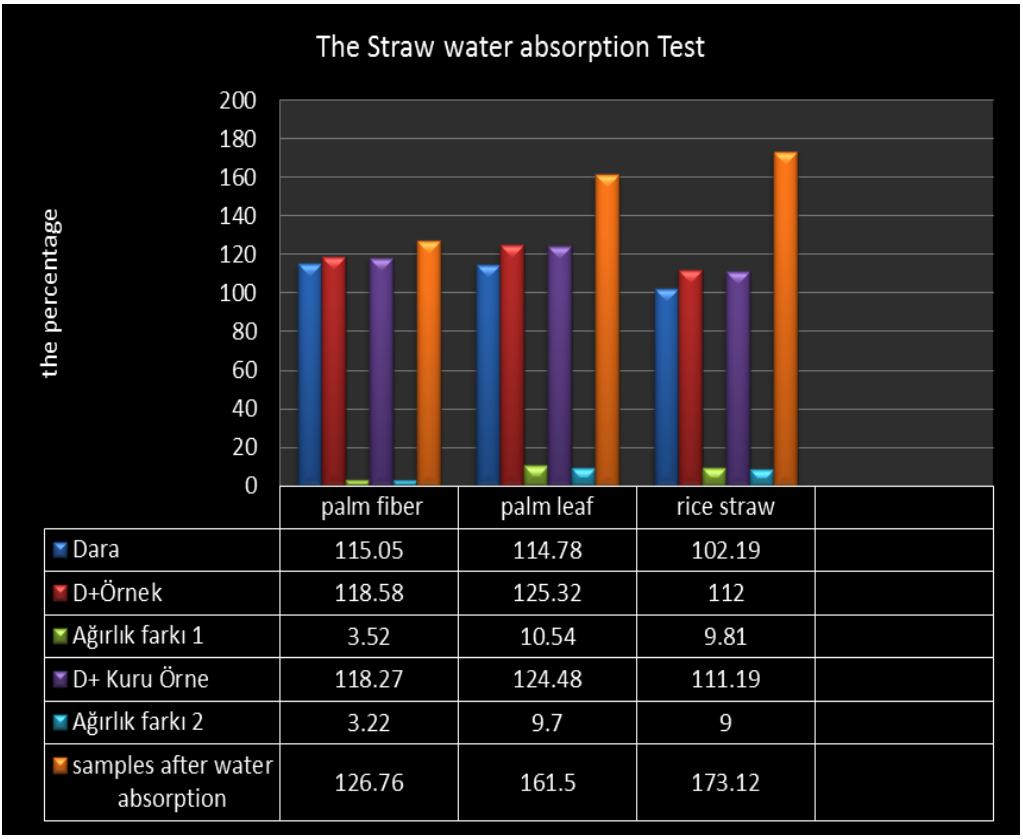
In three samples of rice straw, palm leaves and palm fiber

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

calculated upon absorption ratio

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

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



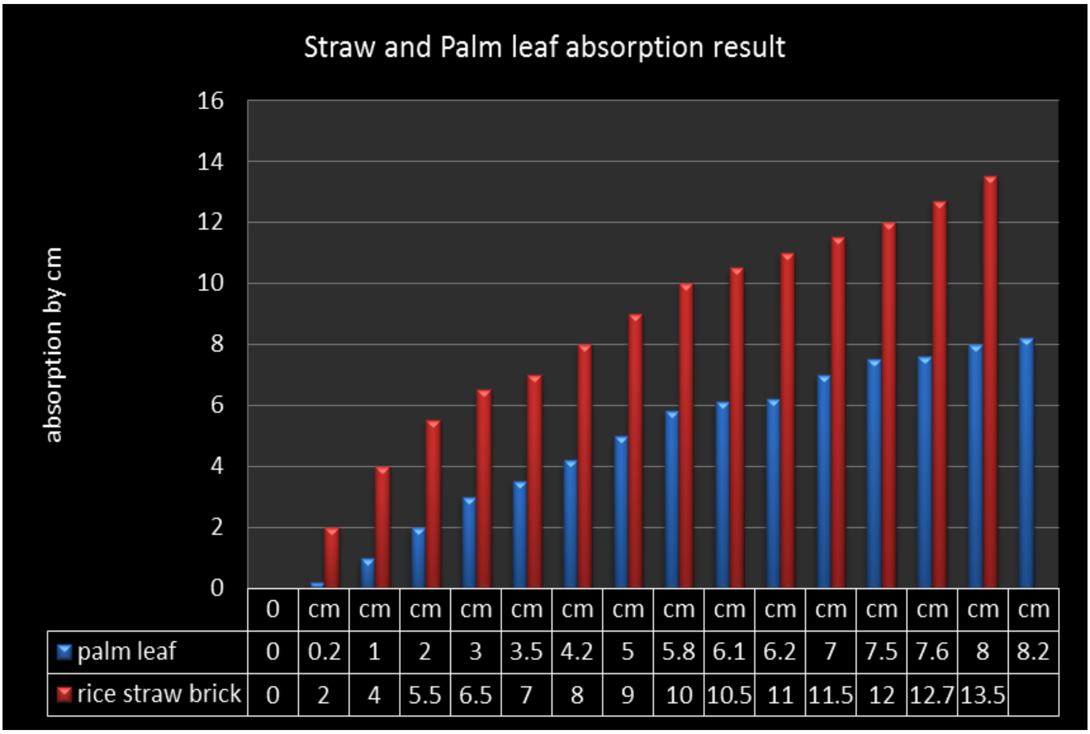
	palm fiber	palm leaf	rice straw	
Dara	115.05	114.78	102.19	
D+Örnek	118.58	125.32	112	
Ağırlık farkı 1	3.52	10.54	9.81	
D+ Kuru Örne	118.27	124.48	111.19	
Ağırlık farkı 2	3.22	9.7	9	
samples after water absorption	126.76	161.5	173.12	

Charts 2. water absorption rate of rice straw and palm leaf

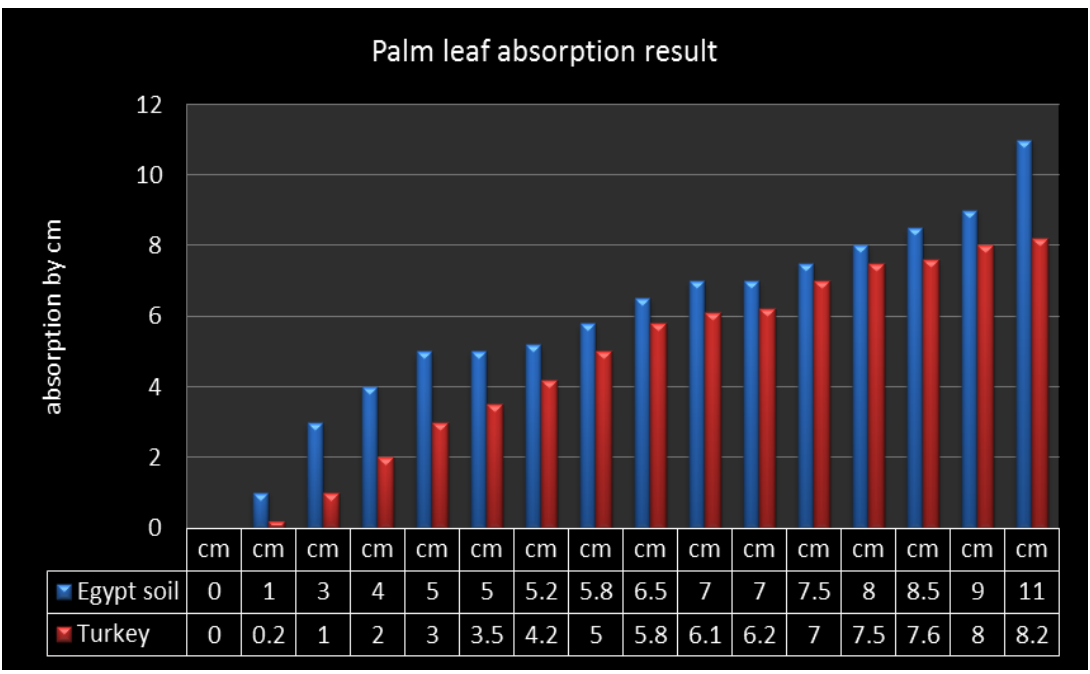
The importance of this test is to know the ability of samples to absorb water, as this fiber is an essential element in the composition of the adobe and therefore the more straw capacity used to absorb water increased the chance of saturation of the brick with water, and this presents the brick to rapid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

4.3 Adobe Water Absorption Test

According to the ASTM C1585 standard which is using in absorbing water test, This test was made to determine the percentage of water absorption in Adobe brick made of palm leaf as a constant fiber and two different soil from Egypt and Turkey, it's for testing the quality of palm leaf with different soils, whereas, our work is mainly on the palm leaf as an alternative to rice straw.



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



Charts 4. Palm leaves constant factor, soil variable factor (Egypt, Turkey)

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

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

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

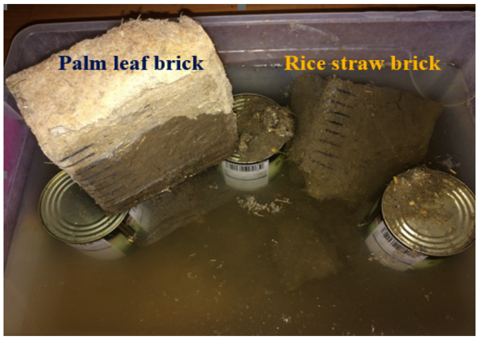


Figure 19. After 12 hours, the final result is the collapse of the rice straw Adobe brick, Author

5 CONCLUSIONS

Adobe construction means (land/plant). So that it changes in some of its properties. The exploitation of surrounding environmental materials, such as rice straw or palm leaf with silt and clay in all cases produces a brick and building environmentally friend, energy-saving and economical in building, all construction materials under our feet in the site. So by using palm leaf as an alternative material to rice straw, the result was positive as follows.

The added palm leaf mixed with the soil proved to be very effective in the low absorption of water, in both cases before mixing it to the soil and while it is raw material, and after adding it to the soil to make Adobe brick, the result was slow absorption and less water compared to the Adobe brick made of rice straw. The importance of this point (absorption of water) in dealing with the Adobe brick later in its resistance to moisture, and slow absorption or interaction with groundwater one of the causes of destruction of Adobe buildings. Also, the lack of water absorption will allow the repaired part to require less periodic maintenance, which can be quickly checked and controlled in the case of discharge water, due to the low and slow absorption of the water in the new mixture made of palm leaves.

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Examples in Kula of the Turkish House with Open Exterior *Sofa*: Spatial Organization and Structural System

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ABSTRACT

The well-known Turkish architect Sedat Hakkı Eldem, who has undertaken the most comprehensive study of the Traditional Turkish House, asserts in his work entitled, Türk Evi Plan Tipleri (Turkish House Plan Types) (1955), that the element of the sofa is the main archetype in the plan of the Turkish House and creates a typology based on the sofa. In this typology, Eldem distinguishes 4 main types: houses without a sofa, with an exterior sofa, an inner sofa and with a central sofa. The most widely encountered scheme of the Turkish House in Eldem's typology is the house with an exterior sofa layout, which is the plan constituting the next developmental phase of the house plan with no sofa. This plan in its most simple form is used in country, town and city, and consists of a room or a series of rooms with an open sofa situated in front. The sofa in this plan is in the shape of a front sofa and appears to be an open but covered veranda with a wooden post/column or arch that looks out onto the street, garden or courtyard. The side of the sofa facing the courtyard is covered with a wide eave. The sofa serves as a space of circulation or distribution that strikes a relationship between this space and the rooms, whose doors open out into the sofa. Daily life transpires in this common space in front of the rooms. Also a sitting and congregational space, the sofa has the additional function of being a service area. The family engages in activities related to its source of livelihood in the sofa. The sofa has been given various names in different regions including hayat, çardak, hanay, sergah, yazlık, or divanhane. Another renowned Turkish architect, Doğan Kuban, who has been recognized for his studies of the Turkish House, has called this type of house "the Hayat House" (Kuban 1996:28), which is known in the Balkans as the House with Çardak.

This study will make an evaluation of the type of "house with an exterior sofa," using examples found in Kula. The exterior sofa type of plan seen in the area will be reviewed in terms of the features of its spatial organization and structural systems.

Keywords: Kula, the Open Exterior *Sofa* House, Spatial Organization, Structural System

1. INTRODUCTION

The renowned Turkish architect Sedat Hakkı Eldem, who is responsible for the most comprehensive study of the Traditional Turkish House, asserts in his work entitled, *Türk Evi Plan Tipleri (Turkish House Plan Types)* (1955), that the element of the *sofa* is the main archetype comprising the plan of the Turkish House and creates a typology based on the *sofa*. In this, Eldem introduces 4 main types of plan: houses with *no sofa, with an exterior sofa, an interior sofa* and a *central sofa* (Eldem 1955:24). The most widely encountered scheme of the Turkish House in

Eldem's typology is the house with an *exterior sofa* layout, which is the plan constituting the next developmental phase of the *house plan with no sofa*. In its most simple form, this plan consists of a room or series of rooms with an open *sofa* situated in front (Eldem 1955: 24, 33). The *sofa,* situated in this way in front of rooms, appears to be an anterior *sofa* that opens out onto the street, garden or courtyard in the form of a roofed but open veranda with wooden posts/columns or arches. The courtyard side of the *sofa* is covered with wide eaves. This is circulation space that provides an interaction between the *sofa* and the rooms, and all of the doors of the rooms open out onto the *sofa*. Sometimes there is a hearth on one end of the sofa. Daily life transpires in this common space in front of the rooms. At the same time, the *sofa* serves as a sitting and gathering space and another of its functions is to act as service space. The *sofa* is the place in the house where different activities take place, depending on the economic status of the household. *The sofa* is called by various other names in different regions, including *hayat, çardak, hanay, sergah, yazlık, divanhane* (Eldem 1954: 16). Doğan Kuban calls this type of house "House with Hayat" (Kuban 1996: 28).

In time, this plan scheme encompassed various sub-types of layout to which were attached an iwan, seki (platform), kiosk and added rooms and which were described as exterior sofa with iwan, exterior sofa with kiosk, exterior sofa with kiosk and iwan, exterior sofa with rooms on one side, exterior corner sofa, exterior sofa surrounded by rooms on one or two sides, and an exterior sofa with rooms on three sides (Eldem 1954: 33-34, 80). The exterior *sofa* type may have one, two or three floors. The houses are accessed from a double-winged wooden door. The courtyard is the part of the house that is used the most and does not always display a regular geometrical shape. If the courtyard is windowless and has high walls to accommodate privacy, it is called *hayat* or *taşlık.* Service areas are found on the ground floor and include elements such as a barn, storage space, stockroom, a kitchen, cupboards, oven, a kindling or coal bin, a hayloft, toilet and hearth.

The house is situated on one side of the courtyard or garden and its south facade looks out on this space. The posted *sofa* is on the upper floor but sometimes the posts of the *sofa* are repeated on the lower floor as well. In the three-floor examples, there is a ground floor, a middle floor and an upper floor. On this floor, known as a *kışlık,* or "winter room," there is usually a kitchen which can also be used as a bedroom if needed, as well as another room and sometimes a toilet. The most prominent structural element of the *kışlık* (winter room) is the stove. The rooms on this floor are extremely austere.

It is the upper floors, which are the main living spaces, that are the most ostentatious and these have an open and posted *sofa* with rooms situated side by side to the back, and if any, an iwan, platform and a kiosk-room. *The sofa* may be straight, or in the shape of an L or U. The rooms on the street side project over the middle floor. This floor is also called the *yazlık,* or "summer room" and its ceilings are higher. The room at either end of this floor is more elaborate than the rooms in the middle in terms of size, decoration and arrangement; this room is called *başoda* or "main/head room." The *başoda* was generally used as a guest room and was located on the south, projecting onto the street.

This study will make an evaluation of the type of "house with an exterior *sofa,"* using examples found in Kula. The exterior *sofa* type of plan seen in the area will be reviewed in terms of the features of its spatial organization and structural systems.

2. KULA HOUSES WITH *EXTERNAL* SOFAS

The little town of Kula, Manisa, at an altitude of 630 m. above sea level, is situated on volcanic topography (Akyüz, Orhun, Yıldırım, Arıtan 1991: 33). The ancients called the area around Kula "Katakekaumene," meaning "burnt, scorched land." This description was seen in the works of the ancient authors Strabon, Vitruvius, Stephanos of Byzantion and Eusthatios. Between the 7th-11th centuries, Kula was Opsikion, one of the Byzantine military and administrative zones. Opsikion was the name for the area in the Byzantine era. This land at that time was divided into four at first and then forty administrative sections called Themas, each under a Strategos (commander), who was responsible for the administration and more prominently, the defense of the region. In the 14th century, Kula passed into the hands of the Germiyanoğulları Principality and its commercial might gained significance during the Ottoman Era.

The houses of Kula have courtyards that are surrounded by high walls (at least 3 m. high) that provide privacy. The courtyard is paved with granite or slate. Access to the houses is through a double-winged wooden door. The walls are of stone on the ground level, and of timber frame at the level of the second floor. The walls on the ground floor are blind. The houses are situated on one side of the courtyard or garden and their south facades look out on the courtyard. This way, the view and the sunshine appear on the same side of the house. The posted *sofa (hayat)* is on the upper floors but sometimes the posts of the *sofa* are repeated on the lower floors as well. The facade of the *sofa* with wooden posts looks down on the courtyard or gardens. The *sofa (hayat)* faces the north and is open to the south. All take in the onshore winds, which are a major climatic feature of the region. The *sofa* with its posts runs the length of the houses, and the walls of the rooms looking onto the *sofa* constitute the main facade. Life in the Kula Houses, which were designed to accommodate the traditional extended family, transpired in the courtyard during the summer and on the middle or top floor in the winter.

The houses generally have one or two stories that lie above a ground floor. There is a smattering of three-story examples as well. The ground floors contain service areas such as barns, storage rooms, granaries, kitchens, cupboards, ovens, wood-coal bins, hay bin, toilets and hearths. The ground floors have an irregular geometry. The walls of these stories are blind; there are no windows looking out into the street.

Some of the larger houses are three-storied. These houses belong to families of a higher socioeconomic level and are made up of three stories: a ground floor, a middle and an upper floor. Besides service spaces, the houses have quarters for the help on the ground floor and above that, a low-ceilinged intermediate floor with a *kışlık* (winter room). On this floor, which can also be used as a bedroom, there is usually a kitchen, a room and sometimes a toilet. This floor is easily heated and insulated and its rooms are smaller. The side of this floor looking onto the street has thick stone walls and the windows are constructed in smaller dimensions in proportion to the other windows in the house, in order to withstand the harsh winter elements. The rooms on this floor look out onto the street but there are never projections here. The most important construction element of the *kışlık* is the hearth. The rooms on this floor are very plain.

The main living space in the houses is the top floor, which is accessed by stairs leading up to the *sofa.* The top floor is the grandest in the house. It contains an open sofa *(hayat)* with a post or an arch of the Bursa type. In the case of arched *sofas,* the tops of the wooden posts are decorated with vegetative or geometrical ornamentation. The balustrade of the sofa (hayat) is of wood and of a unique style that can be seen nowhere else in Anatolia (Fig.1). These balustrades have been used at the same time on the *sofa* (hayat) stairs and on top of the platform *(seki)* (Fig. 2) The balustrades are the most decorative elements in the house.

Fig 1. Stair and sofa (*hayat*) balustrades

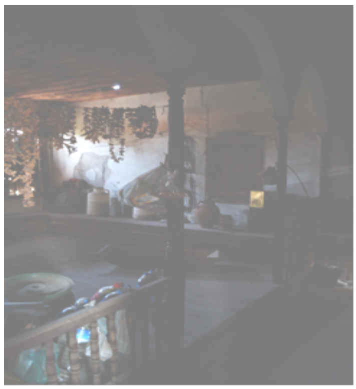

Fig 2. Spaces below and above the platform with balustrades.

In the traditional Kula houses with an open external sofa, the *sofa* (*hayat*) generally lies straight and has rooms arranged in a row in back. This floor is also called the *yazlık* (summer room); its ceilings are higher. The rooms on this floor are in back of the s*ofa* (*hayat*) and are sometimes two, three or even more in number. The rooms looking toward the *sofa (hayat)* have windows. Besides rooms, there are also platforms *(seki)*, kiosks, and iwans in this area. The "plan with an open external sofa" has been used on this floor. The houses in the region appear to have 3 types of plans "with an open external sofa."

1). Two rooms with an External Sofa: The most widely used type of plan in the area reveals a configuration where there is a wooden posted or arched open *sofa (hayat)* in front with sometimes a large and a smaller room and sometimes two rooms of the same size arranged side by side (Fig. 3).

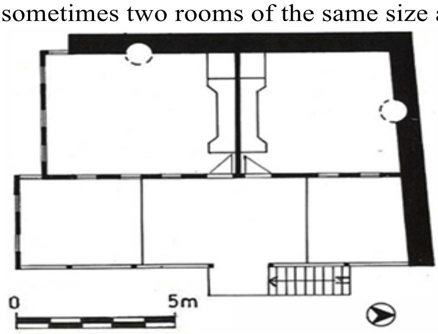

Fig 3. Plan with two rooms and external sofa. Top floor layout of Külkömür Residence (Bozer 1988, Çizim 1).

2). Plan with an External Sofa and *Iwan*: The most popular type of plan after the "two rooms and external sofa" layout is the "external sofa and iwan" type of configuration (Fig. 4). This type of plan features rooms with chamfered doors. At both ends of the sofa *(hayat*) are platforms *(seki)* and the floor of the iwan is at the same level as these *seki* structures (Fig. 1, Left). The *seki* platforms sometimes have two or three double-winged windows of wood.

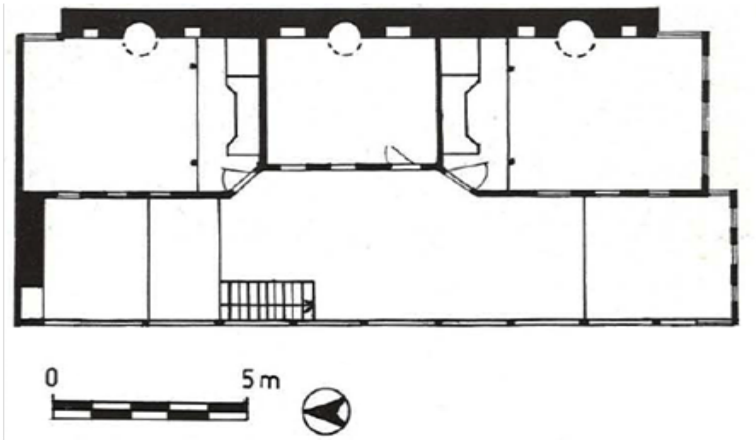

Fig 4. Plan with an External *Sofa* and *Iwan* (Beyoğlu house upper floor. The *iwan* was later closed off.) (Bozer 1988, Drawing 2).

3). Plan with an External Sofa, *Iwan* and Kiosk: In this configuration, the house that was constructed in the order of a "plan with external sofa and iwan" has windowed kiosks on one or both ends of the *sofa (hayat)* that protrude out toward the courtyard (Fig. 5).

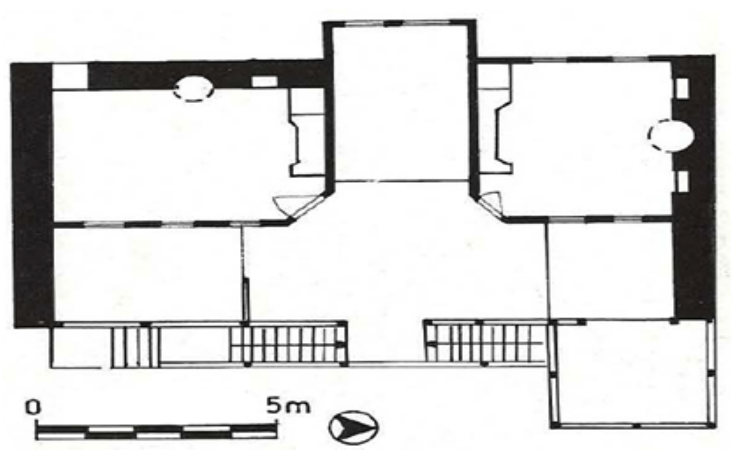

Fig 5. Plan with an External Sofa, *iwan* and Kiosk: (Bozerler Residence) Kiosk on one end of the *sofa (hayat*) (Bozer 1988, Drawing 4).

In situations where the kiosks are annexed to the sofa (hayat) on both sides, the sofa (hayat) takes on an U-shaped form. Examples of the U-shaped *sofa (hayat)* have more than two rooms. In the structure in the region known as the "Büyük Göldeliler Residence", the kiosks are situated at the two ends of the *sofa* (*hayat)* in this six-room house with iwan (Fig. 6A). In the "Terzi Ahmet Residence," there are four rooms (Fig. 4B). In this example, the kiosks have sometimes been turned into kiosk-rooms.

Fig 6. A: Büyük Göldeliler Residence. B: Terzi Ahmet Residence (Bozer 1988, Drawings 8, 9).

In Kula, rooms are called *hane* (section) or *göz* and the rooms in a row for the length of the *sofa* are called *sıra odaları* or "rooms in a row." The rooms at either end of the row are rooms that are given more importance in terms of arrangement and decoration and for this reason are called "baş-köşk" or "main/kiosk-room." This main room which is used as a drawing room protrudes out over the street. The Beyler Residence (Beyoğlu House) and the Zabunlar Residence are striking examples of the configuration where the plan includes these main rooms. The room at either end of this floor is more elaborate than the rooms in the middle in terms of size, decoration and arrangement and is called *başoda* or main room. Sometimes both of these end rooms are arranged as main rooms. The *başoda was* generally used as a drawing room and was generally situated on the south, projecting onto the street. This room usually has two faces and is the house's most decorative room. The main room was lit up by many windows and upper windows (*revzen*) that looked out onto the courtyard and street. Access to the başoda was sometimes from beneath a wooden columned or arched section of platform or *seki* (shoe cabinet). This room, the biggest in the house, had richly decorated walls and ceiling and was accepted as the symbol of the household's wealth and the family's status in the community. The başoda and kiosk-room has wooden bars on its windows. The kiosk and main room *(başoda)* are furnished with low davenports and the ceiling is decorated with *kalemiçi* hand carvings.

All of the rooms in the house have plentiful windows that are distinguished as being below *(seki altı)* and above *(sekiüstü)* the platform. This separation is distinguished by both the difference in floor levels or by either a wooden banister or arch (Fig. 9). Inside the rooms are the interior spatial elements of *bedding closet,* cabinet, and a *gusülhane* or bathing cubicle with wood cabinets*,* davenports and, on two sides of the gusülhane, niches called *gözenek* (Bozer 1988, 11). In almost every room there are hearths with decorative wooden or plaster hoods and davenports. The hearth with its wooden hood is an indispensable element of interior decoration on this floor. The hoods have been adorned in openwork technique. There is a hearth in every room. The hearth shafts are made of large sections of stone and the chimneys visible from the roof are arranged in a bonding system of köfeki stone and brick. There are shelves called *sergen* that stretch out continuously over the tops of windows and walls. These shelves are where the most valuable pieces owned by the household are exhibited. The room ceilings are of wood and have been decorated in geometrical motifs in the *çitakari* woodwork technique. The concentration of adornment in the room and hearths varies in direct proportion to the significance of the space. The decorations on the ceilings, the carvings on the bannisters and posts, the engravings on the doors and cabinet doors, the matchboard wood and other details all reflect a fine sense of elegance and artistic mastery. The centers of the ceilings are generally octagonal. The room doors are single-winged and display *kündekari* workmanship (Fig. 7). In some houses, the walls looking toward the *sofa* (*hayat)* have upper windows made of plaster (*revzen*). The room doors are sometimes plain, sometimes chamfered.

Fig 7. The platforms *(seki*) in the rooms and doors have been carved in *kündekari* style.

Sometimes the rooms on the upper floor on the street side project over the middle floor. The başoda or main rooms have generally been designed to project over the street. Sometimes it is the *seki* that projects out over the street and sometimes the *sofa (hayat*) (Fig. 8, 9). The projections go in two directions in some cases. On the other hand, there are also houses without projections (Fig. 10).

Fig 8. Example of the *hayat seki* and *başoda* projecting out into the street.

Fig 9. *Hayat seki* and main rooms *(başoda)* projecting out into the street.

Fig 10. Open exterior *sofa* houses without projections.

The bay windows (*cumba*) of the region's houses are of two types: straight and squared projection (Fig. 8, 9, 11, 13). The squared projections serve the purpose of protecting against the wind or permitting a view of the scenery on irregular streets. These projections also provide the street with shade. The projections do not have buttresses.

The roof covering of the houses are of *alaturka* brick. The houses have hipped roofs with wide eaves. Alaturka brick is used as a covering for the roofs; these are of the dimension 15-12x30 cm and made in local furnaces.

Fig 11. Kula houses with square projections.

3. STRUCTURAL SYSTEM OF KULA HOUSES WITH OPEN EXTERIOR *SOFAS*

The construction system of the upper floor walls of the houses in the region are timber-frame (*hımış*) (Fig. 10). The main structural material used in the houses is timber. Timber is the material used in the loadbearing system that makes up the timber-frame *(hımış)* structure. The ground floors have horizontal wooden beams and walls of masonry made from local stones (Fig. 12).

Fig 12. The timber-framed system (*hımış*) used to build the walls in the houses of Kula.

Poplar trees are used for the timber-frame system. The frame walls of the stone and mudbrick-filled timber-frame (*hımış)* carcasses of the houses have been arranged so that the main vertical timber posts are planted with specific intervals between the lower and upper bases. The posts at the corners are thicker. The buttresses connect the post and the base in the shape of a triangle. Then timber buttresses have been planted in between the main posts in crosswise fashion (*yanlama, tırnak*) at the 2-story level. Transverse buttresses are used to combat horizontal forces and bending. These buttresses are supported by smaller transverse buttresses. The gaps in-between the main posts and buttresses are filled in with smaller sized intermediate posts planted vertically and diagonally (Fig. 12). The intermediate posts in the houses of this region have been planted very close to each other. The intermediate posts divide the gaps into smaller sections. This system of closely standing posts allows for all horizontal and vertical loads to be transferred to the foundation via the timber components. The filling materials of this timber frame consist of stone and mudbrick, cemented with mud.

The land on which Kula has been built is covered with rock formations of black andesite and basalt as a result of the lava flowing down from the Divlit volcano. A stone masonry wall construction technique using rubblestone cemented with black stone and limestone mortar has been employed in the ground floors as well as in the lower floors of the houses (Fig. 12). Another type of stone used for paving not only on the ground floors and the courtyards but also in the street is *kayrak taşı* or slate. The walls of the ground floors are supported by horizontal beams. The walls of the basement and ground floors as well as the upper floor walls contain stone in blind sections reserved for hearth and cabinet space.

The timber frame (*hımış*) filling of the upper floor walls contain propylite and what is called *küfeki* stone, a lightweight black malleable type of tufa formed by the lava of the Divlit volcano. The filling is cemented with grout made of a white lime mortar. Timber-work *(bağdadi)* is installed on this frame (Fig. 13). The walls have sometimes been plastered with mud-mortar and painted with the colors of dusty rose, light green, light blue or yellow, which are the preferred tones in the region (Fig. 8, 9, 10, 12). In some houses, only the timber frame (*hımış*) of the top floors have been plastered with mud-mortar and painted while in some, the projections have been covered with lath and plaster (Fig. 13). Another area where lath and plaster has been used besides in the projections are the overhangs. The projections are either plain or finished off with a herringbone technique of lath and plaster (Fig. 13).

Granite is seen together with slate on the streets as paving. Slate has been used along the edges of the walls for ease of walking. Other parts are made of granite cobblestone. The doors and windows have lintels and frames of marble that originate from the marble quarries in and around Kula.

Fig 13. *Bağdadi* projections without beams

4. CONCLUSION

The houses of Kula are significant because they carry some of the most original examples of one of the most common forms of the traditional Turkish house layout of the "Plan with Open External *Sofa*." The houses are important because they also contain some of the sub-types of the "open external *sofa*." They are additionally unique due to their systems of construction and because of the local materials that have been used.

Some of the structures have deteriorated over time due to natural causes. The human factor, however, is responsible for inflicting the worst harm on these houses. Today, the original owners of the houses have moved away, migrating to other locations, renting out these structures to tenants of low socio-economic stature. The concrete additions that the new occupants have made to the house have spoiled their outer appearance. The *sofa (hayat)* in most of them have been closed off with railings and very few of the *sofa* stairs have been preserved in their original form.

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Evaluation of Adobe Use in Traditional Istanbul Residential Buildings in The Light of Archive Documents

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ABSTRACT

Himis, adobe filled timber framed construction technique, had an important role in the residential practice of Istanbul in the Ottoman period. Especially in the pre-industrial period, it was generally preferred as adobe was a low-costed and easily obtained material. On the other hand, in the studies conducted on the traditional residential architecture of Istanbul, *himis* structures have been discussed superficially. The aim of this study is to examine the use of soil materials in Istanbul dwellings in historical process.

Information about the existence of *himis* houses in Istanbul before the 19th century is based on Ottoman Archival documents, engravings and observations in travel books of foreign travelers. Industrial developments in 19th century led to rationalization of traditional building production and the use of fabricated wooden elements increased. So, towards the end of the century, unfilled wooden framed with wooden planking houses became widespread. However, adobe filled timber framed construction system continued to be implemented in the urban areas. As from the first quarter of the 20th century, the application of reinforced concrete technique has became widespread in residential construction. This is an indication of the end of traditional construction systems. Nevertheless, archival records and architectural documentation show that the adobe filled timber framed structures, which were built in the previous century, survived in the urban areas until the middle of the 20th century. *Himis* houses of İstanbul which had decreased in number, were completely destroyed after 1950, because of urbanization pressure. Today, *himis* houses can be seen only in rural settlements along the perimeter of Istanbul. In this context, Şile district of Istanbul, a region where traditional *himis* dwellings continue to exist, are discussed in this study.

Keywords: *Himis* houses, Traditional houses of Istanbul, Sile houses.

1 INTRODUCTION

Nowadays, "Istanbul's traditional residential architecture" brings to mind the unfilled timber framed with wooden planking structures. However, the fact that these wooden houses that characterize "Old Istanbul" were built in the period of the late Ottoman when the industrial facilities increased, makes the notion of 'traditional' open to discussion.

Before the use of industrial wood became widespread in Ottoman Istanbul, *himis* technique was widely used in housing construction [1,2]. The choice of adobe as filling material in the *himis* houses is generally explained by the fact that adobe was a cheap and easily obtained material. Therefore, until the last quarter of the 19th century, adobe filled wooden framed houses were preferred by middle and low income people.

In this study, firstly, the use of soil material in Istanbul dwellings is examined from a historical perspective in the light of the Ottoman Archive documents, engravings, photographs and travel books of foreign travelers. Then, the use of soil material in the examples of traditional dwellings that have been able to reach today is discussed through the *himis* structures in the villages of Sile district of Istanbul.

2 HISTORY OF HIMIS TECHNIQUE IN RESIDENTIAL CONSTRUCTION PRACTICE OF ISTANBUL

There are limited sources of information about the construction techniques and materials of the Istanbul dwellings in the 15th century. The most general information regarding the housing stock taken over by the Ottomans from Byzantine, can be obtained from the *Tahrir* Records dated 1455 prepared by Mehmed II. In these records, Istanbul houses are classified as *suflî* (single-storey) and *ulvî* (two-storey) [3]. In Buondelmonti's engraving dated 1420, it can be seen that a significant portion of the buildings perceived as residences in the city are single storey buildings [4]. According to Tanyeli, since wooden material was brought from outside of Istanbul in this period, timber framed system was expensive for the single storey buildings, so the main components of low-rise houses were rubble stone and adobe [1].

The oldest written and visual sources providing detailed information about the construction technique of the traditional dwellings of Istanbul are dated to the 16th and 17th centuries. In a *foundation* record dated 1613, it is clearly stated that a *tahtanî menzil* (single-storey house) was built with *çatma* (timber framed) technique [5]. This information coincides with the description of an early 17th century Istanbul house in an engraving in travel book of Salomon Schweigger [6]. Another traveler, Sanderson, reports that the city had narrow streets and the houses were usually made of stone, wood and ravine brick [7]. Similarly, P. della Valle depicts the Istanbul dwellings in 17th century as adobe filled timber framed. Valle explains that during the construction of the houses, similar to the shipbuilding, firstly the wooden framework was installed, then the roof was placed to protect the frame from the rain, and finally the gaps between wooden bearing elements were filled with soil [8].

According to the information given in Evliya Çelebi's *Seyahatname* (travel book*)*, there were 1000 adobe artisans and 500 brick artisans in Istanbul in the 17th century [9]. This data shows that during this period, adobe was presumably preferred more than brick as filler material in the construction of *himis* houses. However, towards the end of the century, a decision of *Divan-ı Humayûn* (Emperial Council) which was taken as a precaution against great Istanbul fires, is an indication that the use of wood is becoming widespread. In the decision, dated 1696, which was prohibited the use of wood as *elvah* (façade cladding) and *pedavra* (roofing), it was ordered that the houses in Istanbul constructed by using stone, lime or mud, as seen in the dwellings of Anatolia [10].

In 18th century, the demand of adobe material was so high that competition among the adobe artisans developed. In a document dated 1757, two artisans complained to the Kadi of Galata that other artisans hadn't produced adobe in accordance with *Seriyye* Records. In response, the Kadi decided that the adobe orders coming from customers should have to be supplied in order by the adobe artisans [11].
Pococo, who visited Istanbul in 18th century, reports that most of the Istanbul houses were timber framed filled with revine bricks [12]. One of the most important developments in the housing construction technique of this period was the application of the exterior plaster directly on the *bagdadi* laths rather than directly on the filled wall [13].

In 19th century, developments affecting selection of construction techniques and material in housing production arose in parallel with the modernization efforts of the Ottoman Empire. The production of standard wooden elements by using steam powered machines led to widespread unfilled wooden framed with wood planking structures. However, in this period, the application of the adobe filled wooden framed construction technique continued, and even foreign entrepreneurs were granted concessions in the production of adobe. In an official letter, dated 1840, by the Ministry of Foreign Affairs, it is stated that an entrepreneur named Dora was given the privilege to open an adobe workshop. Also it is particularly emphasized that some special tools would used to compress the soil, in order to increase the durability of the produced adobe 14].

One of the interesting documents on this subject is a letter of 1858 written by a French engineer to the Ministry of Foreign Affairs. In the letter, a 10-year concession is required for the implementation of the massive mudbrick construction system, which is called as *pisé* technique [15]. Foreign travelers who came to Istanbul in 19th century state that adobe filled houses were numerous in Galata, but they were flimsy structures [16]. It is possible to see these structures in Istanbul photographs dated to the second half of 19th century [17].

It is difficult to say the exact date which the production of adobe filled houses was finished. However, in this context, the implementation of the reinforced concrete construction technique for the first time in the early 20th century is an important development. After the establishment of the Turkish Republic, the construction of reinforced concrete houses became widespread. So, reinforced concrete construction regulations adopted in the 1930s show that traditional construction techniques have come to an end.

Adobe filled wooden framed houses were survived in the city until the mid-20th century [12]. In some of the Istanbul panoramas in the *Encumen* Archive, it is possible to come across the last remaining *himis* houses of the city [18] (Figure 1). In archive research, only one *himis* house that was decided to be legally protected by Conservation Board of the early Republican period *(Muhafaza-i Asar-ı Atika Encümeni Daimisi)* was found. This building is located in Fatih district on the opposite of Kefevi Mosque (Figure 2). However, in the inventory record of this structure, which was able to reached the 20th century as an exceptional example in terms of construction technique, it is stated that it had to be preserved as it had the value of art history [19]. This structure, which was also documented by S.H. Eldem with architectural drawings and photographs, has not survived [13].

Figure 1. Looking towards the Hacı Ferhat Ağa Mosque in Cibali District of Fatih District [18].

The adobe filled houses, which had decreased in number in the city, were completely destroyed due to the unplanned growth of urban settlements, since the second half of 20th century. Today, it is possible to see examples of traditional *himis* houses only in some rural areas of Istanbul.

Figure 2. A *himis* house in Dervişali Neighborhood of Fatih District [19].

3 SURVIVING TRADITIONAL HIMIS HOUSES IN ISTANBUL

Nowadays, some of the rural settlements where we can see the last remaining examples of *himis* houses are located in Şile district on the Anatolian side of Istanbul. In this study, forest villages of Sile district, adjacent to Kocaeli province (Çengilli, Değirmençayırı, Hasanlı, İmrendere, Teke, Yağcılar and Yazımanayır Villages) were examined.

Traditional village houses in the working area, have been constructed within twigs and mud filled wooden framed construction technique. (Figure 3). In this technique, basket weave with thin branches is made between the wooden bearing elements and then the gaps are filled with straw-added mud mortar. Plaster with a mixture of linen tow and lime was applied to the interior and exterior walls and finally the exterior walls covered with wooden planking. Also in stables and bake houses, adobe filled timber framed construction system was used (Figure 4).

Village name	number of himis houses		number of stables and bake houses	
	in use	empty/ demolished	In use	empty/ demolished
Çengilli	1	2	-	-
Değirmençayırı	1	2	-	-
Hasanlı	3	-	-	-
İmrendere	4	2	-	2
Teke	5	14	-	2
Yağcılar	-	2	-	-
Yazımanayır	3	2	1	-

Table 1. The number of himis structures in the study area.

A total of 46 traditional structures were identified in 7 villages within the study area. Only 18 of these buildings are in use, 28 of which are empty and/or demolished. The smallest number of traditional buildings are located in Yağcılar Village and the highest number of them are in Teke Village. Of the 19 traditional residential buildings in Teke Village, 5 are used as residences and 14 are empty and/or demolised. In the study area, only 17 residential buildings located in Teke Village have been registered with the decision of İstanbul Regional Conservation Board. So, among the villages in the study area, only Teke Village was able to preserve a large part of its traditional residential texture.

Figure 3. A *himis* house in Teke Village (Y.Erdal 20.05.2019).

Figure 4. A *himis* barn in Imrendere Village (Y.Erdal 20.05.2019).

3.1 Conservation ıssues in the study area

In the studied villages, except for Teke Village, it is observed that there are very few traditional *himis* houses. One of the upper scaled problems that cause this situation is the pressure of urbanization. The fact that the traditional houses of Teke Village have been registered with the decision of the Conservation Board has an important role in the protection of the traditional housing texture. However, it is clear that registration only is not sufficient for sustainable conservation.

The most important problems in the study area is the proliferation of the reinforced concrete construction system and the decreasing number of users of traditional houses. The traditional houses in use, are subject to poor repairs due to the decreasing number of traditional building artisans. The most common repair mistake is the implementation of hollow bricks and briquettes between wooden bearing posts

4 CONCLUSION

Himis technique has an important role in the residential construction tradition in the Ottoman period of Istanbul. According to the data obtained in this study, it can be said that the adobe filled timber framed construction technique was widely used in Istanbul from 16th to the last quarter of 19th century. The cheapening of the wood material over time and the increase in industrial facilities have been effective in the prolification of the capital-specific wooden house architecture. However, adobe filled houses continued to be preferred by low-income people.

The examples of *himis* structures existed in the urban fabric of Istanbul until the mid-20th century. Today, this structures only remain in the rural settlements along the perimeter of the city. Because of that they can be described as "fragile heritage". In the villages of Şile district which have been examined in this study, the number of mud and twigs filled traditional houses is decreasing day by day. Teke Village is the only example where traditional settlement texture can be preserved. In this village mud and twig-filled wooden framed houses were registered with the decision of the Conservation Board. However, this step seems to be insufficient to preserve the traditional residential fabric of Teke Village. In this context, a comprehensive conservation-planning work is required to preserve the last examples of *himis* houses along the peremeter of İstanbul without ignoring the basic principles of sustainable conservation.

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Technical Characteristics of Kasimiye Madrasa Building Stones and Analysis of Stone Decay Problems


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ABSTRACT

Kasımiye madrasa is located in Mişkin district of Mardin province. The date of construction is uncertain, it is estimated that it was built by Kasım Pasha (1487-1507) who is the ruler of Akkoyunlu. According to Albert Gabriel, the building was built in the last period of Artuklu domination and the building was completed in the period of Akkoyunlu period. The qasimiye Madrasa has 23 cells, with 12 cells upstairs and 11 cells downstairs, 1 eyvan and 2 masjids. The madrasa was used as a soldier's mansion in the 1960s. It was restored in 1967 and 2007. Landscaping was carried out in 2009. In 1967, the joints of the lower floor vaults of the portico were repaired, plaster operations of the entire structure were carried out in 2007.

Limestone is a natural building material that has been widely used since that human beings began to make housing. In historical buildings, limestone was used as cut stone and rubble stone in traditional construction techniques. The construction material of Kasımiye Madrasah is limestone which is the main ingredient of lime. Cut stone was used in the facades and floor coverings of the building. Limestones variety depending on their physical and chemical properties, they are chosen according to their intended use in structures. Limestones are easier to operate when they are removed from the quarry and they are softer because of their high humidity. For this reason, the building blocks can be processed more easily. As time goes on, its mechanical properties improve by hardening in atmospheric weather conditions.

Due to the atmospheric climatic conditions of Mardin, the physico-mechanical degradation of the buildings is higher. Physical, chemical and biological degradation have occurred in Kasımiye Madrasah due to negative atmospheric and environmental conditions. Superficial abrasions occurred on the stairs of the madrasa due to friction caused by an excessive influx of visitors. In the inner walls of the building, physical deformation such as loss of surface and joint discharges were observed, while deformation such as flowering, loss of surface, joint discharge, discoloration and loss of parts were common on the outer walls. Biochemical degradation was detected in limestone stones due to bird droppings on window edges, eaves and especially on the dome surface.

Keywords: Kasımiye Madrasa; chemical properties of limestone; limestone deterioration; structural damages

1 INTRODUCTION

Mardin is located in the southeast of Turkey. Mardin is located on important trade routes and has been home to different civilizations throughout history. The name of the city first IV. Century by Ammianus Marcellius 'Maride' has been called (Gabriel, 1940). Artukites, Karakoyunlu, Akkoyunlu, Safavids and Ottomans dominated the region. These civilizations have left behind artifacts bearing traces of themselves. Kasımiye Madrasa is one of the most important works from

Akkoyunlu to the present day. The exact date of construction is unknown, because of the inscription is not found. There are various opinions about the Qasimiyah Madrasa, which is unknown by whom and when it was built; One of these views was that after the Kasim Pasha, son of Uzun Hasan, the ruler of the Akkoyunlu, came to power in Mardin, he brought architects from different places to reconstruct the city, which was destroyed as a result of the attacks of Timur, and later he had the Kasımiye Madrasa built(Abdulselam Efendi, 2007). According to Albert Gabriel, the building was built in the last period of Artuklu domination and the building was completed in the period of Akkoyunlu period. The madrasah, which maintained its function during the Ottoman and Republican periods, lost its original function after the First World War(Çağlayan,2016).

2. ARCHITECTURAL FEATURES OF KASIMIYE MADRASA

Madrasa has 23 cells, with 12 cells upstairs and 11 cells downstairs, 1 eyvan and 2 masjids. When entering the madrasa from the monumental portal, There is a Hanafi Masjid on the left side and the mausoleum on the right side. There is a shafi masjid in the eastern part of the built(Figure 1). There is a pool in the courtyard of the madrasa Iwan with Selsebil. The cells are lined up in the lower and upper floors. It is a symmetrical structure except the portal and Hanefi Masjid. There is a summer mihrab in the courtyard. Kasımiye Madrasah was restored in 1967, 2007 and 2009. In the 1960s, in the building which was a military mansion, the soldiers made additions to the madrasah according to their own use (Çağlayan,2017). In 1967, a few on the ground floor and all the portico arches upstairs were renovated (Karataş, 2018). In addition, the building was restored in 1967 and was subsequently allocated to Mardin Governorate in 1974 and used as a museum. During the repair in 2007, the stone surfaces of the madrasah were cleaned. In 2009, landscaping was done. The changes that occurred as a result of the repairs carried out by Kasımiye madrasah are shown in Figure 2.

Figure 1. A general view from Kasımiye Madrasa

In Mardin, limestone was easily found and processed in every period and thanks to this it was used more than other materials (Altun, 1971). The main construction material in Kasımiye Madrasa is limestone. It can be used as coating, adornment, carrier, conglomerate and direct building stone in limestone structure (Şimsek, 2016). In the Kasımiye Madrasa, reddish limestone was used so that it could be formed more easily for portal and other decorations. The stone was rough stone and kut stone was used. The southern facade of the madrasa, interior and the front of the Hanafi Masjid is made of smooth cut stone. The eastern facade is made of rough stone. Over time, as a result of environmental climatic conditions, different types of degradation has occurred in the limestone used as the main construction material of the Madrasa.

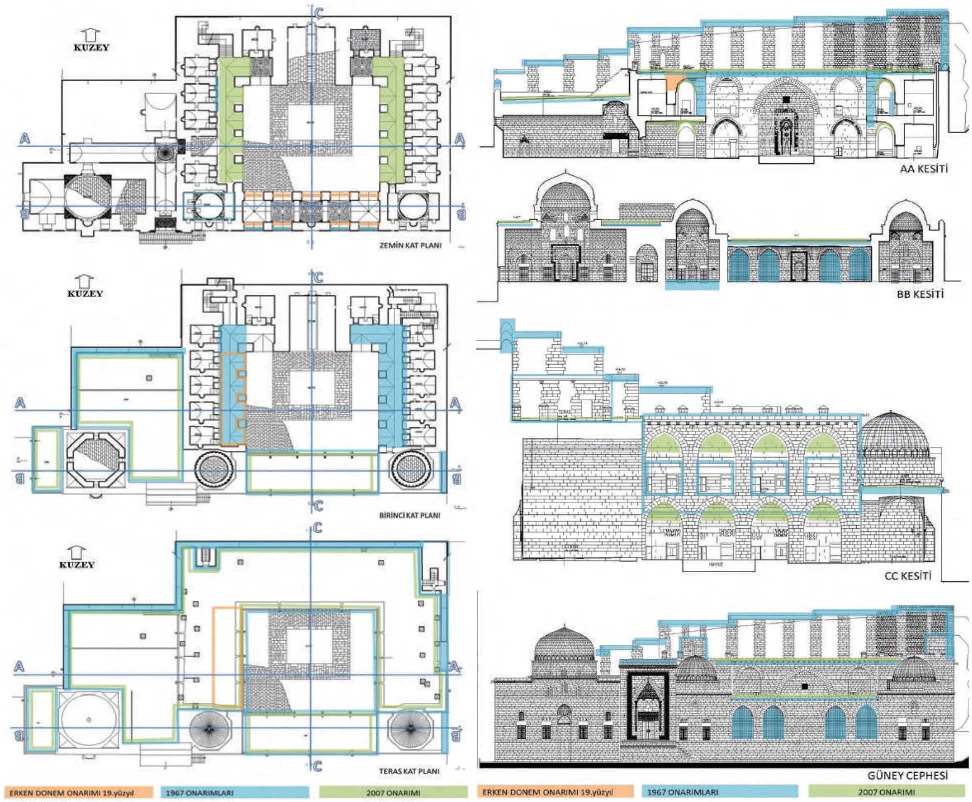

Figure 2. Period interventions of Kasımiye Madrasa on sectional and appearance and facades (M.Çağlayan archive)

3.TECHNICAL CHARACTERISTICS OF LIMESTONE

The raw material of lime is limestone which throughout history has been one of the most used building materials in line with the needs. It has also been used to change the shape and function (Yüzer, 1997). Limestone is a sedimentary stone which is formed by wind, water flow or physical environmental conditions and limestone is one of them (Semerci, 2008). It is not known when limestone was first burned and extinguished lime was obtained and then mixed with water and mortar was made. It is not known the date of the ruins in the east of Turkey, despite being used fully rely on pre-history. Limestone has different physical and chemical properties depending on the location of the limestone. Limestone creates traventine and undersea mineral deposit as result of physical and chemical reaction. The limestone undergoes deformation as a result of external environmental conditions such as temperature, pressure, and as a result of these degradation, the resistance of the stone varies according to its initial value. In addition, many stones do not have a homogeneous property. There are different parts of the stone that have different hardness, these different parts have different resistance, the soft parts are poured into decay. They react differently where there are lots of atmospheric effects (Dal, 2010). Limestones with different characteristics are used in the interior and exterior. In structures horizontal and vertical capillaries and clay fillings are used as long as they are not dense. Table 1 shows the availability and unavailability of indoor and outdoor space.

Stones with as little capillaries as possible should be selected in the exterior and dark stones should not be selected. The bending and pressure standard values of limestones should be according to TS EN 12372 and TS EN 1926. There are quarries in Mardin, Ömerli, Kızıltepe, Midyat and Kabala. It has different characteristics compared to the quarries they are extracted, for example, the clay content of the limestone obtained from the Midyat region is higher (Semerci, 2008). In addition, because the pores of Midyat Stone are larger and the sand ratio is greater, it is more difficult to make patterns of small sizes that require fine workmanship. Unlike the Midyat stone in Mardin, it is easier to process because its pores are smaller (Dinç. 2015). The stones are used in four different ways: cut stone, rubble stone, rough stone and dark yellow limestone which can be easily processed for decoration. Cutting Stone is used in the interior walls on the façades facing the courtyard. Rubble stone is used in walls that are not very important. Rough Stone is used on the rear facades. Easy to use ochre limestone is used for embellishments. These stones are used in different places and are preferred in different properties taking into account physical and chemical properties such as mineral ratios, compressive strength.

Table 1. General uses of limestone according to color - textural characteristics (Gökaltun, 1997)

	İNTERİOR				OUTDOOR			
	HORİZONTAL CLADDİNG		VERTİCAL CLADDİNG		HORİZONTAL CLADDİNG		VERTİCAL CLADDİNG	
COLOR	LİGHT	DARK	LİGHT	DARK	LİGHT	DARK	LİGHT	DARK
LİMESTONE	+	+	+	+	+	-	+	-

+ usable - unusable

3.1 Physicomechanical Properties of Limestone:

The chemical and physical properties of the limestone vary according to the proportion of impurities in the limestone structure. The color of the limestone varies from black to gray. For example, traventine and marble are bright. There are differences in the dimensions of limestones and the way the crystal lattices come together. In carbonates, the bonds between the cations are ionic and the carbonoxygen bonds are covalent. Crystal structure grows continuously with various groupings. The limestone has a very active surface. The most important feature of limestone is its double crystal structure. The hardness ratio increases as the grain size decreases in limestones. Hardness decreases as the fossil content of limestones increases (Semerci, 2008).

Limestone values such as pressure and wear must comply with TS EN 12372 and TS EN 1926 standards. The physico-mechanical properties of limestones are related to grain size, texture properties and minerals. Due to these mechanical properties of limestones, they can be divided into different categories and selected and used according to these properties.

After losing the Mardin stone water, the compressive strength (<500 cm 2/kg), hardness (2.5-3), impact resistance and abrasion of the Mardin stone increase. Occupancy rate is 85-90. 0%, CaCO3 rate is 99.9% (Önenç, 2005). Limestone has different physical and chemical properties according to the region from which it was extracted. Mardin Stone has less clay ratio than Midyat stone. The physical and mechanical properties of limestone extracted in Mardin are shown in Table 2 and Table 3.

Table 2. Physical properties of some natural building stones and building materials and Mardin and Midyat stone (Özısık, 1985)

Material	Thermal Conductivity (W/mK)	Specific Heat Cp (J/kgoc)	Heat Release a(m^2/s)	Density (kg/m^3)
Concrete	0.814	879	$4.9x10^{-7}$	1906
Granite	2.855	816	$13.15x10^{-7}$	2643
Limestone	1.261	908	$5.68x10^{-7}$	2483
Sandstone	1.855	712	$11.65x10^{-7}$	2235
Marble	2.772	808	$3.94x10^{-7}$	2603
Brick	0.692	837	$5.16x10^{-7}$	1602
Midyat Stone	0.715	1032.7	$4.679x10^{-7}$	1490
Mardin Stone	0.7985	987.06	$5.13x10^{-7}$	1580

Table 3. Mechanical Properties Of Mardin Stone (Mardia Mad.)

Property	Compressive Strength	Average Wear Resistance	Hardness (Mohs)	Hardness (Schmidt)
Contents	595 kgf/cm^2	14,3 cm^3/50cm^2		

3.2.Chemical Properties Of Limestone:

The main constituent of the limestone is calcium carbonate, in addition to the other constituents that differentiate the color of the stone (Yüzer, 1997). Limestone deposits are formed in marine or fresh water deposits as a result of various chemical, mechanical and organic reactions. In addition to calcium carbonate and magnesium carbonate, different amounts of iron and sulfur can be found in limestone. Due to these differences, limestones with different characteristics emerge. They take on different characters according to the elements and the way they come together (Semerci, 2008). The chemical composition rates of Mardin Stone are given in Table 4. It has been found to be carbonated limestone.

Table 4. Chemical Composition Of Mardin Limestone (Mardia Mad.).

Compounds	$SİO_2$	Fe_20_3	MgO	CaO	Na_2O	K_2O	TiO_2	Al_2O_3
Value	0,11	0,97	2,94	53,25	0,04	0,09	0,01	0,067

4. DECAYS IN THE BUILDING STONES OF KASIMİYE MADRASA

Distortions occur in the stones for different reasons. The reasons for the deterioration of the stone should be known in order to prevent and protect the deterioration of the stones. (Hasbay ve Hattap, 2017). Degradations can generally be grouped in two ways: degeneration caused by the stone itself and caused by external influences. The problems caused by it are due to minerals and cracks in the stone. External influences are air pollution, environmental pollution, humidity, labor, freezing. (Öcal, 2010; Dal and Öcal, 2013a, Dal and Öcal, 2013b). The cold winter period in Mardin, the summer period due to arid and hot desert climate due to the 'thermal shocks, especially on the surface of the stone material causes capillary cracks and fractures. Also during the spring and summer periods dry steppe plants reach the city by wind blowing from the deserts, these dusts hit the facades of the buildings, leading to wear (Dal, 2017). The main cause of stone deterioration is environmental conditions, as well as degradation can be caused by the properties of the stone itself (Dal, 2012). In Kasımiye madrasa, due to physical conditions such as atmospheric environmental conditions, it is observed that over time, degradation occurs in limestone used as the main construction material. The physical, chemical and biological degradation of the resulting decay can be divided into three categories. Physical degradation is often the result of changes in the physical structure of mechanical external factors. It is diversified as crack, fracture, part breakage, wear, deformation, graffiti, cut, flare, erosion, honeycomb eyesight and high heat (Çetin, 2014). Chemical degradation is a form of decay that occurs in the body of a stone caused by atmospheric factors. Chemical decays can be called salting, crystallization (flowering), deep crystallization, blistering, shell-throwing, confectionery, pollination, foliation, microcarst formation, color degradation. Biological degradation is the change of organic matter in the body. Lichen, micro pit, Moss, Root and leafy plants, puncture, biological accumulation, is named to be (Çetin, 2014). In addition, these decays prepare the environment for each other. In cold and arid regions, physico-mechanical weathering is more common, while in hot and humid regions, chemical weathering is more common. Physico-mechanical degradation and chemical degradation can also be seen in Mardin province. Due to the negative environmental conditions in the city, the dust drifting along with the wind in the buildings also causes the removal of motifs. Capillary cracks are also observed in stones as a result of temperature changes in structures. In addition, air pollution is usually due to more external walls, such as surface pollution degradation is also seen. Surface pollution is in sections washed by rainwater in a thin layer (Bozoğlu, T.,1998). Degradation caused by microorganisms is also present. In Mardin, it is possible to see more capillary cracking, breaking parts and color change in stones (Dal, 2017). Physical distortions seen in Kasımiye madrasa are given in Figure 3. Physical degradation resulting from the internal structure or external effects of the stone results in degradation such as loss of parts, capillary cracks, abrasion. The stairs in the Kasimiye madrasa were made using smooth cut stones and over time eroded in the stairs due to excessive visitation. There is also a change in colour on the stairs due to physical environmental conditions (Fig3a). The interior and exterior walls have joint discharge, crack, part loss and color change (Fig3b). Part breakage and color change are present in the entrance portal and part breakage and graffiti were formed in the entrance door (Fig3c). The feet contain part breakage, surface loss, color change, and cracks (Figs3d). Colour change and wear are also observed in the flooring in the courtyard.

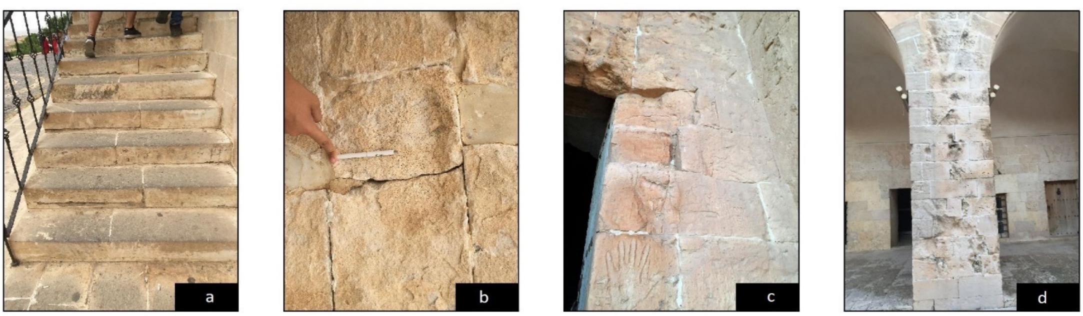

Figure 3. Physical distortions seen at Kasımiye Madrasa

Examples of chemical degradation in Kasımiye madrasah due to atmospheric conditions are shown in Figure 4. Gases in the atmosphere, especially gases reacted with water and converted to acids, cause chemical changes in the structure of the stone. Thus, color changes are observed in the stone. As a chemical decomposition, it is seen that the color change occurs on the wall where selsebil is due to adverse environmental conditions in time and the water flowing from selsebil, which is a humid environment, forms algae after a while. Algae secreted dilute acid and caused degradation of limestone. There is color change in the pool (Anonymous, 2013) (Figure 4e) and on the south side for the same reason. In the dome, especially due to bird feces, degradation of limestone occurred. In addition, water-soluble salts in the stone dissolve and come to the surface due to the effect of moisture and heat. However, they crystallize as a result of evaporation and lead to salinization (Figure 4f). On the main facade, there is color change and salinization (Figure 4g). On the ladder leading to the entrance portal, color change due to environmental conditions (Figure 4h) is also seen.

Figure 4. Chemical distortions seen at Kasımiye Madrasa

The seeds carried by the wind move into the walls through capillaries or cracks and settle and grow over time. This is especially seen extensively in unused, abandoned structures (Dal,2017). Another type of Decay seen in the Kasımiye madrasa are examples of biological decay and shown in Figure 5. The roof section of the madrasa and the dome side are degraded due to bird feces (figure 5i). It is possible to see leafy plants on the western facade of the structure (figure 5j). Plant roots also cause chemical melting by the secretions they form in the structure (Akyol et al., 2013). On the eastern side of the structure there is also an example of leafy plants (figure 5k) on the western side of the structure, biological degradation has occurred due to the combination of different bacteria (figure 5l).

Figure 5. Biological distortions seen at Kasımiye Madrasa

Decays resulting from human effects are factors such as weight and periodic wear, misuse, and improper repair (Hattap, 2002). In Figure 6, the decays seen by human impact are shown. On the facade (figure 6m), above the main portal (figure 6o) and on the wall of the corridor leading to the courtyard, lettering, graffiti is seen. In the same way, hollows were opened within the structure by human influence (figure 6n).

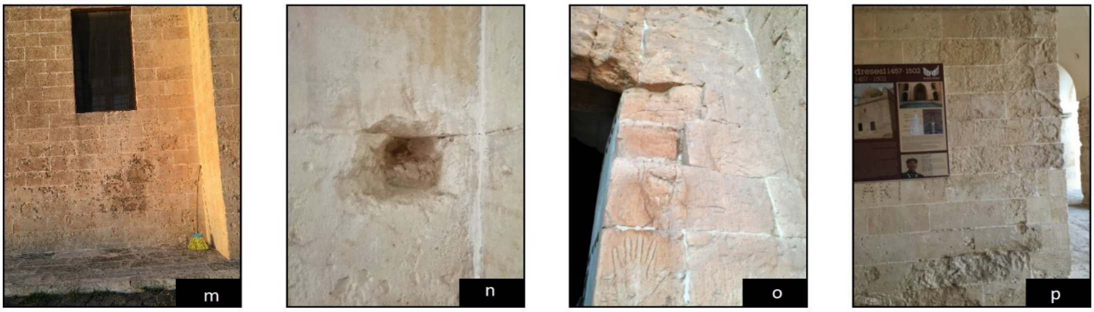

Figure 6. Degradation caused by human impact at Kasımiye Madrasa

5.RESULT

Although it is not known exactly when limestone was used, it is known that it was used in building construction from ancient times to the present day. The physical and chemical properties of limestone, such as its components, compressive strength and tensile strength, differ according to the way the building elements come together. If the character and feature of the limestone is determined, it can be divided into certain categories and evaluated. However, according to the changing climatic conditions, the responses can be determined and good results can be obtained by choosing the right materials. Within the scope of the study, the Kasımiye Madrasa in Mardin province was discussed. Decays in the structure were observed and dealt with in categories. Physical, chemical and biological degradation has occurred over time in the limestone used in the Kasımiye madrasa. In addition, these decays cause each other to accelerate degradation. In addition to the investigations, physical degradation was observed as a result of more adverse atmospheric conditions in the Kasımiye Madrasa. In addition to physico-mechanical degradation, chemical and biological degradation is also present in the structure. Physical - mechanical degradation such as capillary cracks, part loss, wear are present in the structure. However, examples of chemical degradation such as color change, salination have been found. There are biological decays, such as flowering, and degradation, algae retention, which are formed by a combination of different bacterial species. Moisture, wind, freezing, air pollution, damage caused by living things, causes damage to the structure over time, such as the wrong material. However, the features of the limestone, which is the main material of the structure, should be known, degradation types and samples should be determined and a proper road map should be followed and measures should be taken to transfer the Kasımiye Madrasa, which is in the forefront of the historical identity and cultural heritage of Mardin province to the next generations. If the main causes of these decays in the structure are determined and problems are not resolved with the correct solutions, these decays will lead to damages that will cause the Qasimiye madrasa to lose its original quality. The main purpose of this study was to determine the types of decay and to reveal the factors that cause the decay. It is important to make determinations on this issue, to eliminate structural problems and to take necessary measures.

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An Investigation of Silvan Selahattin-i Eyyubi Mosque (Ulu Mosque) in Terms of Construction System and Materials Used


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ABSTRACT

The town of Silvan, which had several names such as Mipherket, Muhargin, Farkin, Sliv and Silva in the past, became one of the largest districts in Diyarbakir in 1873. Once known as Tigranokerta founded by the Great Tigran, Silvan was one of the largest and most important cities in the Hellenistic Age. Besides being one of the most brilliant cities in the Middle Ages during the Islamic period, Silvan became the capital of Mervani State under the name of Meyyefarıkin, the second capital of the Artuqid State and the main centre of the Ayyubids. The town, an important centre in the Middle Ages, hosts important historical monuments. Selahattin-i Eyyubi mosque, named after Selahattin-i Eyyubi, founder of the Ayyubid Dynasty, is one of the oldest and largest mosques in the region as well as a cultural heritage of great importance. A state of endurance and stability in historical cultural assets is closely related with construction techniques, structure and materials. This study has sought to examine the construction techniques, materials and carrier structure used in the Selahattin-i Eyyubi Mosque.

Keywords: Construction techniques, construction material

1- INTRODUCTION

The mosque that is named after Selahattin-i Eyyubi, founder of the Ayyubid Dynasty, is located in the town centre of Silvan. This unique work of architecture that is one of the oldest and largest mosques in the region represents a cultural heritage for Silvan. The mosque, also called Silvan Ulu Mosque, is a work of architecture that bears the traces of both the Artuqid and Ayyubid periods. The structure has undergone several restorations during the civilisations that have ruled the region, every time with new extensions added to the original structure, to further preserve it for the service of Moslems [1]. It is reported that it was built at the place where a structure built by the Mervani State in 1031, which had previously been used as a church, once stood [1].

Ibn al-Azrak reports in his work titled ''Tarih-i Meyyafarıkin'' (History of Meyyafarıkin), the oldest source available regarding the history of Silvan, that it was restored in 1157 A.D after the collapse of the dome in 1152 A.D. From this, it follows that the restoration of the structure was completed in a period of five years between 1152 and 1157 A.D. by order of Necmettin Alpi, the then monarch of the Artuqid State [2].

In 1913 the mosque was subjected to a comprehensive restoration, whereby some ornamentation was made, and the walls of the façades, in particular the one of the northern façade, were further raised, and furthermore flying buttresses were added to the southern side to support the structure.

The ornamentation on the richly ornamented entrance gate and the flying buttresses at the southern façade dates back to the early 20th century [3].

The differences in the outer and inner architecture of the structure indicate that it has been subjected to numerous restorations since its construction up to the present time [4].

The original plan and architectural characteristics of the architectural style of the Seljuk period, the style also used in Artuqid mosques, were also used as the original style in this mosque.

2. THE PLANNING CHARACTERISTICS AND CARRIER STRUCTURE OF SİLVAN ULU MOSQUE

Information is available from several sources which indicate that the mosque has been subjected to numerous restorations and consequently many changes since the time it was built.

The stones used in the construction of the Selahattin-i Eyyubi Mosque is a material rich in lime, sand and clay which dates back to the Miocene Period (the 3rd geological period) [10]. Limestone is a material that can be easily processed and shaped. This stone used in the mosque show similarities to the stones used in historical monuments located in and around Mardin.

The plan of the mosque is rectangular, featuring a dome over the space in front of the mihrap (altar) and a courtyard. It is made of cut stone and brick. The plan is based on a dome over the space in front of the altar in the middle, which is intersected by four transverse naves that extend parallel to the alter (Figure 1). As such, the unit in front of the alter dominates the whole sanctuary. The dome over the space in front of the altar that is in the middle of the structure is the core of the plan. Besides the arch in front of the altar, the dome with a diameter of 13.50 m. is additionally supported on three sides with three arches on each side. As such, the dome dominates the whole structure when viewed from inside and outside [5].

It is seen that the type of the sanctuary with a front courtyard consisting of transverse naves and units in front of the altar later developed on the basis of a central space and bigger units in front of the altar [6].

The dome placed on tromps with stalactites rises layer by layer at the inner side [4] (Figure 2). The dome with three spaces formed by arches on three sides is similar to the one of the Mosque of Melikşah in Isfahan [7]. From the outside, the octagonal tambour of the dome and tromps are clearly distinguishable (Figure 3). There is one window on each side at the level of tromps at the space in front of the altar.

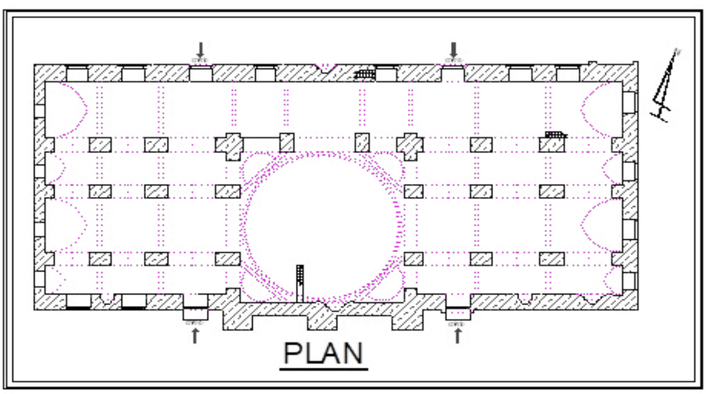

Figure 1. Plan of the Silvan Ulu Mosque

Figure 2. The Tromp used in the Silvan Ulu Mosque

Figure 3. The View of the Dome of the Mosque from the in and outside

The arches that rest on columns form the octagonal structure on which the dome rests (Figure 4). At the southern side, on the other hand, the arches rest directly on walls [4].

Figure 4. The arches on which the dome rests

There are two middle pillars on each side between the corner pillars that support the dome. The dome intersects the parallel naves along three naves. An oblate pyramid-shaped cone currently covers it [1].

The whole structure is built of straight cut limestone, except for the front side of the niche which is built of brick. Unlike the structure, the dome that is built of brick rests on ten supporting elements (pillars), two embedded in the altar wall and eight standing independently in the middle [7]

(Figure1). Cradle vaults running horizontally cover the parts supported by several elements outside the domed space [4] (Figure 1).

Figure 5. The arch that rests on the wall

Even though it was built in the early period, it is seen that the dome structure that was implemented in the Mescid-i Cuma (the Mosque of Friday) in Isfahan was also implemented in this dome with a wide span [2].

Today a mezzanine floor has been built at the five horizontal naves at the northern façade. This mezzanine floor built of metal, which was integrated into the building as an add-on element, is accessed by a flight of wooden steps (Figure 6).

Figure 6. The Mezzanine Floor Later Integrated as Add-on and the Stairs that Provide Access to it

The altar and pulpit of the mosque built of stone stands out with its rich stone masonry. At the lower part there are two different symmetrical altar niches at two sides of the gate. The altar, on the other hand, with fine stone ornamentation was built by Emir Şahabettin, an emir of Ayyubid Dynasty. A second altar of simpler design was built in the 15th century [1] (Figure 7).

Figure 7. The Altars of the Mosque

Figure 8. The Pulpit of the Mosque

3. THE FAÇADES OF THE MOSQUE

The main entrance gates at the southern and northern façades are spectacular (Figure 8) (Figure 9) (Figure 10). As the mosque is based on a plan with a horizontal space and a considerably big dome, there are two gates on each of the two sides of the axis that opens up to the courtyard [1].

There is a window with mouldings around it in the semicircle over the entrance gate with border ornaments at the northern façade (Figure 9). Over the mouldings is a cuspidal arch. There is one corbel at the east and west corners of the northern façade and two rectangular windows at the lower part of each of these corbels. There are two-layered windows at the right and left sides of the altar at the northern façade. The windows at the lower side are built in rectangular form in a niche with mouldings around it [3].

Figure 8. The Northern Façade of the Mosque (URL 1)

Figure 9. The Gate at the Northern Façade
Figure 10. The Gate at the Northwest

There are two entrance gates at the southern façade (Figure 10). While the one at the corner at the west is of simple design, the gate at the eastern corner is similar to the crown gate at the northern façade. The rectangular entrance gate at the northern façade consists of two columns on each side with a five-sliced pointed arch over it. The two columns on each side rest on a base in square form. At the lower parts of the dome that is over the space in front of the altar at the southern façade there are three buttresses. There is a semi-dome over the rectangular one in the middle. The buttresses at the sides, on the other hand, are covered with semi-domes with slices, with lower parts formed with mouldings [3] (Figure 11).

Figure 8. The Southern Façade of the Mosque (URL 2)
Figure 10. The Gate at the South

Even though, in the first years after the building of the mosque, there were lightweight pointed arches resting on oblate columns that extended from one end to the other at the outer façade over the row of windows, today it is seen that only the ones at the east and west sides have survived. At the northern façade there are sliced small arches [2]. There is a series of arches that extend along the upper side of the façade at the southern wall of the courtyard [6]. While the eastern and western façades of the mosque are of simple design, the northern and southern façades represents a relatively ornamental style (Figure 11).

Figure 11. The buttresses at the Façade
Figure 12. The Western Façade

4. THE MINARET OF THE MOSQUE

This work of architecture that was built during the Meyyafarıkin Ayyubids bases on a square plan. It is a five-storied minaret with windows at the upper side opening up to four directions (Figure 13). It is the most spectacular one among the minarets in the region basing on a square plan. It is dominantly located on a hill with view over Silvan. It is positioned at the north-eastern side of the mosque. It was subjected to a comprehensive restoration in 1913 [1]. The part up to the balcony is based on a square plan, and the upper part over the balcony is cylindrical in form.

Figure 13. The Minaret of the Mosque

5. THE COURTYARD OF THE MOSQUE

Basalt stones were used in the ground of the courtyard during the latest restoration of the Selahattin-i Eyyubi Mosque. Recently, toilets have been built below the ground level accessible from the courtyard (Figure 14). The fountain at the back (north-eastern) side of the mosque, also built in recent times, is built of marble and wooden materials (Figure 15)

Figure 14. The Entrance to the Toilets in the Courtyard
Figure 15. The Fountain of the Mosque

6. RESULT

The Silvan Ulu Mosque, located in the Silvan district of the province of Diyarbakır, is a joint work of the Artukids and Eyyubids.

One of the oldest and largest mosques in the region, this work was presented to Silvan as a cultural heritage. The building has undergone various repairs since its first construction.
In the building, which has a rectangular plan and courtyard, the whole building is used with smooth cut limestone, only brick material can be seen in the dome in front of the mihrab. The dome in front of the mihrab in the middle of the structure forms the center of the plan and will dominate the whole structure. In the planning of this mosque, there is a central dome.

The north and south facades of the mosque are featured and the east and west facades are very simple. Each of the two gates on the southern and northern façades are the main gates, all of which are spectacular. These doors are the most prominent architectural elements that stand out on the façade. It is also seen that the originality found on the facades of the Silvan Ulu Mosque, where traditional construction technique is seen, can be preserved to a great extent.

The mosque, which has important architectural features in terms of planning, materials and workmanship, is very important in terms of preserving the original qualities of the mosque and maintaining cultural values.

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An Evaluation on Graduate Dissertations Made in Turkey in the Field of Green Roof



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ABSTRACT

Today, great majority of human population lives in the city centres. In cities, technological developments which appear in multi-storey buildings and dense construction, and which are results of housing need stemming from this density cause environmental problems such as depletion of non-renewable resources, destruction of green areas, global warming and climate change. The fact that nearly half of the energy sources are used buildings brings together the necessity to solve these problems as well. It is especially possible to replace the destructed green area in cities with green areas within architectural scale. "Green Roof" concept, which has been popular especially for the last ten years in the world and in Turkey, turns out to be a sustainable application for resolution of environmental problems. Green Roofs provides many services such as increasing the air quality, retaining the rainwater, keeping dust, decreasing noise, economic benefits, energy saving, social benefits and providing biodiversity. Several studies have been carried out about green roofs in academic fields.

In this study, master and doctorate thesis published in Turkey about green roof have been analysed, and what kind of an inclination is present with the studies performed about the issue and what kind of results and suggestions are present in them have been examined. The sources in questions were reached through National Thesis Scanning Centre of Higher Education Board (YÖK). At the end of the content and literature scanning, it was established that there are a total of 27 thesis 26 of which are master degree and 1 of which is doctorate thesis. All thesis which were studied before have been examined, and they were coded as Ç1, Ç2, Ç3 … Ç27 so that this would provide convenience in analysis, and also similar and different parts of the thesis were analysed and responds to some questions were looked for. The results were presented in forms of Tables and then commented on so that it would be easier to be understood by the readers.

Key words: Green Roof, Graduate Thesis, Thesis Review, Turkey, Analysis

1.INTRODUCTION

The developments of the economy and the increase in urbanization have led to more energy consumption, especially in the construction sector (1). Increase in the number of buildings and in heat dissipation caused by people increase the heat load in urban environment and cause Urban Heat Island problems. The buildings that cover approximately from 20% to 25% area of the cities use around 40% of the city's energy (2). It is predicted that urbanization will have reached 83% in developed countries by 2030. It is an inevitable reality that natural environment will be destroyed more due to this rapid development. Green rain water network applications should be implemented. Applications of biological systems such as rain gardens, green roofs, green walls minimize the negative results of urbanization to great extent; they advances the processes in improving trend (3). One of the passive systems that has less environmental tendency is green roofs (4). Green roofs which have several definitions such as "living roofs", "eco roofs", "roof gardens" is a live plant cover system added over the roof of the building, and it is an effective system which decreases indoor temperature and energy consumption. Moreover, the green roofs have the following positive effects: Filtering rain water, reducing the effects of UHIs, decreasing CO_2 and noise, increasing the life of roof isolation, protecting the biological environment, increasing esthetical reactive areas (5).

Green roofs are classified in three types as intensive green roofs, semi-intensive green roofs and extensive green roofs. These green roof types are composed of different plant types; so, each necessitates soils of different depth (6). Intensive roofs have a soil thickness of 15-40 cm, so they need intensive irrigation and maintenance. Semi-intensive green roofs have a soil thickness of 12-15 cm, so they need to be irrigated at certain intervals and maintenance. Extensive green roofs have a soil thickness of 6-20 cm, so they need low care and irrigation and they are generally used to cover on vast roofs on which no one walks (4).

2.MATERIAL AND METHOD

In this study, content and literature analyses were taken as basis; and the official web site of Higher Education (YÖK) National Thesis Centre was used in order to obtain the documents. After "Green Roof" was determined as key word, all dissertations where this expression passed were investigated. 27 theses, 26 of which are master thesis and 1 of which is a doctorate thesis, were looked for. Of the aforementioned 24 were found to have access permission, while 3 of them were not accessed. The theses that were studied were then coded as Ç1, Ç2, Ç3,…Ç27 to provide ease for analysis, and then the similar and different aspects of the theses were established and answers for the following questions were searched for:

1. What kind of a distribution do the dissertations, conducted in the field of green roof, exhibit according to years they published?
2. What kind of distribution do the dissertations, conducted in the field of green roof, exhibit according to universities and institutes?
3. What kind of a distribution do the dissertations, conducted in the field of green field, exhibit in terms of data collecting tools and methods?
4. What kind of a distribution do the dissertations, conducted in the field of green field, exhibit in terms of education level?
5. What kind of a distribution do the dissertations, conducted in the field of green field, exhibit in terms of themes?
6. What kind of a distribution do the dissertations, conducted in the field of green field, exhibit in terms of suggestions to which data are presented?

The results were created as tables and then they were interpreted so that the readers would easily understand. The coded theses can be seen in Table 1.

Table 1

CODE	THE TITLE OF THE THESIS
Ç1	INVESTIGATION OF PARAMETERS LESSENING ENERGY CONSUMPTION IN OFFICE BLOCKS AND THE EFFECTS OF PASSIVE METHODS ON ENERGY NEEDS
Ç2	INVESTIGATION OF GREEN BUILDINGS IN TERMS OF SUSTAINABILITY CRITERIA IN REAL ESTATE DEVELOPMENT PROCESS
Ç3	AN EXAMPLE BASED DESIGN MODEL SUGGESTION TO BE USED IN VERTICAL GARDEN DESIGN PROCESS
Ç4	ANKARA CITY ROOF GARDEN ARRANGEMENT PRINCIPLES UNDER ECOLOGICAL CONDITIONS
Ç5	AN INVESTIGATION OF GREEN ROOFS ONE OF EFFECTIVE ELEMENTS OF ENERGY EFFICIENT CONSTRUCTION DESIGN OVER THE WORLD AND OUR COUNTRY EXAMPLES
Ç6	"GREEN ROOFS" AS A TOOL OF SUSTAINABLE LANDSACPE DESIGN
Ç7	YEASSESSMENT OF GREEN ROOF SYSTEMS IN TERMS OF WATER AND ENERGY BALANCE "İSTANBUL EXAMPLE"
Ç8	ANAYLSIS OF EFFECTS OF GREEN ROOFS ON BUILDING HEATING AND COOLING LOADS IN OFFICE BLOCKS IN DIFFERENT CLIMATIC REGIONS
Ç9	INVESTIGATION OF GREEN ROOF SYSTEMS IN TERMS OF CONSTRUCTION
Ç10	THE EFFECT OF PLANTED ROOF SYSTEM ON SYSTEM BEHAVOUR IN CONCRETE BUILDINGS IN EARTHQUAKE REGIONS
Ç11	A CROSS-SECTION IN EFFICIENT ENERGY DESIGN: BUILDINGS COVERED WITH SOIL
Ç12	ASSESSMENT OF DEVELOPED BUILDING ELEMENT SYSTEMS USED IN HIGH RISE BUILDINGS IN TERMS OF ENVIRONMENTAL SUSTAIABILITY CRITERIA
Ç13	GREEN ROOF: DESIGN AND APPLICATION EXAMPLES
Ç14	INVESTIGATION OF URBAN HEAT ISLAND SEVERITY AND DEVELOPING REDUCING STRATEGIES FOR İSTANBUL
Ç15	URBAN AND COUNTRY WALL VEGETATION AND THEIR ECOLOGICAL CHARACTERISTICS WITHIN THE CONTEXT OF LANSCAPE ARCHITECTURE
Ç16	ASSESSMENT OF ROOFS IN DECRESING URBAN HEAT ISLAND EFFECT: GREEN ROOFS AND COOL ROOFS
Ç17	GREEN ROOFS WITHIN THE CONTEXT OF ENVIRONMENTAL FOCUS ARCHITECTURAL DESIGN APPROACH AND AN INVESTIGATION OF IT ON APPLICABILITY IN TURKEY SCALE
Ç18	USE OF EPS-BLOCK GEOFOAM IN FLAT ROOF APPLICATIONS AS LIGHT FILLING SYSTEM
Ç19	INVESTIGATION OF SOME OF LEED CERTIFICATION APPLICATIONS IN TERMS OF LANDSCAPE ARCHITECTURE IN İSTANBUL
Ç20	ASSESSMENT OF ENERGY PERFORMANCES OF GREEN ROOFS AND VERTICAL GREEN SYSTEMS
Ç21	ASSESSMENT OF EFFECTS OF GREEN ROOF SYSTEMS ON SUSTAINABLE URBAN LIFE
Ç22	INVESTIGATION OF VERTICAL GREEN SIDES AND GREEN ROOFS IN TERMS OF ECOLOGICAL CRITERIA AND ASSESSMENT OF ITS ENERGY EFFCIENCY
Ç23	ASSESSMENT OF USE OF GRASS PLANTS NATURALLY GROWING IN MARMARA REGION IN GREEN ROOF SYSTEMS OPPORTUNITIES
Ç24	INVESTIGATION OF ROOF AND VERTICAL GREEN BUILDINGS AND AN EXAMPLE APPLICATION IN ERBİL
Ç25	GREEN ROOF APPLICATIONS WITHIN THE CONTEXT OF URBAN SUSTAINABILITY
Ç26	THE EFFECT OF LIVING CRUST SYSTEM ON RAINWATER CONTROL: ITU TAŞKIŞLA CAMPUS
Ç27	INVESTIGATION OF THE EFFECT OF GREEN ROOF SYSTEMS ON TEMPRATURE DROP ON THE ROOF WITH GENETICAL PROGRAMMING

3. RESULTS

In results part, the results obtained with the help of analysing the data are given place.

Table2. The distribution of graduate studies carried out in the field of green roof according to publishing years and departments

DEPARTMENT / YEAR	ARCHITECTURE	LANDSCAPE ARCHITECTURE	CIVIL ENGINEERING	ENVIRONMENTAL ENGINEERING	MEREOLOGY ENGINEERING	REAL ESTATE EDEVELOPMENT	INFORMATICS TECHONOLOGY	MECHANICAL ENGINEERING	PUBLIC ADMINISTRATION	TOTAL
1996		Ç4								**1**
2009						Ç2				**1**
2010								Ç1		**1**
2011		Ç5,Ç6					Ç3			**3**
2012	Ç10, Ç9,Ç12	Ç7								**4**
2013	Ç8	Ç11								**2**
2014	Ç17	Ç13								**2**
2015	Ç20	Ç15								**2**
2016	Ç16, Ç26		Ç18		Ç14					**4**
2017	Ç22	Ç19		Ç21				Ç27	Ç25	**5**
2018		Ç23, Ç24								**2**
Total	**9**	**10**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**27**

When Table 2 is examined, it attracts attention that the first study about green roof was carried out in 1996 and there was no study for 12 years after this. Also, 2017 is the year when the issue is studied most with 5 theses and it is followed by 2012 and 2016 with four theses each.
In addition, it is established that green roof issue is handled in landscape architecture most and after this comes architecture department.

Table3. Distribution of graduate theses carried out in the field of Green roof according to universities

UNIVERSITY / YEAR	İSTANBUL TECHNICAL UNIVERSITY	KARADENİZ TECHNICAL UNIVERSITY	ANKARA UNIVERSITY	DOKUZ EYLÜL UNI.	İSTANBUL UNIVERSITY	GAZİ UNIVERSITY	OKAN UNIVERSITY	SELJUK UNIVERSITY	GEBZE TECHNICAL UNI.	MALTEPE UNIVERSITY	İSTANBUL AREL UNI.	VAN 100^{TH} UNIVERSITY	SÜLEYMAN DEMİREL U.	YILDIZ TECHNICAL UNI.	ERCİYES UNIUVERSITY	TOTAL
1996			Ç4													1
2009	Ç2															1
2010	Ç1															1
2011	Ç3, Ç6	Ç5														3
2012	Ç10, Ç12			Ç9	Ç7											4
2013	Ç11					Ç8										2
2014			Ç13											Ç17		2
2015		Ç15								Ç20						2
2016	Ç14, Ç26						Ç18				Ç16					4
2017				Ç25				Ç22	Ç21				Ç19		Ç27	5
2018					Ç23							Ç24				2
TOTAL	9	2	2	2	2	1	1	1	1	1	1	1	1	1	1	27

When Table 3 is examined, the distribution of graduate theses carried out in the field of Green Roof can be seen according universities. In this, it is seen that the highest number of studies has been carried out by İstanbul Technical University.

Table4. The distribution of graduate theses carried out in the field of Green Roof in terms of data collecting tools

DATA COLLECTING TOOLS / THESIS CODE	LITERATURE STUDY	SIMULATION PROGRAM	SAMPLE BUILDING EXAMINATION	SURVEY	INTERVIEW FORM	EXAMPLE GREEN ROOF CONSTRUCTION	UNKNOWN
Ç1	X	X					
Ç2	X		X	X			
Ç3	X	X					
Ç4	X				X		
Ç5	X		X	X			
Ç6	X						
Ç7	*X*					X	
Ç8	X	X					
Ç9	X						

Ç10	X	X					
Ç11	X						
Ç12	X		X				
Ç13	X		X				
Ç14	X	X			X		
Ç15	X		X				
Ç16	X						
Ç17	X						
Ç18	X					X	
Ç19	X		X				
Ç20	X	X					
Ç21	X		X				
Ç22	X	X					
Ç23	X						
Ç24	X		X				
Ç25							X
Ç26							X
Ç27							X
	24	7	8	2	2	2	3

When Table 4 is examined, it is seen that the all reached graduate theses applied literature study. In addition, the used data collecting methods have been as follows: 7 simulation program, 8 sample building examination, 2 survey, 2 interview form and 2 example green roof construction.

Table5. Distribution of graduate theses carried out in the field of Green Roof in terms of education level

TYPE	AUTHORIZED	UNAUTHORIZED/UNATTAINED	TOTAL
MASTER DEGREE	23	3	26
PH DEGREE	1	0	1
TOTAL	24	3	27

As can be seen in Table 5, 1 doctorate level, 26 master level graduate theses have been conducted in the field of Green Roof, while 3 of master level theses have been closed to access.

Table6. Distribution of graduate theses carried out in the field of Green Roof in terms of themes

THEMES / THESIS CODE	GREEN ROOF	GREEN WALL	SUSTAINAB ILITY	A ENERGY CONSUMPT ION IN	RENEWABL E ENERGY	COMPUTER INTERFACE SUGGESTIO N	HEAT ISLAND	FLAT ROOF APPLICATI ONS
Ç1				X				
Ç2			X					
Ç3						X		
Ç4	X							
Ç5	X							
Ç6	X							
Ç7	X							
Ç8	X							

Ç9	X							
Ç10	X							
Ç11	X				X			
Ç12			X					
Ç13	X							
Ç14							X	
Ç15		X						
Ç16	X						X	
Ç17	X							
Ç18								X
Ç19			X					
Ç20	X	X						
Ç21	X							
Ç22	X	X						
Ç23	X							
Ç24	X	X						
Ç25	X		X					
Ç26	X	X						
Ç27	X							
	19	5	4	1	1	1	2	1

When Table 6 is examined, it is seen that 19 graduate theses directly study Green Roof, while the rest of 8 theses study the issue indirectly.

Table7. Distribution of graduate theses carried out in the field of Green Roof in terms of presented suggestions

CODE	RESULTS AND SUGGESTIONS
Ç1	Significant energy savings are achieved in all consumption through improvements in buildings with sustainable design parameters.
Ç2	Arrangements about implementation of green buildings taking into account the ecological design of developers and investors should be performed and sustainability conditions and incentives to be determined by local and central governments should be put into action.
Ç3	As with any sample-based design system, the designer can develop an application with a sample library that he can use in the vertical garden design process.
Ç4	Giving place a widespread use of green buildings with roof gardens in the city of Ankara, and establishing connection of all these areas with the existing green spaces in and out of the city will provide great benefits to the city both ecologically, aesthetically and functionally.
Ç5	In our country, building technologies, which will adapt to climate change, are needed. International studies reveal that the green roof system is one of the building technologies that adapt to climate change.
Ç6	Landscape architects, like all professional groups, will play a role in increasing the momentum in achieving the expected expectations for sustainable development with the responsibilities they will undertake. With this

	momentum, while creating more liveable spaces in a short time, sustainable development targets will be approached and thus the level of social welfare will rise.
Ç7	Considering the principles determined in the green roof systems at the urban scale and including them in the urban planning works will provide a significant contribution to the improvement of the quality of environmental life and the urban scale.
Ç8	Research and development projects, master and doctoral theses, academic articles, papers and reports should be done from different angles by analysing their effects on the performance of green roof building work in Turkey. These studies should be supported by state bodies and users and owners should be made aware of the results of the work with the support of non-governmental organizations.
Ç9	It is thought that the interest in green roofs in the society will increase in ecological terms if certain institutions implement advertising projects on green roof applications in our country as abroad and that the care given for growing a plant in daily life shown for a green roof will contribute to the city scale in every aspect, which will be an appropriate behaviour.
Ç10	In such structures, it is particularly recommended to carry out a comprehensive structural examination / calculations as followed in this study before applying the planted roof system. Numerical results show that earthquake safety does not change practically when the structures are considered as a whole. Since the increase in behaviour sizes is mostly seen in roof beams, it is possible to improve / strengthen these floor beams in particular.
Ç11	Green roofs, one of the green spaces in the city, have the chance to be both green and sustainable. The green roof sector, which is trying to develop, can benefit from the experience of the soil covered structure and green roof systems can be reviewed and new and sustainable natural materials can be developed.
Ç12	In the future, it is inevitable to build tall buildings at an increasing rate, while the development and applicability of sustainable technologies will inevitably increase. In every design that is respectful to nature, the more sustainable system and building elements are used considering the building function, design requirements and climatic characteristics, the more sustainable the system and building elements will be, the more sustainable the buildings and the less environmental damage will be.
Ç13	Green roof applications should be increased as a result of information and incentives to be provided by local authorities on green roofs.
Ç14	If green roofs have dense vegetation and watered sufficiently, they can provide effective solutions such as cool roofs.
Ç15	Urban areas are becoming increasingly deteriorating areas in terms of ecological conditions with the rapid construction and destruction of green areas. With the green walls and green roof works to be done with natural species, ecological conditions in cities will be improved with minimum cost and maintenance and cities will become more liveable areas.
Ç16	In our country, entrepreneurs need to be encouraged for green roof and cool roof applications and solar pavements, roof openings and roof ponds should be examined in more detail.
Ç17	Many applications related to green roofs have been made on existing or new buildings. In parallel with the increasing importance of developing technology and ecological approach in today's conditions, green roof system applications are expected to diversify.
Ç18	In the evaluation of the long-term performance of lightweight filling geofoam applications to be performed in our country, it is recommended to make long-term instrumental observations by placing total pressure plates and seating plates in the system.
Ç19	Landscape needs to play a more effective role in LEED certification system. New approaches are emerging in landscape architecture designs with developing technology. Certification needs to be made more efficient by taking into account the factors such as plants with low water need, plants suitable for the flora of the project area, materials that prevent excessive water loss of the soil, more efficient and less irrigation designs, and preparation of new environments for people's healthy life with running tracks and sports fields. It should not be enough to use only grey water in landscape items.
Ç20	Green roof systems that prove the benefits of energy should be defined more in our country, should be supported by the state, users and owners should be informed and encouraged to use.
Ç21	With green roofs, dead space in roofs will be coloured and added value will be created in our country which is the paradise of renewable energy with developing technology. The amount of green areas per capita will be increased in our country and in this case, it can help reduce the negative impact of work stress and city stress on human psychology.
Ç22	Although there are disadvantages such as cost, maintenance and operation; vertical green facades and green roofs are environmentally sensitive systems with many positive features such as regulating air quality, reducing urban heat island effect, reducing and increasing temperature, saving energy consumption, positively affecting human health, providing noise and wind isolation, which makes you comfortable. Especially in the long run, people should not underestimate its benefits in the context of structure and city.
Ç23	In our country, green roofing practitioners prefer ready-grown and imported plant material because of their availability. It is seen that there is a great burden on the discipline of landscape architecture in changing the perception of green roof systems and landscape concept. In order to preserve the natural plant existence of our country, to use and develop instead of imported species, the support of landscape architects is needed.

Ç24	In spite of all the benefits, roof gardens are not used in city planning of Erbil. Since the city of Erbil is faced with many environmental problems due to its dense population, roof gardens and wall gardens should be applied during the urbanization process. Local authorities should pay more attention to green roof and encourage building owners to convert traditional roofing into green roof
Ç25	Unknown (Study is closed to access)
Ç26	Unknown (Study is closed to access)
Ç27	Unknown (Study is closed to access)

4. DISCUSSION AND RESULT

In the study carried out, it was targeted to analyse graduate theses about green roof. As a result of the analyses the following results were obtained:

- Most of the graduate studies about green roof was carried out in 2007, and 26 of them have been made in the last 10 years,
- 26 of the graduate theses performed about green roof were of master degree, while only 1 of them was of doctorate degree,
- It was observed that most of the graduate theses carried out in the field of green roof were made by landscape architecture department.

Modern green roofs started at the beginning of 1960s in Germany to reduce the energy consumption (3). As a result of analyses, it is seen that the first green roofs were started in 2009 in Turkey and it is understood that our country is nearly 50 years back of the leader countries in this issue. The studies carried out recently have attracted attention that they only investigate the issue as literature researches, and merely examine the green roofs via examples.

It is recommended that the green roof issue be studied and implemented more since it has many positive and significant effects on social, economic and most important environmental results on only in terms of our country but also individual bases.

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Material Use in Diyarbakir Rural Architecture


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ABSTRACT

Each dwellings zone contains traces reflecting its own residential texture, nature, culture and social life. In the structure of rural settlements is observed that different materials and construction techniques are used depending on geological, geographic and topographic conditions of the region. Each dwellings zone contributes to the formation of a distinct architectural texture variety by the use of types of materials appropriate to the geological features of the region.

The construction materials used in rural communities in the province of Diyarbakir are closely associated with topographic and geological features of the areas where settlements occur. The construction materials used in the rural areas of the province vary depending on the variety in the geological structure of each region. The variety of materials, type of use and application details, which all vary from region to region within the provincial borders, contribute to the diversification of the rural settlement texture. In this study are examined types of materials, variety of use and construction systems used in residential buildings belonging to the rural architecture settlements located in different regions in the province of Diyarbakir by addressing their architectural characteristics.

Keywords: Rural Architecture, Traditional Materials

1 INTRODUCTION

The types of construction in rural architecture are shaped by the culture, natural and environmental data of each region. Life culture and physical environment characteristics that differ from region to region constitute the most important elements that provide diversity of rural architectural identity in the region.

The first and the foremost of the characteristic elements contributing to the architectural diversity of the local settlements are the local material types and techniques. The geological structure of the dwellings zone has been a determinant factor in terms of material use in rural housing, which vary by region. In local housing, it is observed that the use of materials which are easily available and require less costs are common, in parallel with the geological and geographic properties of the residential area. The physical environmental data which vary by region, however, have developed the use of material types in different construction systems. In this respect, the most important indicator reflecting the identity of local housing is that local materials are constructed by means of different construction systems. This difference in type of material use, however, contributes to the increase in diversity of rural architecture in every region [1].

A variety of characteristic architectural identity is also observed in architectural housing in rural settlements located in different regions of the province of Diyarbakir. The most important element which creates this diversity is the materials use and construction system techniques, which seems different in regions. Various materials such as various types of natural stones, adobe, wood, soil-borne mortar and plaster play an important role as an essential factor in the province's rural architecture.

2. MATERIAL IN DIYARBAKIR RURAL ARCHITECTURE

Local materials are the most significant component of the buildings in the development of the rural architectural identity. Local materials found in the immediate vicinity of residential areas are economically preferred owing to the facts that they are easy to procure and plentiful. Geological structure of the region is the most distinctive factor in types of local materials which may vary from region to region. Local materials varied depending on the nature of the geology appears to be the most obvious elements that make up the distinct architecture of the dwellings zones. The variations in the geological structure of the region are observed to contribute to architectural diversity in the local architecture of the rural areas in the province of Diyarbakir. The basalt lava of Karacadag, situated in the southwest of Diyarbakir, forms the most basic construction material used in the rural architecture of this region. The use of basalt stones is not seen in residential housing in other rural areas in the province due to the diversity of geological characteristics. The local housing in these areas however use limestone rock, brick and wood as construction materials.

2.1. Usage Areas of Stone in Local Architecture

Stone has been widely used as a construction material from past to present since it is a kind of material which can both resist to destructions in time and remain standing through long ages, depending on its types. Types of stone used in building are particularly preferred to be homogeneous, resistant to atmospheric effects and to have high compressive strength and physical properties (Figure.1.). Stone walls, depending on the type of stone, are the construction elements that create the physical structure of the region and design the architectural identity by their bonding techniques and textures. Each culture reveals the most convenient way to use the local materials. Thus, the development of local application techniques depending on the material is effective in the formation of local architectural texture.

In south-western region of the province of Diyarbakir, the only construction material of rural settlements is basalt stone due to the geological structure of this region. The type of stone used in other regions is limestone [3].

Basalt stone comprising of the basic material of rural architectural settlements in south-western region of Diyarbakır is a very hard and heavy igneous rock, homogeneous by appearance. It has a tiny crystalized structure. It is dark gray and black in color. It has an aphanitic, fine-grained structure. Minerals it contains are very minuscule to be observed.

Basalt is mainly formed by the solidification of the fluid and basic lavas in the form of five-sided or six-sided columns perpendicular to the cooling surface. In addition, the outer sides and flowing edges of these kinds of lavas may be hollow because of the air contact. This gives the rock an appearance of a cinder block. The gas particles coming out of the cooling lava allow the formation of this vesicular texture. As moved inside the rock, these pores get smaller and decrease in number. Such porous basalt is called vesicular basalt. It absorbs more water and its absorbing capability is excessive. Its workability is quite easy. The on-porous basalt on the other hand has a flat structure. The non-porous basalt, having a harder structure, is more resistant to impacts and carrier feature is strong [4]. Since the water absorption capacity of vesicular basalt is high, it is used in the floor of the constructions and it helps to create a microclimatic effect in environment, especially in summers.

Figure 1. Basalt use as building material (Diyarbakır-Hacı Koç Village)

Another type of stone widely used in the local architecture is limestone. Limestone is a type of sedimentary rock, mainly composed of calcium carbonate ($CaCO3$). It appears in different colors due to mineral oxides it contains. Its workability is highly easy. It is used as rubble stone, freestone and cladding stone in constructions [4]. It is possible to observe the use of stone in local architecture in Diyarbakir in the majority of architectural components such as foundation, load-bearing walls, lintel, eaves and the courtyard wall. The diversity of these architectural components in the use of stone material has a distinctive feature regarding the diversity of the local settlement texture (Figure.2.).

Figure. 2. Limestone as a building material (Diyarbakır-Boyunlu Village)

Depending on the type of stone, different uses and bonding techniques in the walls, the bearing element of the buildings, has created the architectural identity differences. Basalt stones are sometimes used as rubble stones, but mostly pitch-face stones, in bond systems (Figure.3.) (Figure. 4.). Mortar is used to bind in bonding systems using pitch-face stones. It is also seen that the basalt stone is used in walls in dry bond or soil-bound systems, as well (Figure.5) (Figure.6). When used as rubble stone, bearing capability is considered as of importance and emphasized by filling smaller stones between larger stones in order not to have space between the stones. The walls of the barns, designed as separate places outside the buildings, are constructed using rubble stones in dry bond system. Besides, the use of basalt stones is highly widespread as applied as rubble stones without any mortar. In addition, the coping applications in the building wall use stone material cut into flat plates [3].

Figure.3. Pitch-faced use of stone (Diyarbakır- Hacı Koç Village)

Figure.4. Rubble use of stone (Diyarbakır- Hacı Koç Village)

Figure.5. Stone wall – Dry bond (Diyarbakır- Karakoyun Village)

Figure.6. Stone wall – clay mortar (Diyarbakır- Silvan-Boyunlu Village)

Limestone, another stone type commonly used in the region, is used by different bonding systems and various types of planning in buildings which are the main elements of the settlements, when compared to the basalt use. Limestone used has been the main factor in the development of the architectural texture of the settlements due to differences in building techniques and topographic factors. Wall facades has gained a characteristic appearance according to the bonding techniques used and type of stone [3].

The use of limestone as a wall element is seen as pitch-faced stone and rubble stone. There exist regular and irregular use of stone quantities. Binding is provided by the mortar. In rural architecture samples, bonding timber is used to order the rows of the walls or support the walls at approximately 50cm intervals along the wall height (Figure.7.). In wall bonding systems, stones used in the corners are longer. The bonding timber used on doors and windows can be wood or limestone. Arches are available at the doors and windows some buildings (Figure.8.). Semicircular or flat arch is used at the windows while the use of semicircle and pointed arches is seen at the doors. Limestone used in arches is longer. Limestone is also used outside the building, in the yard or garden walls, as rubble stone and applied without any mortar to bind. In architectural planning in mountainous regions, houses are generally two-story buildings, and stairs to the second floor are constructed by stone material [3].

Figure.7. Examples for the use of bonding timber in walls (Diyarbakır-Boyunlu Village)

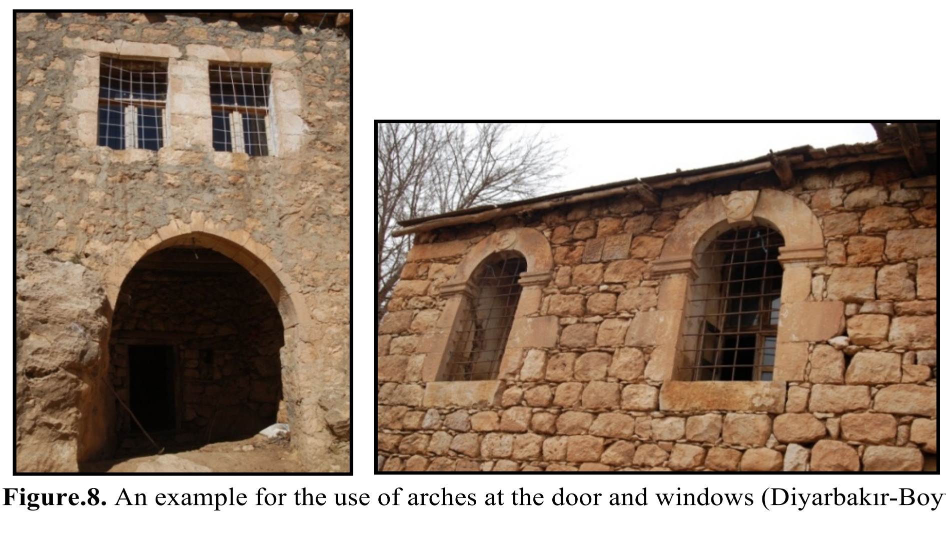

Figure.8. An example for the use of arches at the door and windows (Diyarbakır-Boyunlu Village)

The matrix used in traditional plaster and mortar applications of the buildings in the region consists of soil borne materials. Plasters, prepared by adding fibrous materials such as straw and cotton waste in these soil borne materials which have plastic properties, are applied to the inner and outer surfaces of stone walls. They are also used as masonry mortar or fill material in the stone wall bonding systems in order to obtain a homogeneous section. The mortar is also added sand aggregates. The interior surfaces are generally covered with a layer of lime whitewash, after they are plastered.

2.2. Uses of Soil in Local Architecture

Adobe, which is prepared by proportionately mixing water, straw and other different additives into clay or soil, is the leading traditional building material people benefit since ancient times.

Adobe, shaped and sun-dried in blocks, is used as a preferred building material since it is a natural and healthy material, easily available as a local material produced at low-cost, which provides a healthy, comfortable and balanced climate for interior spaces.

Clay, the main material of adobe, mixes comminuted hard materials, from the smallest grain of sand to large stone ballasts, just like dough. Since well-prepared and sun-dried adobe is fairly homogenous and compact, it is used as a load-bearing wall material in the buildings. Because its structure is porous, it quickly absorbs moisture in the air and can release the moisture into the air quickly. Thus, the interior climate is neither too dry nor too damp. Temperature is balanced spaces of adobe constructions. It is a good heat insulating material. It provides a good bio-climatic comfort in interior spaces during the summer-winter periods. Constructions built with adobe better balance the humidity of the indoor climate when compared to other building materials. Since it has bulky mass and porous texture, it is enough in terms of sound insulation. When moistened, its heat insulation subsides but the amount of sound insulation increases. It is a building material which declines the load-bearing capability when it is wet [5] [6].

Physical formation of the settlements in rural areas is determined by the materials and material use. Materials located near the settlement areas constitute the main construction material of the settlements. The soil constitutes the main construction material in rural areas of Diyarbakir where the stone is less but the soil is more abundant. Samples of adobe constructions within the rural architectural planning of Diyarbakır region are seen in lowland settlements. All the adobe constructions built in plain areas are single-story, and samples of two-story houses aren't seen.

Adobe surfaces cannot show resistance against external conditions without a layer of plaster. The mud plaster manufactured to protect adobe from external effects is broken in a short time. It is therefore required frequent replenishment. Otherwise, if this is not done, the buildings will be damaged. Plaster application appears to be in all of the examples of structures in the region (Figure 9.). Earth-based plasters, usually applied on the inner and outer wall surfaces in the buildings, are coated with lime to prevent infestation and weed formation (Figure.10.).

Figure 9. Use of soil plaster in adobe constructions (Diyarbakır - Akdere Village, Erler Village)

Adobe blocks, which are 30 – 35 cm long, 15 – 17 cm wide and 10 – 12 cm high, are used on the walls of the houses in these areas. The wall thickness of the houses studied vary and is approximately 50 cm. Utilizing the binding properties of the clay the soil contains soil has also been used as a mortar material. Wall construction is performed by mixing the soil and the mortar, comprised of loam, clay and sand mixture.

In adobe construction samples in the region, bonding timber is used on doors and windows (Figure 11.). Bonding timber used increases resistance by ensuring the walls operate as a whole. Window size used in the buildings are planned to be small, and the outer surface are found to be coated with grid systems made of materials like iron. This application aims to fulfill security concerns of the households and to prevent the intrusion of small cattle into the spaces [3].

Figure.10. Use of lime on soil plaster in adobe constructions (Diyarbakır-Akdere Village)

Figure.11. Use of bonding timber at windows (Diyarbakır-Akdere Village, Boyunlu Village)

Adobe, one of the principal materials in rural architecture, is also used in the construction of stables and poultry houses outside the house. Spaces used as stables, where cattle, sheep and goat live, are located either within house planning or near the building as a separate part. Poultry houses where poultry live, however, are made of adobe and often located adjacently to the outside of the building (Figure. 12.). Using this form adjacent to the building allows the reduction of the space adjacent the outer wall surface area. This is a quality which reduces heat loss in spaces. In the courtyard and garden walls of adobe buildings, rubble stone is used as without mortar (Figure. 13.).

Figure.12. Location of the poultry houses (Diyarbakır-Akdere Village)

Figure 13. Use of service units (WC-tandir) (Diyarbakır-Bismil-Erler Village)

Earth, the main ingredients that make up the walls, is also used in the cover coat of the buildings. The cover coat type in local architecture of the region is applied as earth-covered roof on wooden beams. Earth-covered roofs are shaped by social and cultural lives of local people because of the region's hot and dry climatic characteristics. Earth-covered roofs assume functions such as product drying space, storage space or sleeping and living space in summers. The earth used in roofs is added substances such as straw, cotton waste and salts. Earth on the roof is rammed in winter periods when there exists heavy snow and rainfall by using a stone cylinder. The cover coat type that helps local people meet their needs is effective on architectural identity. Flat-roofed architectural elements are one of the elements that create the rural texture [3] (Figure.14.).

Figure.14. Cover coat type – Earth-covered roof (Diyarbakır Sumaklı Village /Diyarbakır-Bismil-Erler Village)

2.3. Uses of wood in local architecture

Material which has a very significant role in the formation of architectural identity can be obtained from the closest distance. The geological structure and climatic characteristics of the province of Diyarbakir in particular are influential factors in the diversification of building materials. Harsh continental climate and semi-arid plateau climate are dominant in the region. Summers are very hot, dry and long; winters are cold and a little rainy. Therefore, forested areas are scarce and rare. Steppe vegetation usually outweighed by the herbaceous plants creates natural vegetation. Poplar and willow trees are partly seen on the banks of Tigris River. Due to the lack of forested areas depending on climatic conditions and geological structure, the use of wood in the local architecture in Diyarbakir region is not common. Its areas of utilization are very limited. It is observed that wood material is commonly used on the cover coat. In the short direction of the space openings take place wooden beams. Either wooden mats or roof boards are perpendicularly tiled on these wooden beams. The cover coat is formed by pouring adobe loam on the wood planked [3].

In settlements in mountainous areas in the district of Silvan, northeastern part of Diyarbakir, wood is used in tandem with limestone as wall materials. For applications in this area, it is seen that the bonding timber is used in the masonry. The bonding timbers used to improve the wall's loadbearing capacity are used in some buildings frequently without regular intervals or in some others at approximately 50 cm apart [3] (Figure.15.).

Figure.15. Use of bonding timber in walls (Diyarbakır-Silvan-Boyunlu Village)

In rural architectural planning, the length of the wooden beams used in the ceiling is determinative when deciding space dimensions. It is sufficient to size places such as living space, kitchen, store and bathroom designed for the needs of local building users according to the length of the wooden beams in terms of requirements of use. However, this space is insufficient in terms of the size of the stables where cattle are sheltered. Stables are sized and used by repeating the base quantity specified dimensionally side by side. In this type of sizing, wooden beams used on the ceiling are superimposed over each other to gain length. At points where wooden beams are superimposed, another separate wooden beam perpendicular to these beams is used and these points are supported by wooden pillars. In this way, wood is used as a bearing material for the roofing elements in spaces [3] (Figure.16.) (Figure.17.).

Figure 16. Wooden beam construction in stables

Figure 17. Wooden beam construction in housing units

It is possible to observe the use of wood material in buildings as bonding timber in upper parts of the door and window openings. Apart from that, it is also used as a profile material for the door and window frames (Figure.18.). The use of wood also observed in eaves construction in the entrance of the houses (Figure.19.). Wood has shaped the architectural texture with such types of use in the region [3].

Figure 18. door and window frames (Diyarbakır - Silvan Boyunlu Village)

Figure 19. Use of wood as an eaves element (Diyarbakır - Silvan Boyunlu Village)

In some houses, it is observed that wooden plaques, 1-2 cm thick, are used as partition walls, not to bear load but only to separate spaces indoors (Figure. 20.). Use of these partition walls is used on the upper floors of the house with two stories. Partition walls used as well as the load-bearing walls have a negative impact on providing climatic comfort.

Figure 20. Use of wood as a partition wall (Diyarbakır - Silvan Boyunlu Village)

3- CONCLUSION

There are many factors affecting the architectural shaping in rural settlements. These factors vary from region to region. It is observed that factors such as climate, topography, availability of local materials, social and cultural structure are quite influential in the formation of the rural architectural settlements in the province of Diyarbakır. The architectural characteristics of the buildings in rural settlements in the region have improved diversity thanks to the solutions found in terms of use of materials and physical environmental characteristics. Multiple architectural identity formations are available in the region as a result of the use of materials and construction systems. This diversity of architectural identity can be observed in different residential characters in different parts of the region. Determination of the architectural characters which are distinctive quality of the settlements and conservation and improvement of applications will contribute to ensure the sustainability of rural settlement diversity.

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The Restoration of The Church of S. Egidio A Sigillo Ancient Seal in The Territory of The Aquila

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ABSTRACT

It appears around 1398 in a bull and depended on the church of Santa Croce in Bourbon, known for its processional cross, dating back to around 1320-1330, one of the most extraordinary masterpieces of art in the region as it survived with few others to the group of monumental crosses preserved in the Angevin sanctuaries of the Aquila area. The church of S. Egidio presents a restoration of 1666 (the date is stamped on the entrance to the church) and another of 1856 (date stamped on a roof table); in 1987 the altar and the oil painting of the Saint, to which the church is entitled, was retouched. The church presents problems of humidity due to infiltration from the roof, deteriorated due to the breaking of roof tiles by frost, and by the rotting of planks. A further infiltration occurred due to the waters descending from the rock face next to the church towards the mountain. This infiltration led, probably in the 20th century, to the construction of a plastered brick wall, on the right side with respect to the entrance. The outer wall towards the mountain also has no mortar joints due to corrosion. The base part of the entire church inside presents problems of plaster degradation. Further ascent is due to the internal floor, placed incorrectly at the same level as the external one. Also the altar in some points shows phenomena of degradation of the painting and plaster; the altar of the '700 was "restored" in 1987 by a painter, with different materials from the original ones. The project focuses on the following phases: Remediation of roof infiltration humidity: The roof is integrated in the degraded parts with new boards, after a survey that allows to verify the good condition of the trusses and the joists; only 12 can be substituted, not having a structural character, placed at the corners, with equal big-bells. As the course of the planks is irregular in that the thin chestnut planks have deformed and had been regularized with stone and concrete fillings that reconstituted the floor, as an improvement, phenolic panels overlap in order to reconstitute a regular plan on which to lay the tiles. Some old tiles are reused, and others replaced with antiqued tiles. Previously, a waterproofing sheath is applied to the tiles.

Keywords: Key words church; infiltration; structural, stone

1 HISTORICAL ANALYSIS

It appears around 1398 in a bubble and depended on the Church in Borbona, known for its processional cross, dating from about 1320-1330, one of the most extraordinary masterpieces of art in the region as it survived with few others to the group of crosses preserved in the Angioini shrines of the Aquilan territory.

Figure 1. Borbona's Cross

The church of St. Egidio presents a restoration of 1666 (the date is imprinted in the entrance portal to the church) and another of 1856 (date imprinted in a table of the roof) ; In 1987 the altar and oil painting of St. Egidio, to which the church is named, was retouched. In the area in the 15th century were active the Master of Our Lady of Mercy and Sylvester of the Eagle; The period of Margherita d'Austria dates back to nearby Borbona paintings near Stradano and in the 1600s to Ludovico Carracci. The passage of the Fiorentini route, used for the trade in textiles and yarn, led to the area the workers from northern Italy, in particular the Mastri Lombardi. The construction of the Church of St. Egidio is attributed by tradition to a Florentine.

The church had moisture problems, due to infiltration from the roof, sicked, due to rupture of frost cups, and rottenness of boards. Further infiltration had occurred due to the waters descending from the rock face next to the church towards the mountain. This infiltration had led, probably in the 20th century, to the construction of a counterwall in plastered brick, on the right side of the entrance. The wall of the church, outside, towards the mountain also presented itself without the mortar joints due to corrosion.

The basal part of the entire church inside had problems with the degradation of the plaster. Further ascent was due to the interior floor, which was mistakenly placed on the same level as the outside floor.Even the altar in some places exhibited phenomena of degradation of painting and plaster; The painting of S.Egidio altarpiece of the 18th of the 19th year was "restored" in 1987 with materials other than the original ones. The color of the walls was yellow, with a niche finished in green in recent times; the altar area was white, shabby with lime, but the saskiing had also invaded the vault, painted in ancient celestial. There was a hole in the front for the Enel lap and a green colored niche inside to place the counter. The sail bell tower was presented, at the dismantling of the cups, lacking at the base of mortar and tins and treated with bastard mortar, gray. The external portal was also painted with enamel and bears the inscription WGESU in the lintel. The door bears two layers of paint, green and brown, one of cement.

Figure 2. Chestnut table on the roof of S.Egidio

Progetto di restauro The restoration1 is strongly desired by the parish priest and private associations of the place. The project focuses on the following steps: Remediation of roof infiltration moisture: The roof is integrated into the degraded parts with new boards, after a survey that allows to check the good state of the trusses and joists; only 12 non-structural "palombelli" are replaced, placed at the corners, with equal poles.

Figure 3. Conservation of the roof

Since the table's progress is irregular because the chestnut plates, thin, have deformed, and had been regularized with stone and concrete carry-overs that reconstituted the floor, as an improvement intervention overlap the panels overlap phenolic, in order to reconstitute a regular plan on which to lay the cups.

Figure 4. The ancient poles

Some antique cups are reused and others are replaced with antique cups. A waterproofing sheath is used before the cups. The cups are stopped with clippers and places of the eaves (and descendants) copper canals. The descendants, who previously, in galvanized sheet, were placed on the facade, are placed sideways. In order to overcome the phenomenon of descent and stagnation near the outer wall of the meteoric water coming from the mountain, a channel is put in place made of stones, hydraulic mortar and showers to form an open channel, with slope towards the back of the church.

The sickjoint joints are always replenished with hydraulic mortar. The new funnel, which collects the water, is dropped with a difference in altitude at the back of the church, in which a line with stones is created. Mortar joints in the outer back wall are also compensated to further limit infiltration.


Figure 5, 6. Conservation of the roof and waterproofing

The altar is integrated only in small gaps, both plaster and color, with similar colors. Stratigraphic surveys are carried out (9 pieces in all) to check for frescoes. They were not frescoes but only a clear ochre colour throughout the church, including the area surrounding the altar. Originally the back wall was not plastered but directly painted on stone. Interno



Figure 7, 8, 9. Protection of the altar, restoration of the inner and outer part of the door

Figure 10. Protection of the altar restored during the work of the church

Inside the church, the entire base part of plaster is reconstituted, previously bewildered, always with products based on hydraulic lime.

Figure 11. Single-cooking floor choice
Figure 12. Presbytery, use of thin terracotta in the siding with the step

The tint, at the bottom, is reproposed as the previous one. In the presbytery area, the marble placed in the 1970s is removed and a thin mono-cooking is placed, due to the low thickness available. On that occasion it is noted that the screed is in lime-concrete, so it is not possible to lay the terracotta floor without demolition works, which in the good of artistic historical interest it is preferable not to carry out, because of their destructive nature, even since the potentially harmful vibrations to the structure

Figure 13. Lavorazione del pavimento in cotto

The flooring continues in the rest of the church by placing in place a single-cooked centimeter of cm.3 with tavelle similar to those used in the vault above and basket processing, as in the previous flooring. The difference in altitude that is created means that no more water is infiltrated from the access door. The 1970s marble skirting board was also removed and the plaster was reinstated. The electrical system first subtrack is replaced with a braid in accordance with and the track is compensated, with lime plaster. The floor is treated with waterproofing. The travertines of the external portal, as they had traces of enamel paint, are sandblasted and then shapped with lime/land yellow ochre. The date of the first restoration is read as a result of the removal:1666. The bell tower is plastered because it was presented in a grey and colored bastard mortar with lime color and yellow ochre earth.

Figure 14. Restoration of the sailing bell tower

The flooring continues in the rest of the church by placing in place a single-cooked centimeter of cm.3 with tavelle similar to those used in the vault above and basket processing, as in the previous flooring. The difference in altitude that is created means that no more water is infiltrated from the access door. The 1970s marble skirting board was also removed and the plaster was reinstated. The electrical system first subtrack is replaced with a braid in accordance with and the track is

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Figure 15. Away from the rainwater from the side wall

CONCLUSIONS

The restoration work in S.Egidio was carried out taking into account the financing by private individuals that would not have allowed particularly expensive work and was limited to an ordinary maintenance of the entire building with small additions.

The building has been completely restored. It is therefore an effective example of how it is possible, by carrying out constant routine maintenance, to arrive at a complete restoration of the entire structure and allow its preservation, thus passing it on to the future in dignified conditions.

Figure 16. La canalizzazione del tetto in rame

Figure 17. The restoration of the altar completed

Figure 18-23. The final aspect of the restoration

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The Role of Cotton Seed Oil as an Additive Material in Adobe: Ardakan's Adobe Structure Samples

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ABSTRACT

Earth and clay for a long time has been known as an important element in architecture. The breadth of the soil in the architecture of the desert to mountainous areas, cold and warm district is so large that it could not be classified just for a specific climate. However, the soil has been used widely in the desert areas as the most significant element of architectural maturation and has led to the formation of large houses, villages and towns. Iranian architects have used different methods in accordance with the needs of the environment from the soil and, with their knowledge and experience, have created different structures for the use of soil. They used what nature provided to them to empower strengthen and resistance of soil and clay in their architectural structures.

Ardakan in Iran is one of the desert marginal cities that its native architecture is based on adobe (mud bricks). The traditional architects of Ardakan have long been trying to use nature in order of architectural advancement.

Straw, Common reed, ropes which are made of date fibre (Sazoo) and cottonseed oil are some of the natural materials which are widely used by Ardakanian architects in various admixture compositions. Because Common reeds and ropes which are made of date could resist against decay and insect attack they have been used as an armature of an adobe structure.

In addition to the above examples, cottonseed oil is a natural additive in cooking traditional bread and even it was used in flambeau of pitmen. In addition, it has been used to raise the resistance of soil overlays that are exposed to sun, rain and frost. In this paper, we will examine the properties of this oil and its effect on soil and clay adobe.

Keywords: Soil, adobe, adobe structure, cottonseed oil, Ardakan.

INTRODUCTION TO COTTONSEED

Cottonseed is a Herbaceous plant with one meter or a bit more height, the leaves are a combination in dark colour, angiosperm type with sharp needle tips. Flowers grow in shine yellow with purple dots.
Cotton is a soft, fluffy staple fibre that grows in a boll, or protective case, around the seeds of the cotton plants of the genus Gossypium in the mallow family Malvaceae. The fibre is almost pure cellulose. Under natural conditions, the cotton bolls will increase the dispersal of the seeds.

The mature seeds are brown ovoid's weighing about a tenth of a gram. By weight, they are 60% cotyledon, 32% coat and 8% embryonic root and shoot. These are 20% protein, 20% oil and 3.5% starch. Fibres grow from the seed coat to form a boll of cotton lint. The boll is a protective fruit and when the plant is grown commercially, it is stripped from the seed by ginning and the lint is then processed into the cotton fibre. For the unit weight of fibre, about 1.6 units of seeds are produced. The seeds are about 15% of the value of the crop and are pressed to make oil and used as ruminant animal feed. About 5% of the seeds are used for sowing the next crop.

The plant is a shrub native to tropical and subtropical regions around the world, including the Americas, Africa, Egypt and India. The greatest diversity of wild cotton species is found in Mexico, followed by Australia and Africa. Cotton was independently domesticated in the Old and New Worlds.

2 COTTONSEED OIL

Is a vegetable oil refined from round cottonseeds, Gossypol is a toxic, yellow, polyphenolic compound produced by cotton and other members of the order Malvaceae, such as okra. This naturally occurring coloured compound is found in tiny glands in the seed, leaf, stem, tap root bark, and root of the cotton plant. The adaptive function of the compound facilitates natural insect resistance. The three key steps of refining, bleaching, and deodorization in producing finished oil act to eliminate the gossypol level. Ferric chloride is often used to decolourize cottonseed oil.

Cottonseed oil is cholesterol free and low saturated fatty acid. Its fatty acid profile generally consists of 70% unsaturated fatty acids (18% monounsaturated, and 52% polyunsaturated), 26% saturated fatty acids. When it is fully hydrogenated, its profile is 94% saturated fat and 2% unsaturated fatty acids (1.5% monounsaturated, and 0.5% polyunsaturated). According to the cottonseed oil industry, cottonseed oil does not need to be hydrogenated as much as other polyunsaturated oils to achieve similar results.

Cottonseed has a similar structure to other oilseeds such as soy seed, sunflower seed, having an oil-bearing kernel surrounded by a hard outer hull; in processing, the oil is extracted from the kernel. Cottonseed oil is used for salad oil, mayonnaise, salad dressing, and similar products because of its flavour stability.

3 COTTONSEED USAGE

Cotton is one of the world's most important industrial crops. The United States is ranked third in cotton production, behind China and India [1]. Most of the cotton land area in the U.S. is in the Southern and Western states, e.g., Texas, Georgia, Mississippi, Alabama, North Carolina and California [1]. Economically the most important part of the cotton plant is the fibre, which is used mostly in textiles. However, the plant also yields various products from the seed [2]. For example, cottonseed linters are converted to cellulosic derivatives and used to form coatings and films; cottonseed oil is an important edible oil; and cottonseed meal contains high levels of protein, which is used primarily as animal feed. [2]

The cottonseed meal after being dried can be used as a dry organic fertilizer, as it contains 41% protein. It can also be mixed with other natural fertilizers to improve its quality and use. Due to its natural nutrients, cottonseed meal improves the soil's texture and helps retain moisture. It serves as a good source of natural fertilizers in dry areas due to its tendency of keeping the soil moist. Cottonseed meal and cottonseed ashes are also sometimes used to supplement organic hydroponic solutions. Cottonseed meal fertilizers can be used for roses, camellias, or vegetable garden through suitable processing, cottonseed protein isolate can be obtained from cottonseed meal [5].

Cottonseed is crushed in the mill after removing lint from the cotton ball. The seed is further crushed to remove any remaining linters or strands of minute cotton fibres. The seeds are further hulled and polished to release the soft and high-protein meat. These hulls of the cottonseed are then mixed with other types of grains to make it suitable for the livestock feed. Cottonseed meal and hulls are one of the most abundantly available natural sources of protein and fibre used to feed livestock.

4 HISTORY OF COTTONSEED OIL

Growing cottonseed is almost as old as agriculture history, for example in Pakistan since 3000 BC or 1500 BC in india it had been a main agriculture product.

There are photographs as and reliable evidence of growing cottonseed in "AGHDA" (small village in 30 km north of Ardakan) in 1908 and baking a local bread called" LITRIK" witch is fried in cottonseed oil. Litrik is engaged with a religious ceremony Eid al-fitr as a fast opening meal.

This type of bread is only baked in Ardakan and Yazd area, and what makes this special type of bread very famouse is baking procedure with cottonseed oil.[6]

Although heritage documents from 300 years ago gives us more evidence of availability of cottonseed oil in the area, but with a smart look at Zoroastrian traditions we can found more signs[7]

The cottonseed oil in the local language is known as candle oil, in the museum of the anthropology of Ardakan there are light bulbs from 1400-1550 AD fueled with cottonseed oil, other light bulbs found in Ardakan central mosque for 1720-1800 AD was also same types

In other hand existence, several cottonseed refinery workshops inside the urban culture of Ardakan is proof of the amount of popularity of this product.

The refining oil from cottonseed had become a tradition in this city and its social effect is emerging expertise and family names such as" ROGHANGIR"(oil extractor).

Cottonseed oil also plays a role in the traditional architecture industry in Ardakan." Sim gel" is a coating method used for improving water resistance of adobe(mud brick) produced from combination of clay, straw,water in outside walls and top roofs of buildings.

This technique is almost outdated for more than 70 years the main reason might be the adobe structure constructing is obsoleted.

In this investigating we was able to retrieve the traditional combination of" simgel "from interviewing with traditional architecture professionals and test the efficiency of this combination in laboratory.

5 LABORATORY TEST AND ANALAYSES

According to the history of consumption in architectures, Cotton seed oil has been tested as an additive in samples with varying degrees. In this section, the oil is combined with certain proportions with the soil and the bending strength has been tested to measure the elasticity level of the surface.

These tests are examined at the laboratory of cultural heritage base in Ardakan and have a good scientific reputation. The laboratory was constracted in 2008 by the Catherine Research Institute under the supervision of the University of Grenoble, to analyze and test the methods of clay processing and production, as well as analyzing Ardakan region's architectural clay structures to revive the traditional and clay base architectures. The laboratory since then has been operating and after re-equipment it has based at the "Mazloom historic house", the headquarters of the cultural heritage site of the historic city of Ardakan.

In order to properly analyze the tests, some common factors must remain at a constant level. Hence two factors, water and soil, remain constant. Distilled water was used in this experiment to prevent the pH of the water from affecting the resistance level.

Second Factor
The soil was carefully examined in this test. For this purpose, after determining soil's moisture content it was grained in a moisture method. Soil aggregation demonstrates the amount of grazing and soil grains. At this level, the final sieved soil is used to determine the extent of soil sedimentation in the hydrometer test.

The following tables show the moisture content and soil grains.
Determining the moisture content infers how much soil can absorb moisture in normal conditions. Then it is possible to determine the ratio of water which required for the construction of clay.

After aggregation, three kilograms of soil is blended with 28% distilled water for the production of clay in the traditional way, water (the molds are soaked with water and at the same time removed from the mold). Three specimens are extracted from each resistor to determine the average of the three specimens as resistance degree. After mixing the water and soil, put 24 hours to prepare the soil for production in a plastic bag.

selecting this soil is based on a study carried out in 2015 on the soils of the Ardakan region, and only one of the six soil mines was suitable for soil resistance testing. This is the. This mine is located in Aliabad area which is at the end of the northern lands outside the Ardakan fence.
After soil selection, samples have been tested for flexural strength with cotton-seed oil compounds.

6 TEST DESCRIPTION OF COTTONSEED OIL'S FLESURAL STRENGH

There are three examples of oil mixing persentage in this experiment, which, according to the traditional method, the oil ratio has been changed. three samples were us 7.6% soil weight that was used in the traditional method, and in the other samples they were doubled and tripled traditional oil usage. A simple test, reduction the length, was used to find the most suitable amount of additive.

This test is carried out in molds of 40 cm length, 4 cm width and 3 cm height, which examined The sample's breaking at length, as well as the rate of reduction of the width are monitored after drying .

7 CONCLUSION

The result of this experiment infers that the addition of oil to a blende"Simgel" plastering could affect the longitudinal fracture in the sample and in fact created a good coherence. But the important thing is that when the amount of oil in the composition is increased more than 20%, the sample drying process has slow down and the sample does not actually come to a complete self-discharge. As much as 30% of the oil, in fact, causes the disintegration of the compound. Then, the sample contains 30% of the oil tests were suspended. Instead of the third specimen, a new sample was created with a larger amount of water, named after Example 5. In addition, another example was made with a 5% oil content, which is named after Sample 4.

Note: when a higher amount of oil in the test was used, the water content was reduced. This is due to the creation of a fit between the fluids in the mixture. However, considering that the increase in oil causes on the reduction in the mixing pressure, in sample number 2, the water content is increased due to the proper self-regulation and a new sample is given by number 5.

Table B4 shows the percentage of mixing. images from the samples are in the A2 table.
fracture in sample No. 2 with a 2% oil content could be observed. In sample number 5, more coherence can be traced due to increased water content.

Of the above examples, only three mixtures of numbers 1,4 and 5 have been selected. As it was said, sample 2 was also removed from the flexural strength test due to the failure of this stage.
In the bending strength test, from each mixture, three samples were cast in standard cast iron plates with dimensions of 4 * 14 * 14 cm, and the average of them was used in table B5.

8 RESULTS

1- Increasing cottonseed oil to water according to the amount of soil needed should not exceed 20%, in addition to proper fitting with water.
2- Cottonseed oil in the soil does not increase the flexural strength due to these experiments, even when this additive is not mixed properly, it causes a lack of uniformity of the mixture.
3- Cottonseed oil could produce an insulation level on surface and increase the soil's surface coherence.
4- The use of oil can help plaster's lifetime and if the proper amount is chosen between 5% and 10%, it does not cause discolouration.

A1 Table
Ali Abad region's soil graining
the laboratory of cultural heritage base in Ardakan

B1 Table			
Determine moisture content			
Sample: Ali Abad region Date: 2016/02/14		Sampling site: Ardakan traditional soil mines Laboratory: Soil and Clay Laboratory of Ardakan Cultural Heritage Bureau	
Humity:20%	Temperature 23:2	End at: 1440 minute later	Start at :8.5
Size of the largest seed in the sample: 10 Milimeter		Soil weight: 2K	
Wet sample's weight		= 200D 2000 gr	
Dry sample weight		1968 gr	
Water's weight		32 gr	
Dry grain's weight		256.9 gr	
Water percentage in sample soil		1.6%	

B2 Table				
Graining determination: Ali Abad Region				
0.106 mm		Choose the size of the last seive		
Sample specification for preliminary grainingfine seeds Diameter of the largest grain:10 mm				
2500 gr		Wet sample's weight		
Control 200D<m<600D				
Graining sample of soil				
Persentage of soil which passed through the seive	Persentage of the remaining soil on the sieve	The weights of the remaining soil on the sieve in gram	Sieve size on milimeter	Sieve number
-	-	-	18	$^3/_4$
-	-	-	9	$^3/_8$
95.22%	0.136%	3.4	4.75	4
95.04%	0.18%	4.5	2	10
94.684%	0.356%	8.9	1	18
93.92%	0.764%	19.1	0.425	40
92.572%	1.348%	33.7	0.212	70
85.08%	7.492%	187.3	0.106	140
	85.08%	2127		Under sieve
	The soil which passed through the last sieve T_n =2127 gr			
	The weight on the last sieve R_n=256.9 gr			
	$(R_n + T_n)$=2383.9 gr			
Perth survey (the amount of soil that may spill out and can not be reversed for any reason) x100=<2% $\frac{m_d-(R_n+T_n)}{m_d}$				

Table B3

Sample's name	Average flexural strength of typical clay sample MPa	Average tensile strength of typical clay samples MPa	Average compressive strength of typical clay sample MPa
Ali Abad	1.186	15	4.682

B4 Table

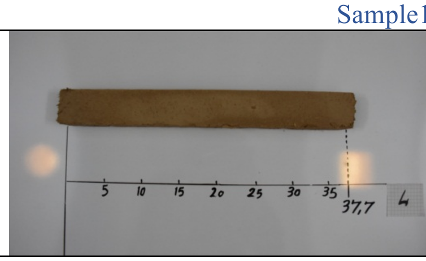
Weight of water	Oil content based on percentage of soil used	Weight of Straw in gram	Weight of soil in KG	Sample's number
850gr	10%-230gr	190	3	1
620gr	20%-460gr	190	3	2
965gr	5%-115gr	190	3	4
900gr	20%-460	190	3	5

TableA$_1$

Sample2

Sample1

Sample5



Sample4

B5 Table

Average flexural strength of typical clay sample - MPa	
1.025	1
1.190	4
1.016	5

TableA**2**

Sample4

Sample1

Sample5

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Explaining the orientation of Qajar houses' wind-catchers in Yazd according to their location in the houses and relative spaces

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ABSTRACT

Yazd city is well-known to wind-Catchers' city. A lot of wind-catchers which the most of them relate to Qajar's period houses are being in Yazd city. While Yazd traditional houses are divided to four section that each one was used in the particular time and season, the wind-catchers almost are located in summer-section space and in some houses in spring-section. While the orientation of traditional houses in Yazd has 15 degrees round clock from North-East to South-West, The orientation of wind-catchers is two direction that they are perpendicular to each other (parallel and perpendicular with the houses' orientation). This article aims to explain the direction with considering the wind-catchers location and relative spaces. The method of research is that some traditional houses are selected as statistical society, then they categorize in specified details, finally the data is derived by logical observation.

Keywords: Orientation, Wind-Catcher, Relative Spaces, Traditional House & Yazd.

1. PREFACE

Yazd city is located in the center part of Iran where the climate is hot and dry and it is surrounded by deserts. There is a big temperature difference between night and day, but over the thousands years, Yazd people could learn to match buildings with the strict weather so that they had a comfort conditions. They had used some features and elements in their house like courtyard, wind catcher, and others, before the new method of building did not pay attention to them. All parts of these houses including foundations, walls and roofs are of mud plastered adobe [23].
The most of the Yazd traditional houses have a courtyard, but some houses which they belonged to the luxurious families can be found that they have 2 or more courtyards [27]. A typical central court house in Yazd is surrounded by built area on all four sides and rooms on 2, 3 or 4 sides of the central court [24]. It seems that the orientation of them has 15 degrees difference with the northeast-southwest direction, and it is along in the Qible direction. The form of the central court is usually a rectangle, but in some houses, the shape of it is square or Octagonal.

2. YAZD TRADITIONAL HOUSES QUALITIES

First of all, Yazd historic houses' qualities are displayed. The typology of Yazd historic houses is that a courtyard is surrounded by some spaces that they have a different function and each one of them is used in different time and seasons [28]. The orientation of Yazd historic house has a 15 degrees different with north-east and south-west direction as long the Qible direction. The seasonal using of spaces is that north-east part were used in the winter, south-east in spring, south-west in summer (the wind catcher is located in this part), and north-west in autumn [25] (Fig.1). The main reason of these moving is that controlling the sun's wave in different season (absorption or reflection). Different spaces were used in different times in the past for example, 5-Dari used in the middle of winter and Cellar used for sleeping in afternoon days of summer [26].

The two stories southern side has an upper level which is a little higher than the other three sides of the house [29]. This side contains a very big, high space called the ''Talar".

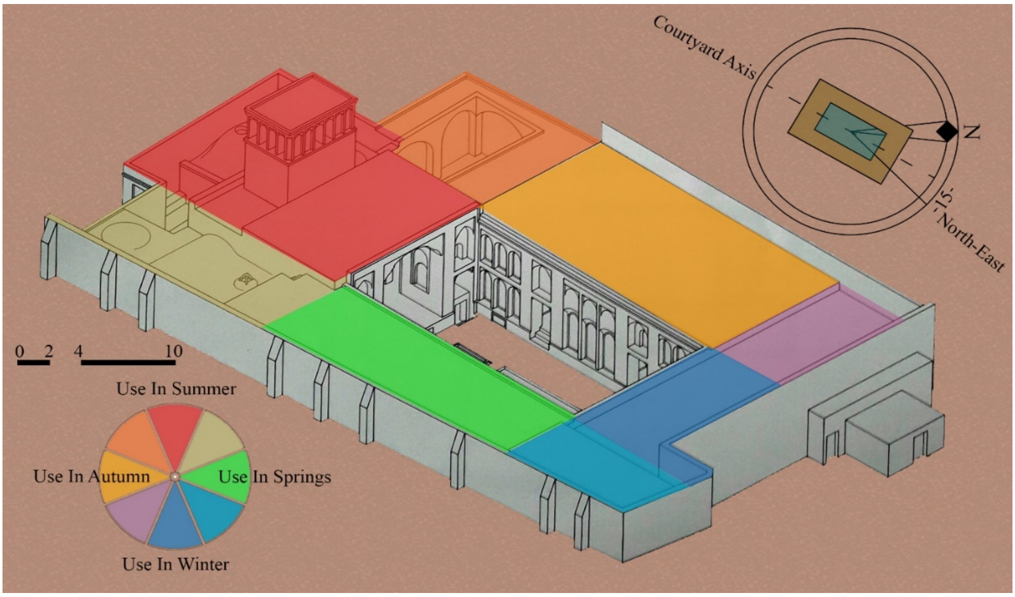


Fig. 1. Typology and Seasonal Using of Yazd Historic Buildings- Tehraniha House (author with ciation to Haji ghasemi [27]).

3. METHODOLOGY

28 traditional houses which they have wind catcher and go back to Qajar period in Yazd are surveyed by the author as sample. They are categorized into 3 different tables, because they can be analyzed easily. The content of different tables is divided by the traditional houses that they have a wind catcher and a courtyard, another is a wind catcher with two or more courtyards, and the other is two or more wind catcher and courtyards. The information are classified in 5 columns for each house: Houses name, Wind catcher orientation, Wind catcher's spaces relation, Courtyard orientation, and the schematic plan. The north direction of each house is toward above the page (∆ North). The reference of houses images in the tables is specified in front of their name separately.

3.1. The houses have a wind catcher and courtyard

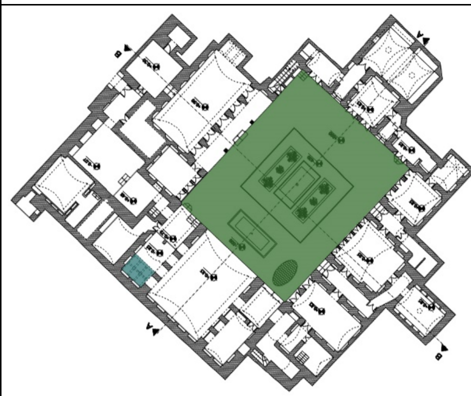
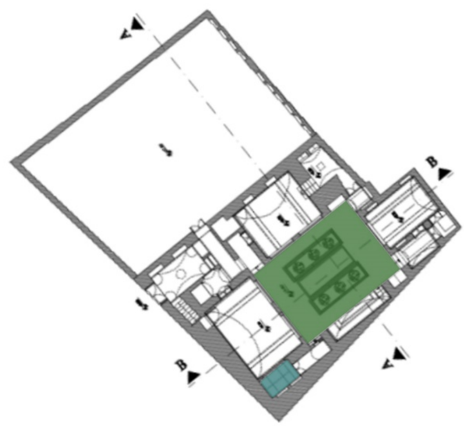
Table 1 shows the twelve traditional Qajarian houses in Yazd that they have only a courtyard and wind catcher. Generally, the dominant orientation of wind catcher is perpendicular on Qible direction.

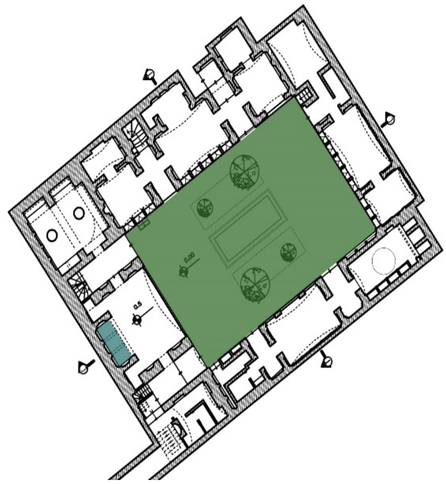
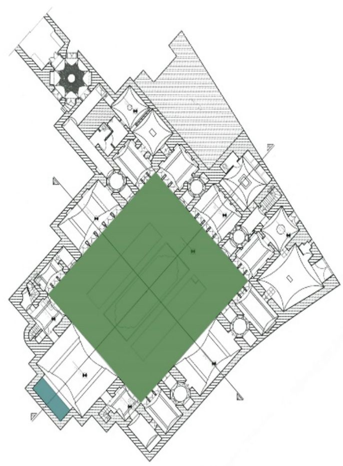
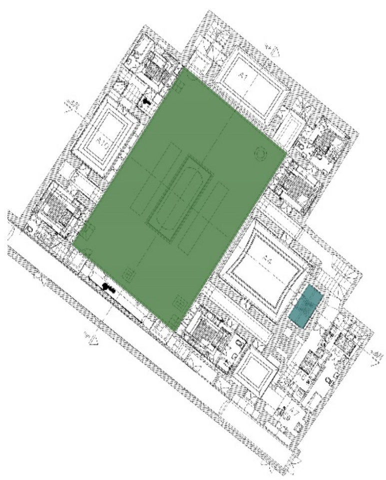
The courtyard orientation for some houses is different with the other. For example, Heirani, Najjari, and Malek o Tojjar courtyards' orientation has a bit more angle than the dominant orientation of courtyard in Yazd while Zargar Yazdi's orientation is less than it. The courtyard orientation of Papoli house is perpendicular on the dominant direction. The RasolHosseini has a completely different orientation with the others.

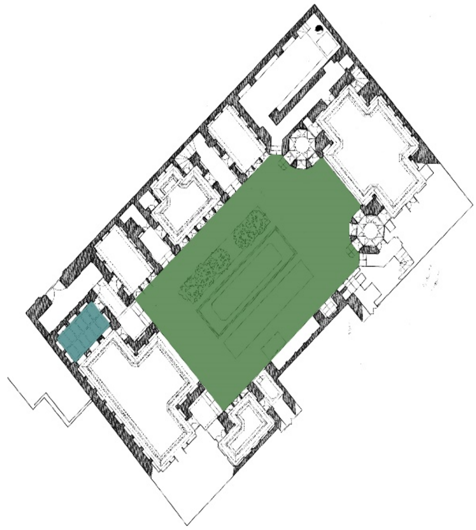
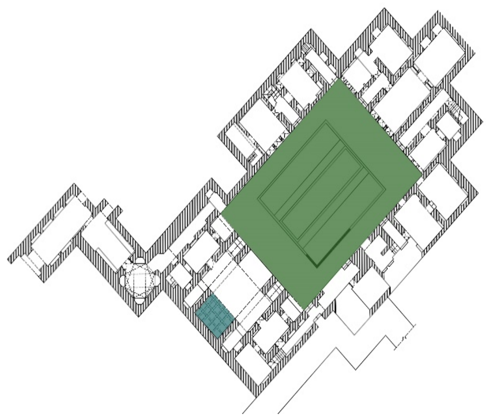
Talar is the main space that it has the relation with wind catcher. The location of wind catcher in Talar has two different part, in the axis of it like Bidast house or in the corner of it like Amanin. Although in the most houses Talar and wind catcher are located in the summer part, the wind catcher and Talar of Malek o Tojjar and papoli houses are put in the spring part. RasolHosseini's wind catcher and Talar is placed in the south part of its courtyard. Only in the Najjari house the wind catcher has a relation with the different space (Shekam Darideh).

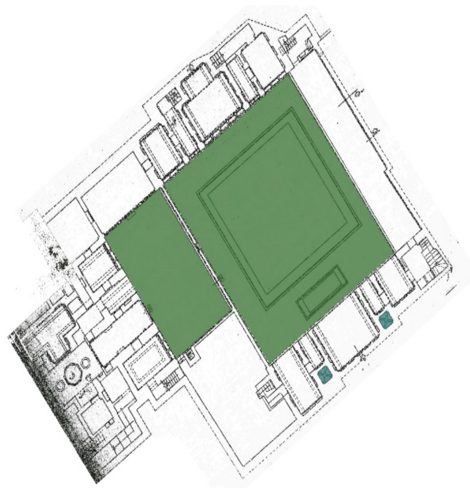
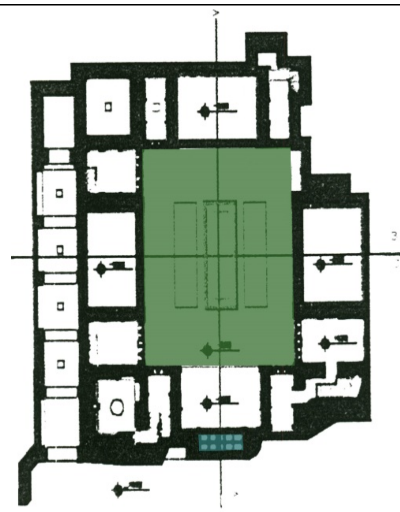
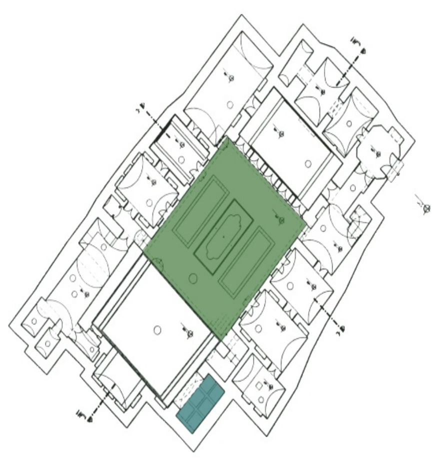
The wind catcher orientation of some houses is parallel with Qible direction (Anguzeie, Malek o Tojjar, Maveddat, and Salehi). Although the Papoli house has twin wind catcher, the plan of them is square and they do not have the tendency to any direction. Like the courtyard direction of RasolHosseini house, the wind catcher orientation is completely different with the others.
The wind catcher orientation is parallel with courtyard orientation in some houses: Anguzeie, Malek o Tojjar, Maveddat, and Salehi houses while in the most of these houses they are perpendicular on each other.

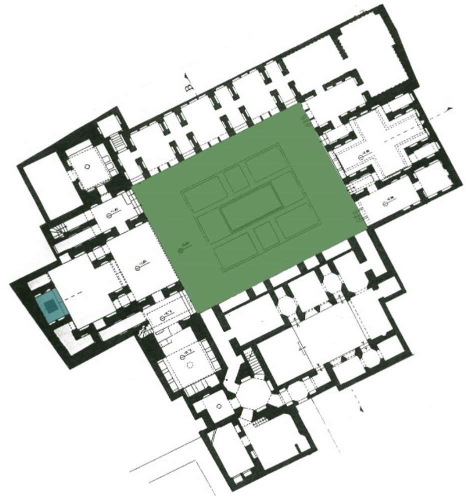
Table 1. the Yazd Qajarian tradtional houses which they have a wind catcher and courtyard (author with citation by different source)

Houses Name (courtyard or wind catcher)	Wind Catcher Orientation	Wind catcher's spaces relation	Courtyard Orientation	Schematic Plan
Amanian [19]		Talar		
Anguzeie		Talar		

Bidast [17]	⤡	Talar	⤢	
Heirani [18]	⤡	Talar	⤢	
Malek o Tojjar [27]	⤢	Talar	⤢	

Maveddat [6]		Talar		
Mir Zadeh [2]		Talar		
Najjari [27]		Shekam Daride		

Papoli [11]	Without Direction	Talar		
RasolHosseini [13]		Talar		
Salehi		Talar		

Zargar Yazdi [12]		Talar		

3.2. The houses have a wind catcher and two or more courtyards

Table 2 illustrates the six traditional Qajarian houses in Yazd that they have only a wind catcher and two or more courtyards. It is obvious, the dominant orientation of main courtyard is along the Qible direction and the wind catchers are located in this courtyard.

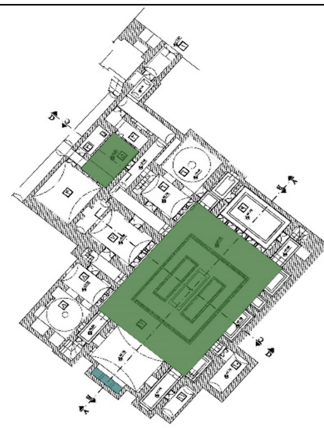
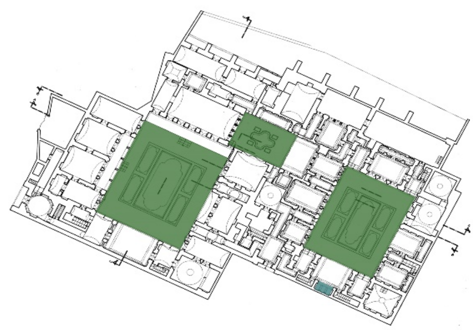
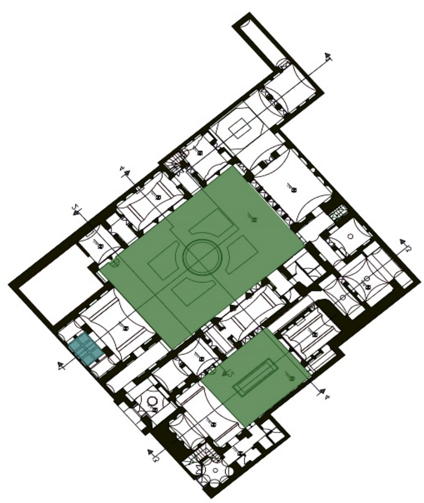
As far as refereed, the Qible direction is the original one for main courtyard, but the secondary courtyards orientation in some houses have the opposing position with the main courtyard orientation. For example, in the Golshan House which it has 3 different coutyards, the smallest courtyard orientation is completely different with the others. Although in Malek Zadeh and Ziarati houses the main courtyard have the specific orientation, the others courtyards do not have any orientation and the plan of them is square.

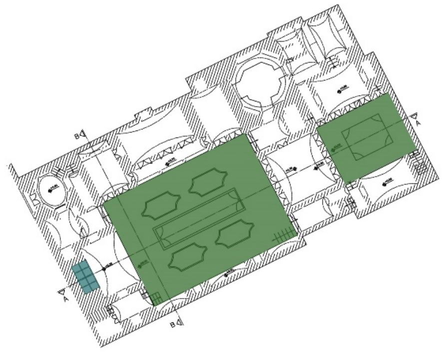
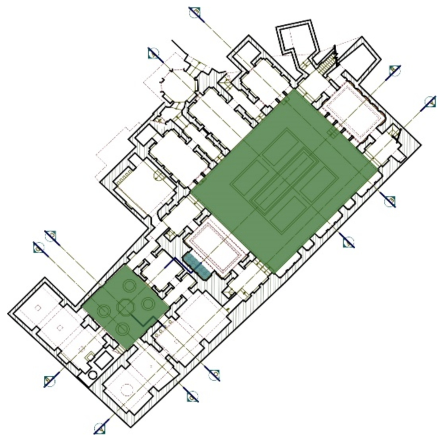
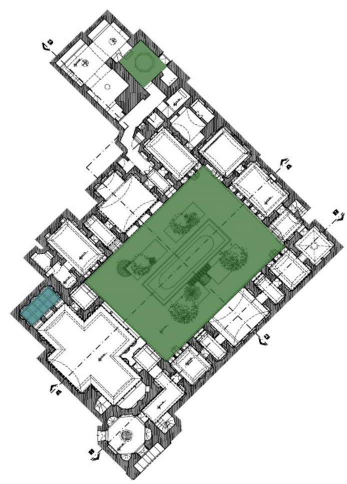
Like the former group, Talar is the main space that it has the relation with wind catcher. The location of wind catcher in Talar has two different part, in the axis of it like Daneshmand house or in the corner of it like only Ziarati. All of the wind catcher in this category are located in the summer section. Only in the Ziarati house the wind catcher has a relation with the different space (Shekam Darideh).

Only the orientation of Ziarati house's wind catcher is along the Qible direction, but the others have almost 90 degrees difference with it.

Generally, the wind catcher orientation is perpendicular on the main courtyards orientation of these houses except in the Ziarati house. The Ziarati house is the manifest sample in this group which it has completely the different Characteristic.

Table 2 the Yazd Qajarian tradtional houses which they have a wind catcher and two or more courtyards (author with citation by different source)

Houses Name (courtyard or wind catcher)	Wind Catcher Orientation	Wind catcher's spaces relation	Courtyard Orientation	Schematic Plan
Daneshmand [20]	⤡	Talar	⤢	
Golshan [10]	⤡	Talar	⤢	
Herandi [21]	⤡	Talar	⤢	

Hobab [27]		Talar		
Malek Zadeh [8]		Talar		
Ziarati		Shekam Darideh		

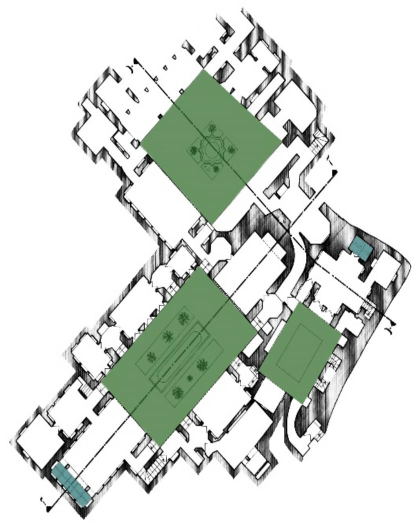
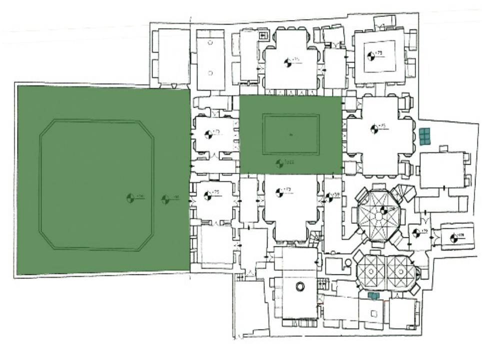
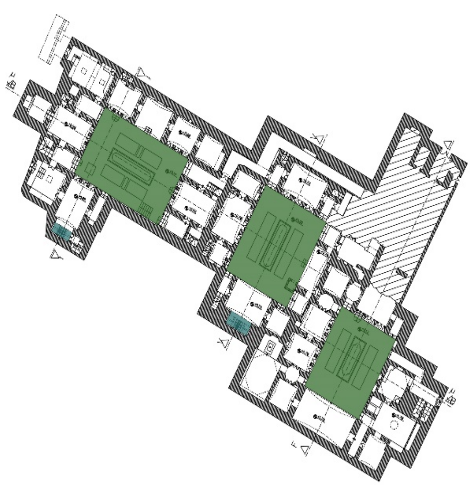
3.3. The houses have two or more courtyards and wind catchers
Table 3 displays the ten traditional Qajarian houses in Yazd that they have two or more wind catchers and courtyards. Generally, the different courtyards of houses have a simple orientation. In this table the courtyards that the wind catchers are located them are surveyed.

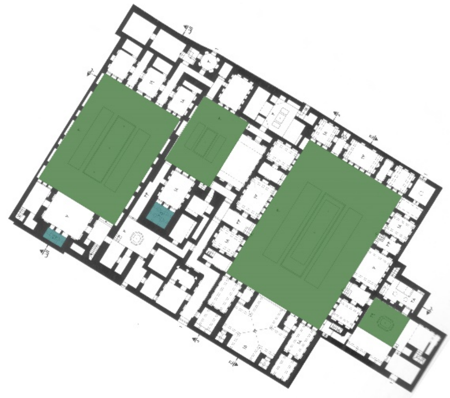
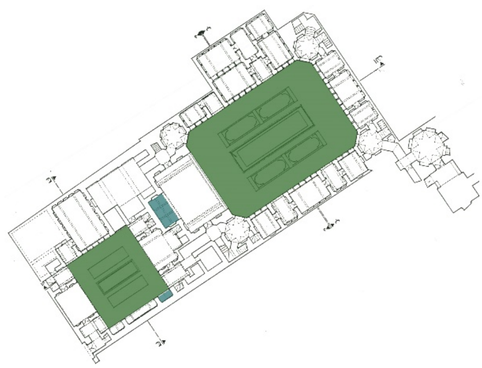
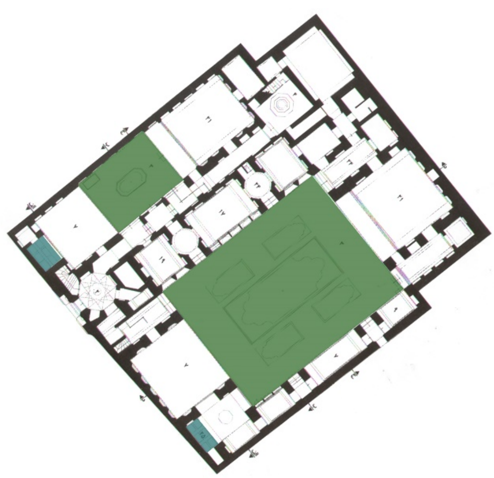
The different courtyards orientation of each house has two principal same or contrary. In the most houses of this society, courtyards have the same orientation like: Abrishami House, while some houses are been that their courtyards orientation has 90 degrees difference like: Kazeruni house. Although in Aghaee Zadeh house the courtyards orientation are the one nearly, the main axis of the small courtyard has a little difference with the big one. Like the former and later group, the Emamzadeie house is the exception of this type. It has two courtyards, one of them is named big one while it has less area than other one, but it has a relation with the largest wind catcher of this house. The orientation of this courtyard is West-East and completely difference with the others type of this group courtyards. The orientation of Rouhani's major courtyard is North West-South East while the other one shape is square nearly. Despite the fact that, Shoukuhi and Sigari Houses have three courtyards, the rows of small courtyards are not filled, because they do not relation with the small wind catchers of themselves.

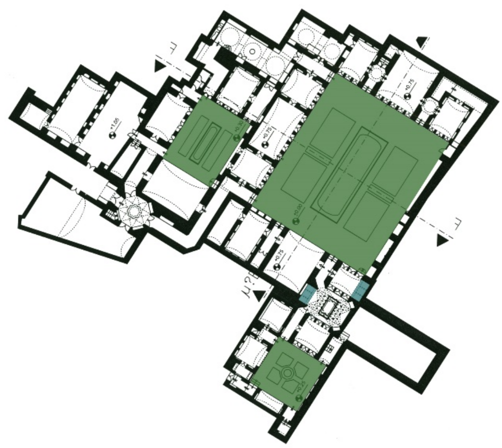
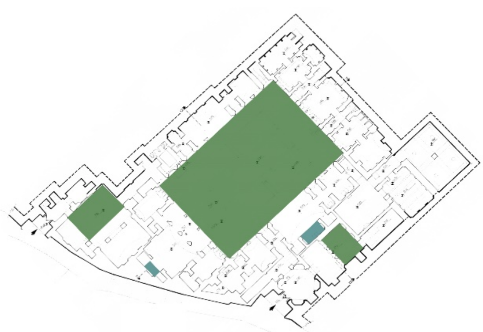
Like the two former group Talar is the main space that the wind catchers have a relation with it, but some new relation with some new space are been in this type like: Shekam Darideh in Emamzadeie house. The small wind catcher of Mortaz house is the strange sample, because it does not have a relation with any spaces and it is located in the sidewall which any spaces is not being there. Like the former houses, almost all of the wind catchers are located in the summer section, but some samples are located in the other section. For example, the small wind catcher of Aghaee Zadeh house is the unusual sample, because it is only sample that is located in the north part. The big wind catcher of Shokuhi house has a relation with the 3-dari room and in the summer section, but the other wind catcher has a relation with … and its location between two courtyards and it is not specified exactly. The orientation of wind catchers is divided to three parts exactly, and they can be same or contrary direction for the different wind catchers of each house. The wind catchers of Shokuhi house are the same direction and they are along the Qible direction while samples of others are been that the orientation of their wind catchers are the same and has 90 degree with this direction like: Abrishami house. The wind catchers of Mortaz and Sigari houses are the contrary direction with the other one. The Emamzadeie house's wind catchers have two different direction that they are perpendicular on each other, one of them is North-South and the other one is East-West.

Table 3 the Yazd Qajarian tradtional houses which they have two or more wind catchers and courtyards (author with citation by different source)

Houses Name (courtyard or wind catcher)	Wind Catcher Orientation	Wind catcher's spaces relation	Courtyard Orientation	Schematic Plan
Abrishami (Big One) [22]		Talar		
Abrishami (Small one)		Talar		

Aghaee Zadeh (Big One) [16]		Talar		
Aghaee Zadeh (Small One)				
Emamzadeie (Big one) [7]		Shekam Darideh		
Emamzadeie (Small one)			Not Related to wind catcher	
Kazeruni (Big one) [9]		Talar		
Kazeruni (Small one)		Talar		

Mahmudi (Big One) [3]	⤡	Talar	⤢	
Mahmudi (Small One)	⤡	Talar	⤢	
Mortaz (Big One) [5]	⤡	Talar	⤢	
Mortaz (Small One)	⤢	Not Specified	⤡	
Rasoulian (Big one) [1]	⤡	Kolah Farangi	⤢	
Rasoulian (Small one)	⤡	Talar	⤢	

<table>
<tr><td>Rouhani (Big one) [14]</td><td>⤡</td><td>Shekam Darideh</td><td>⤡</td><td rowspan="2"></td></tr>
<tr><td>Rouhani (Small one)</td><td>⤡</td><td>Talar</td><td>Square</td></tr>
<tr><td>Shokuhi (Big One) [15]</td><td>⤢</td><td>3 dari</td><td>⤢</td><td rowspan="2"></td></tr>
<tr><td>Shokuhi (Small One)</td><td>⤢</td><td></td><td>Not Related to wind catcher</td></tr>
<tr><td>Sigari (Big One) [4]</td><td>⤢</td><td>Talar</td><td>⤢</td><td rowspan="2"></td></tr>
<tr><td>Sigari (Small One)</td><td>⤡</td><td>Talar</td><td>Not Related to wind catcher</td></tr>
</table>

4. DISCUSSION

28 traditional houses which they date back to Qajar period in Yazd, are surveyed, this study includes 40 wind catchers and 35 courtyards that they belong to them. In the statistics society, the twin wind catchers are calculated two times, and the courtyards have a relation with wind catchers are counted. The table 4 demonstrates the percentage of wind catchers and courtyards which their abundances in four directions. This table is derived from the three former tables by authors. The Emamzadeie house records the least amount in the table. The orientation of its wind catcher and courtyard for the big one are North-South and East-West respectively.
The North West-South East direction has the maximum percentage for the wind catcher's orientation (62.5 percent), but the North-South direction has the minimum amount only 2.5 percent while the opposite direction can reach to 5 percent. The abundance of Qible direction for the wind catcher is 9 and it records 22.5 percent.
The trend of courtyards orientation is different with the former one. The courtyards which their orientation are Qible direction record the topmost of the table 28 abundance and 80 percent while the second rank belongs to North West- South East direction for courtyards orientation (11.4 percent). The two other direction record the least amount jointly only 2.8 percent.
It is obvious, the most amount belongs to houses that their orientation of wind catchers and courtyards are North West-South East and Qible direction respectively.

Table 4 the number and percentage of wind catchers and courtyards orientation in the surveyed houses

Elements	Orientation	Number	Percentage
Wind catchers	North-South	1	2.5%
	East-West	2	5%
	Qible Direction	9	22.5%
	North West- South East	25	62.5%
Courtyards	North-South	1	2.8%
	East-West	1	2.8%
	Qible Direction	28	80%
	North West- South East	4	11.4%

The table 5 presents the number and percentage of wind catchers' relative spaces and location in Qajarian houses that they are surveyed.

Talar is the main space which it has a relation with wind catchers (70 percent). The four relation between wind catcher and Shekam Darideh is discovered. The relation between wind catcher and Kolah Farangi only find in the Rasoulian house. The percentage of other spaces which they have the relation wind catcher is 17.5 percent.

The wind catchers are located in the summer section of these houses records the maximum amount 75 percent. Only a house is found that one of its wind catcher is located in winter section (Aghaee Zadeh house). The 5 samples are found that the wind catchers are located in the spring section.
Generally, although the most percentage of wind catchers' relative spaces belong to Talar, the four wind catchers are located in spring part have a relation with Talar.

Table 5 the relative spaces of wind catcher in the different surveyed houses

Element	Relative Spaces	No.	%	Location	No.	%
Wind catchers	Talar	28	70	Summer Section	30	75
	Kolah Farangi	1	2.5	Winter Section	1	2.5
	Shekam Darideh	4	10	Spring Section	5	12.5
	Others	7	17.5	Others	4	10

5. CONCLUSION

As far as refereed, the most of wind catchers of Yazd houses which they date back to Qajar period are located in summer section and The Talar is the main relative space with it and their orientation are perpendicular on Qible direction unlike the courtyards' orientation.

The prevailing wind direction in Yazd city is blown from the Northwest to Southeast, it may cause the main reason for orientation of Qjarian houses' wind catchers to benefit from it. Although the main direction of court yards' orientation is the Qible direction, the orientation of wind catchers is perpendicular on it while some orientation can be found that is parallel with it. On the other hand the most of wind catchers are located in summer section and have the relation with the Talar. Although in this paper some factors can be derived about the courtyards' orientation and wind catchers' location, relation, and orientation, others factors can be affected in these houses.

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Recognizing the role of Central Courtyards as a Model of Sustainable Architecture in the Houses of the Yazd Historic City

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ABSTRACT

The rapid changes of urbanization in the historic city of Yazd, and consequently the change of the spatial organization of contemporary houses in order to meet these changes, has caused transformation in spatial patterns and, consequently, the role of spaces that have responded to the cultural and social needs of Iranian people for centuries.

The most important component of the historical texture of Yazd is its houses, and the main structure of the houses is their central courtyards. The pattern of building a central courtyard in Iranian homes has a deep history and has been employed significantly in various cities of Iran. The central courtyard in these houses played a role as an organizing and systemic element, as other residential spaces were formed around the courtyard. The historic texture of Yazd due to its natural and organic form does not have a regular geometric shape. However, even if the constituent parts of the house are angled, inside the perimeter of the house, the spaces are arranged around a rectangular or square courtyard, which creates a general order in the texture. Today, this pattern has lost its place in the houses. Therefore, recognizing this important element is essential.

This paper uses historical and descriptive methods to investigate the role of the yard in the spatial organization of these houses in order to achieve sustainable development. For this purpose, several examples of central courtyards in Sahl-ebne-Ali neighborhood of Yazd have been studied and analyzed. The results show the creativity and wisdom of the architects in creating a space coherent with the environment, social criteria and cultural values of the owners and the users of the building. From today's perspective, the values of native architecture have been shaped by a sustainable approach that can be used to design contemporary buildings in order to create a sustainable architecture.

Keywords: Historical Houses, Central Courtyard, Sustainable Development, Yazd, Architectural Pattern

1 INTRODUCTION

One of the beliefs of the Iranian people has been to value their personal lives and their dignity, which has intrigued introverted Iranian architecture. Introversion is a concept that has existed as a principle in Iranian architecture and has organized various elements of the home such as the courtyard or semi-closed platforms, in a way that the openings and the windows open to these elements and there is nothing but clay on the exterior of the house. Introversion in Iranian traditional architecture is clearly visible in a variety of forms, and in the warm and dry climates of Iran, it is shown in the central courtyard. The courtyard of the houses is the heart of the building, and Iranian architecture has provided an architectural response to the climate and has provided comfort for the individual at all times. Thinking about nature, its components, its elements, and the laws governing the system of existence is one of the most important issues that Iranian culture relies on. Therefore, respect for nature has deep cultural roots and the harmony of man, architecture, and nature in traditional architecture is quite evident, and Iranians have never been willing to break with nature.

In the Iranian traditional architecture, energy conservation has been sought in various ways. In the warm and dry climates of Iran, the form of buildings, both in terms of appearance and in terms of the composition and distribution of different spaces, provide for the reduction of energy consumption. In these areas, by creating a central courtyard in the middle of the building and incorporating a water pond and a garden, it increases the humidity in the living space of the building [1]. One of the goals of sustainable architecture in hot and dry areas is to enhance the ability of buildings to provide spaces in a way that requires minimal energy consumption while providing climate comfort [2]. One of the most important and critical issues in architecture, sustainability and environmentally friendly design. Environmental sustainability will not be achieved unless human activities are regulated and their thinking changed so that natural resources are preserved for the future. Environmental sustainability emphasizes more on reducing energy loss in the environment, reducing the production of harmful factors for human health and using renewable resources, maintaining and renewing energy without generating pollution.

Iranian traditional architecture has a strong support for various aspects of Iranian sustainability, art and culture, and exhibits a special contribution and value to this art and culture. By examining Iranian architecture, we find that the symbols of the cultural values of each community, especially the Iranian community, are manifested in the construction of the residential environment, reflecting the identity, cultural values and beliefs of each community. In such a way that Iranian architecture, like the culture of Iranian society, is intrinsic and induces a sense of belonging, a combination of balance and a coherent balance and proportionality of functions [3].

The present study, while investigating the central courtyard of the historic houses of the Sahel-ebne-Ali neighborhood of Yazd, attempts to find answers to questions such as the extent of sustainability in the central courtyard of traditional Yazd houses. In this regard, after a brief overview of the literature on the subject, several courtyards in this neighborhood have been discussed and analyzed.

2 IRANIAN HOUSE

The Iranian house has been a place of relaxation and a gathering place for the family [4]. To this end, man designed a building that balances its parts, and built it according to its climatic conditions and needs. In Iranian houses, elements such as the courtyard, the rooms, the corridors and so on can be seen. In the meantime, the courtyard is an important element in organizing the space around which all spaces are arranged and has an important role in shaping introverted homes. [5]

3 THE COURTYARD

The central courtyard not only provides a natural space and a relaxing atmosphere for introverted buildings, but also provides spaces for communication [6]. The tradition of building a central courtyard and arranging closed, semi-closed and even open spaces around it has always been common in the historic city of Yazd. The courtyard provides a good view for the porches and rooms of the house, sometimes connecting various spaces and making space for some of the daily activities of family members in most seasons. Therefore, its adaptation has been very important. The geometric shape of the yard has always been square or rectangular, and the possible disproportionate geometry of the land has had no effect on the landscape [7].

In traditional Iranian houses throughout history, the courtyard was used as the center of the building. The central courtyard along with the porch on each side was a feature of Iranian architecture from a long time ago. Even though it was possible that the courtyard was not geometrically the center of the house but in terms of living and activities and connecting the different parts of the house, it would act like the center of the house. The central courtyard is the main space of the house. The water pond is in the middle of the courtyard and the gardens witch surround it have trees that need little water, such as pomegranates, oranges, almonds and pistachios, which reduce the dryness of the air and provide cool air and shade.

4 SUSTAINABLE DEVELOPMENT

It is necessary to provide a clear definition of the concept of "sustainable development" in order to better understand the concept of sustainable architecture. Sustainable development means on the one hand maintaining balance between human needs and improving the way of life and the sense of well-being and on the other hand preserving the natural resources and ecosystems that we and the future generation depend on. Each community can learn from the others, evolving the most promising approaches to managing ecosystem interactions. In the long run, the most successful sustainable development initiatives will likely look rather a lot like ecosystems; diverse, complex, and evolving. At a time when sustainable futures are so direly needed, this continuing evolution of ideas is very welcome [8].

Figure 1. Sustainable Development

4.1. The Concept of Sustainable Architecture

All designs made with regard to sustainable systems should be able to provide some kind of predictions for the future. For example, a building should be designed in such a way so it can be reused. This futuristic vision is also used to meet the needs of the next generation [9]. Sustainable architecture can be interpreted as creating a stable built environment [10]. Sustainable architecture is a logical response to the problems of the industrial age. The principle of sustainable architecture is based on the fact that a small building is a periphery that should act as part of the ecosystem and be in a lifecycle [10]. Sustainable architecture is to find architectural answers, which are related to health and peaceful coexistence of different groups [11].

4.2. Sustainability Approaches

According to the current understanding, sustainable development has three principles: environmental support, economic development and social development. Accordingly, there are three approaches to sustainable development. Economic Approach, Environmental Approach and Social Approach.

Figure 2. Sustainability Approaches

Environmental sustainability: The idea of environmental sustainability is to leave the Earth in the best shape for the next generation. In this view, human activity is only environmentally sustainable when it can be implemented without diminishing or degrading natural resources. Environmental sustainability includes the following. Saving natural resources, reducing toxins, reducing energy waste, minimizing the use of non-renewable energy sources, protecting the environment, recycling and similar solutions.

Economic Sustainability: This view includes the following. Protecting the level and stability of economic growth, organizing the economy, reducing costs, reducing energy consumption, reducing raw materials consumption, providing a solution with ease of production, a forward-looking solution and the like.

Social Sustainability: Experts believe that development must be shaped by the workforce and individuals in that community. The social dimension considers the psychological, social and cultural aspects of human existence as an important part of achieving sustainable development and includes the following. Social justice, fair use of natural welfare, social cohesion, cultural identity, healthy living, adaptability, security and the like [12].

4.3. The Background of Traditional Sustainable Architecture

The existence of principles in Iranian architecture allows everyone to use the general language among them. The principles of traditional Iranian construction, through a standard measurement unit, modular design and proportion in design can become sustainable [13]. What sets out the principles of Iranian architecture is based on attention to the stages and levels of design and construction management.

Table 1. Aspects of sustainability in the central courtyard of traditional houses

Environmental sustainability	Economic Sustainability	Social Sustainability
Connection with nature; Increased sense of respect for nature **Native materials**; increased durability, maintainability **Orientation**; Increased use of natural resources **Pollution control**; Reduces the spread of toxic and polluting materials and preserves the environment	**Utilizing natural resources**; reducing pollution and current costs **Value of the building**; increase in the overall price of the building **Avoiding inefficacy**; Saving Resources **Functional Flexibility**; multipurpose use of space and reducing the cost (Weddings, Funerals, Meetings, etc.)	**Sense of belonging**; giving space to characters **Creating a space for socializing and dialogue**; Strengthening social relationships **Communication with nature**; increasing dynamics and vitality **Separation of private and public territory**; increased social security

5 CASE STUDIES

Case studies have always been considered as one of the useful parts in the subject recognition phase. Therefore, in this article, considering the importance of central courtyard in historical houses of Yazd World Heritage Site, we will consider some examples of central courtyard.

5.1. Haj Kazem Rasulian House

Figure 3. From left to right: inner courtyard- outer courtyard – Rasulian House ground plan

It was built in 1904 and was designed by Mohammad Hassan Mohammed Rahim. The children of the original owner have dedicated the building to cultural-educational work. The building consists of two inner and outer sections with two courtyards. The interior is a single-story south-facing porch that is called a Talar, is used for the summer residence, and has a shallow porch to the north. On the eastern side of the courtyard, there is a shallow porch and on the opposite side a five-door axis with two corridors divided into two three-dimensional spaces. The smaller or outer courtyard has a sash room with a five-partition as a winter section, and the summer section is a large Talar with the same proportions [14].

5.2. Mortaz House

Figure 4. From left to right: outer courtyard- Inner courtyard- Mortaz House ground plan

It was built about 150 years ago and was co-founded by Ali Agha Shirazi the son of Haj Mohammad Shiraz Ismaili. During the years 1979 to 1993 the war settlers sheltered there and then the heirs dedicated the building to Yazd University, which was added to the university complex after its restoration. Away from the Rasulian house, students have been allowed to walk through some of the beautiful alleyways of Yazd's historical fabric, which is one of the main goals of creating a university in the historical context. The building connects to the alley with a simple doorway, which a beautiful vestibule reaches the larger courtyard. Like all the traditional houses of Yazd, this outer courtyard has a cross-shaped south Talar. Situated on a smaller section of the cross-shaped Talar is the wind-catcher that drives cool air to the Talar. In the north or winter section is a five-door room. Connections to the inner courtyard are made through two vestibules at the corners of the courtyard, similar to those repeated at all four corners. These corners are the most important architectural feature of the building [14].

5.3. Kasmaei House

Figure 5. From left to right: sunken courtyard views- Kasmaei House ground plan

The Kasmaei house and Rasulian house are probably from the same era and it covers an area of about 520 square meters. The building is distinctive from other buildings in the complex with a sunken courtyard and appears to have been part of the Elliein house, which was later separated. Another point is that the building has no winter section, which is justified if we consider Kasmaei house and Elliein house as one. The courtyard entrance is from the corridor of the outer courtyard of the Rasulian house. The sunken courtyard seems to overcome the need for shadowing, humidity, proper temperature, adequate water, spatial organization, social interactions and in fact, it is somewhat more suitable for hot and desert areas than the normal courtyard [14].

Table 2. Comparing sustainable approaches in three houses of Yazd

Sustainable approches / Case Studies	Economic Aspect				Environmental Aspect				Social Aspect			
	Utilizing natural resources	Value of the building	Functional Flexibility	Avoiding inefficacy	Connection with nature	Native materials	Orientation	Pollution control	Sense of belonging	space for socializing and dialogue	Communication with nature	Separation of private and public territory
Rasulian House	x	x	x	x	x	x	x	x	x	x	x	x
Mortaz House	x	x	x	x	x	x	x	x	x	x	x	x
Kasmaei House	x	x	-	x	x	x	x	x	x	x	x	-

The following can be deduced from the above table and studies:

Social aspect: In the sense of belonging, creating a space for socializing and dialogue, privacy and communication with nature, all three houses are at the same level and meet the standards. However, in terms of the separation of the private and public territory, the Rasulian and Mortaz houses are better than the Kasmaei House due to the fact that Kasmaei house has one courtyard comparing to the two (inner and outer) courtyards of the Rasulian and Mortaz houses. Among the things that needs to be mentioned in the social discussion is that the courtyard, is a venue for various ceremonies such as religious, wedding, and ethnic gatherings [15]. It was usually designed as a quadrilateral and determined the size and number of spaces around it. Each courtyard usually had a pond and several gardens, which varied depending on different local conditions such as climate and cultural factors. The organization of the enclosed courtyards was tailored to the seasonal variations and functions of the adjoining rooms.

Nayebi views the yard as the center and heart of the house, pointing out that the existence of a central courtyard in traditional Iranian houses is a manifestation of introversion. Introversion is one of the features that exemplifies the degree of importance of the inner being over the appearance, and is essentially an affirmation of the unseen world and an interpretation of one of the divine attributes [16]. The central courtyard spaces is designed to provide the opportunity for multiple families to live in one house in such a way that the interconnection of spaces and their connection to the courtyard shapes social life on a smaller scale.

No authentic house in the dry and hot climate can be found with unwanted views from the outside. The vestibule, corridors and high walls and the way various spaces are arranged and organized around the courtyard, in a way that perfectly illustrates the concept of Hijab, so that the inhabitants of the house live in peace, comfort, security and safety, out of sight. According to the activities and design of the house, the courtyards are divided into inner and outer courtyard. The houses with one courtyard are common in Yazd, and with two courtyards (outer and inner courtyards) are mostly common. The form used as a pattern of houses is the most desirable form of enclosure for adjusting the acute climatic conditions, especially in hot and dry desert areas. The rooms open to the central courtyard, thus protecting against summer heat, winter cold and wind, and storm and sand, which is common in desert areas [17].

Environmental aspect: All three houses have been successful in integrating and adhering to the principles of Iranian and climate architecture in factors such as orientation, use of native materials, and communication with nature in environmental aspects of sustainable architecture. The central courtyard defines a safe area in harsh environments and climates, providing comfort and security to residents and people living in homes with a central courtyard in incompatible environments. It also provides a central and limited outdoor space with water and bushes and trees combined for the residents to feel lively. Yards will vary by climate, for example, and the dimensions of the courtyard in hot and dry climates will be different from in cold mountainous climates, but privacy is maintained in both.

Native architecture in the desert areas of Iran was formed without relying on fossil fuels and saving energy, and the open central courtyard, with its dimensions, orientation and targeted location, was a crucial element in energy conservation. In these areas, dense textures have brought about adaptation to the climate, and energy savings have been made possible by reducing the radiation exposed surfaces. Energy conservation is provided through the compacted housing units so that some housing units are even connected to other units from all four sides [18].

The central courtyard is one of the main spaces of the arid and desert houses. The water pond with maximum dimensions in the middle of the yard holds the sun's energy. Surrounded by enclosed spaces on all sides, the courtyards, like a trench, secrete cool night air and use it on warm days. The practice in these homes reflects the sustainable architecture that the past had realized and designed their homes upon.

Economic aspect: All three houses, due to being in the organic context of the city, as in their past, are able to develop in all areas (economic, physical, social, human, etc.) and have greater economic flexibility. The use of renewable resources such as natural light, ponds, numerous gardens, etc. has reduced current costs. In terms of functional flexibility, the Rasulian and Mortaz houses have a better surface area than the Kasmaei house because of their size and wider dimensions. Among the issues that can be mentioned in the economic discussion is that the courtyard can provide space for various events such as religious, wedding and ethnic gatherings, which greatly reduce the cost of the ceremonies.

The benefits of using a central courtyard are the benefits of using natural energy (wind, radiation, geothermal, etc.) and avoiding the cost of fossil fuels. As thermal comfort comes in line with existing climates, it is the result of climate measures of the region's native architecture and even affects the future economy of energy consumption. In a way, the optimum light enters the space through the openings all day and makes it bright and warm. The wind in contact with the water of the pond fountains will cool and reduce the temperature so that no artificial ventilation is required. The existence of a central courtyard increases the quality of the architectural spaces of the building. Proper landscape of nature gives nature most structural spaces to become functional and useful space. In addition to the economic dimension, the presence of fruit trees in the central courtyard provides a lasting link between man and nature [19].

6 CONCLUSION

Surveys show that the three case studies were built introversion; in addition to their cultural aspect, they considered the climate aspects too. These buildings are generally four seasons, using three types of outdoor, semi-open and indoor (courtyard, porch, room) shows the hierarchy of space that is often seen in traditional architecture of Yazd. By studying on native architecture of Yazd and how people interact with the environment, we find that sustainability-based thinking is not a new and unprecedented approach. The architecture of this region is amazingly converging with the principles of sustainability. Therefore, this study explores the role of open spaces- especially the courtyard in the integration of Yazd's native architecture with sustainability principles. The results of the research indicate the pivotal role of open spaces (courtyards) in the creation of sustainable indigenous architecture of the city and a pleasant and nature-related space used throughout the day and night; unlike modern houses where the courtyard is only a space for passage and reaching closed space. The structure of the courtyard itself is not only sustainable-oriented but also provides the basis for achieving sustainability in native architecture through this structure. On the other hand, contemporary houses with distinct orientation and dimensions in accordance with contemporary urban planning have not been able to replicate many of the uses of the past courtyards.

-The orientation and specific dimensions of contemporary courtyards have failed to provide proper privacy and visibility for residents.

-Limiting the courtyard to a particular facade has led many rooms to seek light from the outside

-The disappearance of interfaces has diminished the hierarchy and thus the role of the courtyard.

-Orientation of the rooms to one point reduces the climatic role of the courtyard

Studies and analyzes demonstrate the functions of the central courtyard are consistent with the three environmental, social and economic aspects of sustainability. The courtyard space is not merely for the occupation of land or for the division of spaces, but rather as an arena for the formation of spatial qualities dependent on nature to bring dynamism, vitality and life to the architecture of Iranian houses. It also influences people's culture so that they do not forget the principle of keeping up with nature in their lives and architecture. That is why the quality of place, space and living in traditional Iranian homes lasts and sustainability is formed.

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Arasta Sipahiler Bath

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ABSTRACT

Arasta Bath, which was built in 1609 by Sultan Ahmet I, with the Architect Sedefkâr Mehmet Aga, is one of the first structures built in the Sultanahmet Complex. The building was severely damaged during the fire in 1912, and it remained unused and obscured afterwards.

The purpose of the paper is to give information about the operation of traditional Ottoman baths over the example of Arasta Bath; and to discuss on the proposals for the reuse of the building in the terms of integrated protection. Various archive documents were used in the study, as well as in-situ surveys.

Keywords: Turkish Bath, Complex, Conservation.

1 INTRODUCTION

The word «hamam» which is originally pronounced as «hammam» in Arabic language, derived from the root of the verb «hamm», which means "a heated place", is used for buildings that serve the purpose of bathing for public in Islamic and Turkish countries [1].

Besides cleaning the body is an obligation of Islamic religion, it has become a tradition to take bath in a public place at least twice a month, in years. Although it has become a part of luxurious care in contemperary life, Turkish bath is still believed to be the best way of body cleaning and is good for physical health.

The origin of Turkish bath culture is formed during the process of settling in Anatolia. As a result of the integration of Turkish and Seljuk tribes with Byzantine and Arabic societies, the bathing habits of both societies were influenced by each other and «Turkish bath» culture emerged [2].

2 BATH ARCHITECTURE DURING THE OTTOMAN PERIOD

It has been popular among public during the Ottoman period getting a bath built within a complex, because it was both a good way of doing charity for public and a beneficial operation for the complex as well [3]. For these reasons bath buildings increased rapidly in number through years. Since the consumption of water and wood has been very high, restrictions were imposed on the construction of baths in the 18th century [4].

2.1 General Properties of Ottoman Bath Architecture

The interior arrangement of the Ottoman baths consists of four parts [5]:

1. Cold space (Locker room),
2. Lukewarm space,
3. Warm space,
4. Furnace.

These four parts take their places in an order according to their required interior temperature as 'Fig. 1'. The warm space is the nearest one to the furnice because it is the main space of the bath where it should be the hottest place.

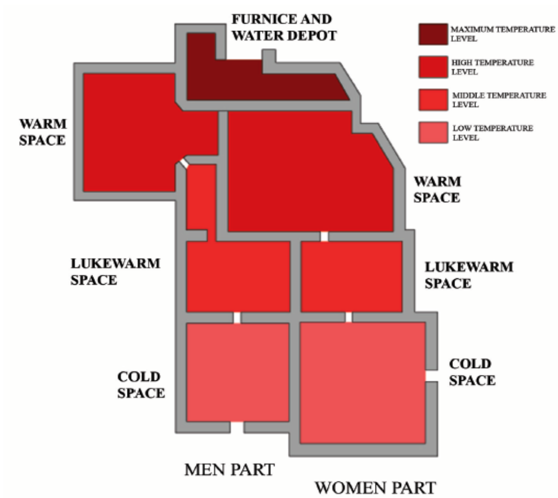

Figure 1. Hierarchy of the spaces of a Turkish bath according to their interior temperature [6].

In the Ottoman baths, the heating system of water and the spaces, include hot air ducts connected to the furnace as 'Fig. 2' [7]. The heating of the bath is provided by the passage of hot smoke circulating inside the raised floor under the spaces [4]. This system is very similar to the hypocaust system in Byzantine baths and called "cehennemlik" (which means "hell").

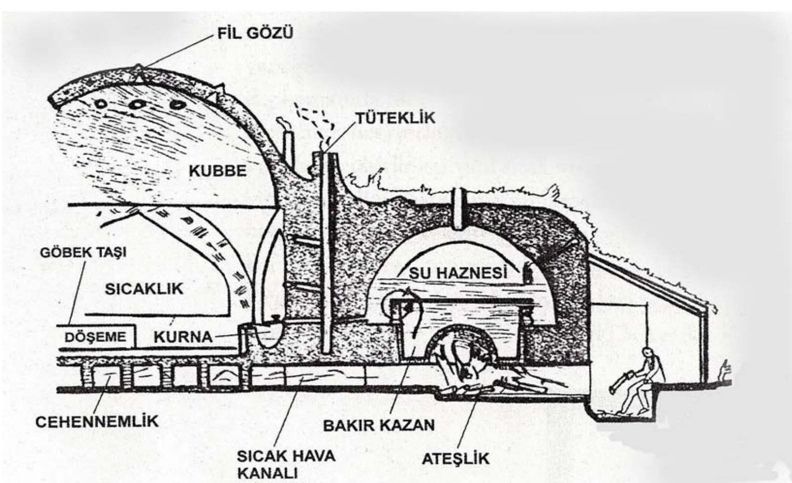

Figure 2. A sketch showing the heating system in bath [7]

In the Ottoman baths, lighting was provided with round curved windows resembling oil lamps, to prevent heat loss. These windows are called «filgözü» (elephant's eyes) as 'Fig. 3'[7].

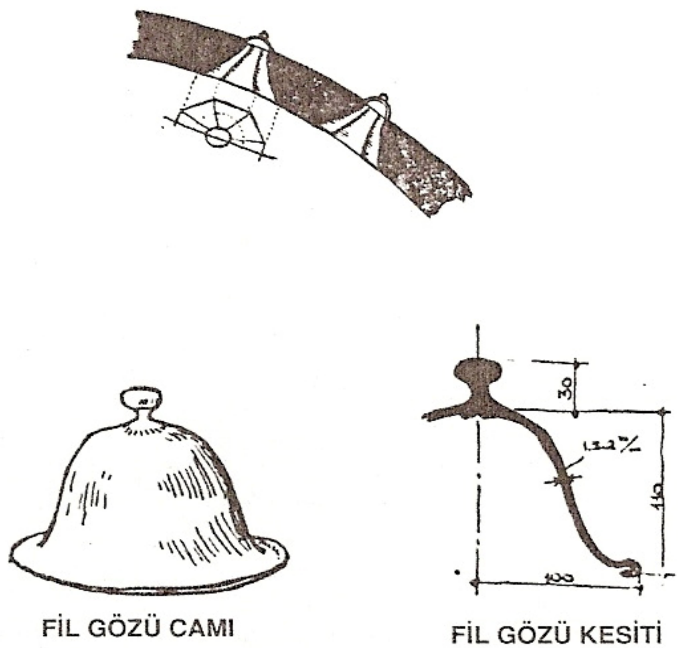

Figure 3. A sketch showing "filgözü" windows of the dome [7]

2.2 Bath Structures in Istanbul

The most effective and special role in the transfer of bathing and water culture from the Byzantine-Christian community to the Turkish-Islamic society is the the city of Constantinople/Istanbul with its hundreds of small and large bath buildings. In many districts of Constantinople of the Byzantine, baths, mansions and churches formed a kind of neighborhood trio. In Ottoman Istanbul, the mansion-mosque-bath continued as an important element in the social structure of the neighborhood. Although this continuity is valid in terms of bathing ceremonies and heating technology, it is remarkable that the Turkish Bath was separated from the Roman-Byzantine Bath in terms of its architectural features. Although this continuity is valid in terms of bathing tradition and heating technology, it is remarkable that the Turkish Bath was separated from the Roman-Byzantine Bath in terms of its architectural features. The Ottoman baths gave importance to define clear and sharp geometry as a plan. Unlikely to the linearly formed complex structures of the Byzantine and Roman baths, the Ottoman baths consist of geometric forms that generally symmetrically complement the central domed main space [1].

According to Evlia Cselebi the traveler and story teller, who traveled a great deal in the areas of Turkish occupation at that time, there were 151 Turkish baths in Istanbul in the 17th century [8].

3 ARASTA BATH

3.1 Location and Short History of Arasta Bath

Arasta bath, also known as Sipahiler Bath, is located on the left corner of Küçük Ayasofya Street and opposite Tavukhane Street, southwest of Sultan Ahmet Mosque. In response, there is the ruin of Iskender Pasha School and Tomb, Gungormez Sultan Mosque (Kanli Masjid) and tomb, Arasta

Bazaar big gate, Sultan Ahmet Mosque fountain and ruins. In the immediate vicinity, there is the Reis'ül-etıbba Ömer Efendi Bath, known as the Healing Bath.

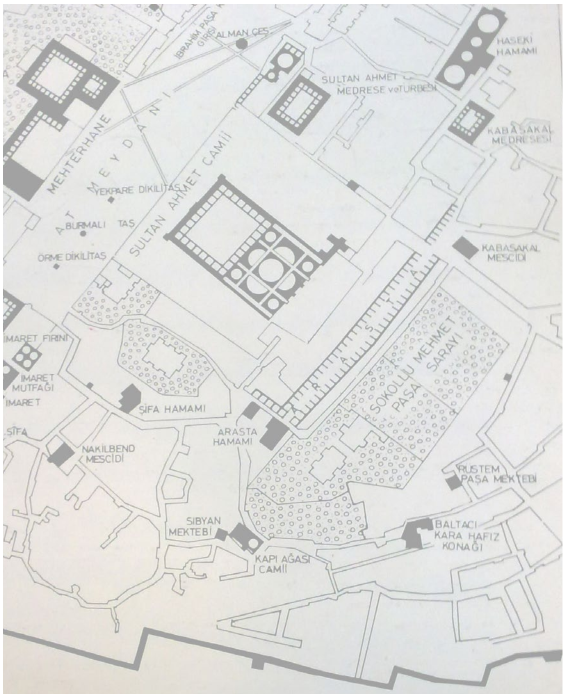

Figure 4. A sketch showing the location of Arasta Bath [5]

Arasta Bath is located within the scope of Sultanahmet Complex 'Fig. 4' which was built by Sultan Ahmet I (1603-1617) to the chief architect of the time, Sedefkar Mehmed Ağa. The complex was built between 1609-1620 and consisted of mosque, sultan's school, medrese, arasta, bath, dârüşşifâ (with masjid and bath), imâret-i amire, tabhâne, han, dârülkurrâ, shrine, dispensers, fountains, shops, rooms, cellars, coffeehouses and houses [9]. The bath was located at the exit of Sultanahmet Arastası, where dominantly the materials needed by the soldiers were sold. Although there is no official record in this respect, it is stated in various sources that the baths are only used by sipahilers (a class of horsemen grooming soldiers in the Ottomans as 'Fig. 5'[10]).

Figure 5. Sipahi (a class of horsemen grooming soldiers in the Ottomans) [11]

In the fire of İshakpaşa Neighborhood in 1912, the cold space (locker room) was destroyed and then the marbles were removed and sold [12].

3.2 Existing Condition of the Arasta Bath

The bath substantially burned in the year 1912 and has been left derelict afterwards. After the dome has collapsed because of the squalidity of years, the deterioration got faster and the building got into today's irreversible condition.

3.3 Restitution

The oldest photographs of the bath obtained from the archives of the Istanbul Archaeological Museum show an excavation work in 1937 as 'Fig. 6'. The area has been excavated in order to find traces of the Great Palace of Byzantine period [13]. A fire in 1912 has been reported for the neighborhood and it is understood that the building was damaged since the beginning of the 20th century.

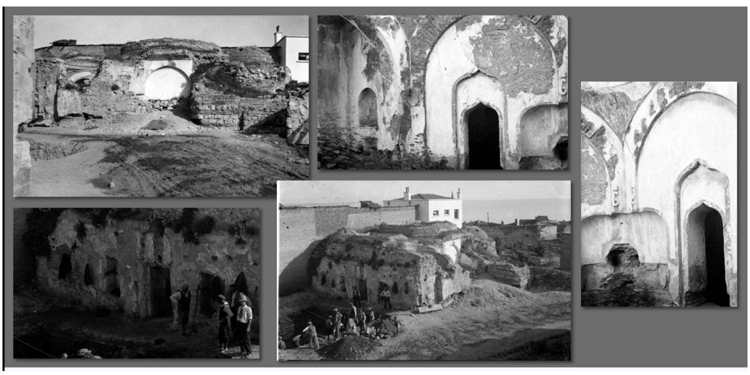

Figure 6. Photographs of Arasta Bath showing an excavation work in 1937.

Many sources were examined during the restitution process of the bath. One of these is the twelve lines that mention the Arasta Bath of a long epic of 150 lines written by the poet Tosyalı Aşık Mustafa, who was supposed to come to Istanbul between 1810-1820, in order to praise the baths of Istanbul [13]. The poem gives some information about the structure, such as the lines which say "this bath special for soldiers", "the sprinkler in the middle of the cold space" and "18 kurnas in total" as 'Fig. 7'.

"Bir hamam da nâmı olmuş Araste
Şifâ bulur her âşıkı dilhaste
Erenlerin gazilere duası
Bir destan idelim şikeste bester

Buyur beyim derler buyurun ağam
Askere mahsus bu dilküşâ hamam
Cümle uşaklarımız şahbâz şehlevend
Virdiler İrana Tûrânedek nâm

Ayağında nâlin abanoz şimşir
Kimi kumru, kimi gazal, kimi şîr
Siyah ibrişimden peştamal ile
Sancak açmış sanki leşkeri Kişmir

Câmekan sofası gayetle mâmur
Ortada fiskiye nurûn alâ nûr
Hamamcı ağanın himmeti aşkı
Çamaşırın en âlası bulunur

Üç sofası vardır, dört köşe halvet
Cümle kurnalı on sekiz adet
Her kurnanın ayrı olmuş uşağı
Hizmete koşarlar istemez dâvet

Her kurna başında bir gümüş selvi
Ak mermere vurmuş yanak alevi
Kimi mîmar olmuş kimi yıkıcı
Yapup yıkdıkları bir gönül evi

Sipahî çıplağı cümle dallâki
Zeyn etmiş şehbazlar hamâmı pâki
İçlerinde yoktur şehir oğlanı
Kopup geldikleri Anadol hâki

İsmi şerifler Satılmış, Muslu
El ayak iri, hep boylu boslu
Araste Hamamı efendim bura
Civan uşakları gaayet namuslu

Muhkem kise vurur misâli Ferhad
Can ile baş ile hizmetde üstad
Hem edeb sahibi hem tok gözlüdür
Bahşişe intizar olmamış mûtad

Üç nefer naturlar pâkû pâkize
Nezâketle hizmet iderler size
Gice ile gündüz sıdkile dâim
Duada Pâdişah efendimize

Bir zâri gaar ile Âşık Mustafa
Gelüb bu hamama sürmüştür safâ
Zâhiri Bâtınî kir ile pası
Yunup çıkdık gayetle pâk musaffâ

Yâri gaarimiz de sipâhîzâde
Yüzbin altın değer çıksa mezâde
Kasem etti sîmîn pençesin basup
Sözümde noksan var yoktur ziyâde"

Figure 7. The twelve lines that mention the Arasta Bath of a long epic poem of 150 lines written by the poet Tosyalı Aşık Mustafa

Arasta Hamam was restitued by analyzing the baths of the same period and examining the remaining parts which are original. During the restitution process, a research excavation was carried out under the supervision of Istanbul Archaeological Museum and the underground heating system of the Bath has been unearthed. The channels and posts of the heating system have been surveyed and drawn within this process as 'Fig. 8'.

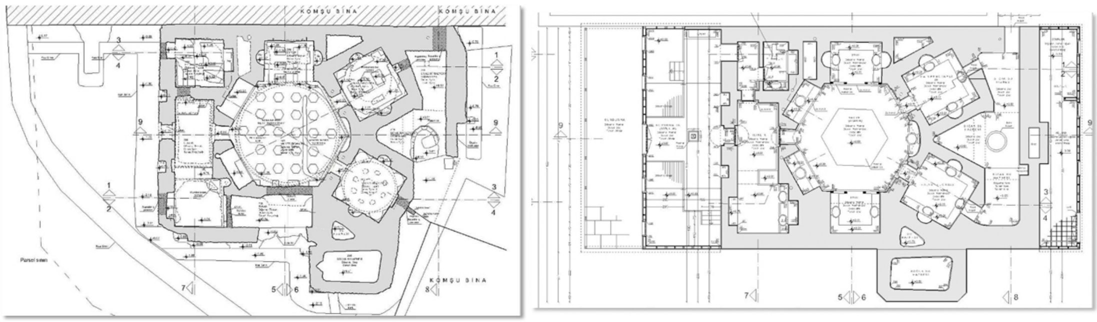

Figure 8. The survey and the restitution plan of the Arasta Bath (drawn by Saltuk Akatay Architecture Office in 2012)

The cold and hot water networks of the bath were determined with the help of traces found in the site and they were evaluated for the restitution of original places of «kurna»s as 'Fig. 9'.

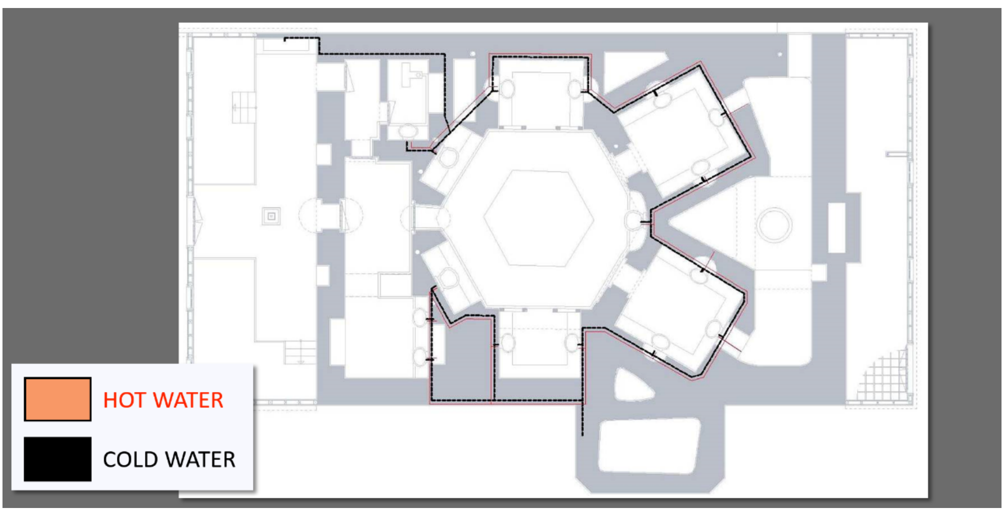

Figure 9. Sketch showing the water distribution system of Arasta Bath

4 CONCLUSION AND TERMS OF RESTORATION

The restoration project of Arasta Hamam is being prepared in accordance with a refunctioning process due to the touristic character of the region after the existing parts of the structure have been consolidated and the missing parts are completed. Refunctioning within the scope of restoration is a positive decision for historical buildings both in terms of providing the required economic sources for regular maintenance and getting the building kept in touch with the society. However, the necessity of the function to be appropriate with the structure should never be forgotten.

The function of Arasta Bath after restoration has been determined as a restaurant considering the needs of the surrounding neighborhood. The existing part of the heating system and other elements of the structure shall not be destroyed in the arrangement to be made according to this function and shall be exhibited covered with transparent surfaces such as glass floor.

5 ACKNOWLEDGMENTS

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Earthquake Risk Preparedness on In-use Bearing Walls

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ABSTRACT

Bearing wall systems are not in curriculum of higher education in most of the countries. As traditional architecture and construction are carrying the basic knowledge for safe living in bearing wall systems, research has focused on traditional architecture. The horizontal layer with different elasticity was the base for energy dissipation of earthquake forces. After proving the energy dissipating behavior of horizontal layers on bearing wall samples in the lab., the new hypothesis established to apply the element on existing bearing wall. Energy dissipating horizontal details has been created with the horizontal "surface-cut" of existing bearing walls. The surface-cut has been applied deeply from the base upwards horizontally every 40 cm of the wall, where the horizontal emptied linens has been filled with wooden lath or mud. The test on horizontally-cut-wall has shown that the force act on weakened area and the cracks are horizontal. The wall with the horizontal cracks is still able to carry the forces.

Keywords: Bearing wall system, earthquake, risk preparedness, in-use building

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Structural Analysis and Protection Problems Of The Traditional Adobe Houses in Central Anatolia

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ABSTRACT

The buildings that are made by traditional methods in rural areas; have different features depending on local materials, economic opportunities, people's needs, climate and social life. Due to the geographical characteristics of each region, local building materials are varied and are preferred in building construction with its quick availability and economy. Beside these features, kerpic (adobe) and soil material are healthy building materials, which have been used in building construction since the first settlements of history in Anatolia.

Bilecik province, Gölpazarı, Tongurlar Village has been an important settlement since prehistoric times; which bears kerpic (adobe) architecture characteristics. The whole settlement, which has the traces of the Ottoman period, was constructed by kerpic (adobe) building material, determined by the analysis and survey studies. The kerpic material was used with masonry technique or wooden carcass filling system. Depending on the climatic conditions of the region and the properties of the kerpic (adobe) material; the occupancy of the buildings, the projections (cumba) and the balconies are specialized. However; with the change of modern living conditions, the vernacular architecture has begun to deteriorate with the uncontrolled and inaccurate interventions. With the increase of immigration to cities, the rural architecture has been lost.

In this study, the structural analysis of the rural architectural buildings in Gölpazarı were examined and the protection problems were determined. In order to ensure the sustainability of the kerpic (adobe) buildings, a conservation model has been tried to be introduced through a building, which has been restored.

Keywords: Rural architecture, Conservation, Sustainability, Adobe houses

1 ADOBE BUILDINGS

Earth is an ancient construction material that has been used with people's housing activities [7]. It has been used as a structural material and is also used as a plaster material. It is preferred especially in rural areas because it is easy to supply and economical.

Adobe, which is widely used in building construction in Anatolia, is a building material where clay soil and water are mixed and poured into molds and dried. The use of fibers in adobe is seen in many buildings in Anatolia [9]. The first adobe buildings in Anatolia were constructed in Çayönüi Diyarbakır which dated to 8500 BC. It provides thermal insulation and the most convenient climatic conditions and makes the most advantage of solar energy [1]; that emit heat energy and maintains heating when the source is cut. Because it is a porous material, it traps moisture and provides the moisture balance of the structure; thus providing natural climatic comfort [5]. Its production is easy and production costs are low [1].

With modern architecture, the adobe has been removed over time; it has been seen as a primitive material compared to new building materials in today's industrial age. Whereas it is more ecological, environmentally sensitive and energy saving material from production phase to usage phase; compared to contemporary building materials. Nowadays it has gained importance again with these features.

The adobe provides an advantage in building construction with its fast and easy production. It is poured into molds by human hand, no pressure is applied to compress and is expected to dry in sunlight. Although it is an ecological material, it has low pressure resistant and it is weak to moisture; when it is used as a structural element that should be paid attention to these features [7]. In the construction of the masonry system, it is necessary to plastering in order to protect the structure against external conditions. In order to increase the strength of the adobe material and prevent dusting, admixtures such as tow, straw, gypsum and sometimes cement are added to the adobe blocks depending on the local conditions [1]. It is seen that it is used with wooden skeleton, bearing system, as flooring material, as well as a finishing element on the walls and ceilings like adobe plaster. In order to be resistant to rain water, the adobe used in exterior plaster must be made with clay earth or additive.

2 BİLECİK, GÖLPAZARI DISTRICT AND ADOBE HOUSES

Bilecik province, Gölpazarı district where is on the way of Bilecik - Sakarya and Bilecik - Bolu (Taraklı), is the subject of this study. Because of its location, has been used as an active market area for a long time; also, still have transportation density. The residential area of the district and villages has been preserved substantially and today it is in danger of consciously and unconsciously demolition activities.

Karaağaç Tumulus, Yassı Tumulus and Arıcaklar Tumulus in Gölpazarı are belong to the Copper, Hittite, Phrygian and Lydian civilizations. This area was the settlement of the Bithynia Empire from the 3rd century BC. Osman Bey took the Golpazari Harmankaya Tekfurluğu from the Byzantine Empire and started to expand the Ottoman Empire on these lands.

"Göl" (lake) name of the district depends on the plain which located in the south was a lake before Ottomans. In this period there was a marketplace around the lake and the settlement was more intense and frequented. It is named also Nefs-i Göl, Akcaoba, Akcaova then Ottoman period, it was finally named Gölpazarı [4]. In the 17-18th century, timber was supplied from Bilecik and its environs in order to build warships at Gemlik shipyard [11].

There are 48 villages in Gölpazarı. Kasımlar, Büyükbelen, Aktaşlar, Tongurlar, and Keskin villages also 7 more villages were examined in this study. In these villages, people did fruit growing and the houses were built with adobe.

In the district, the site plan was arranged parallel to the main roads and the houses are directly related to the roads. The topography rising from the district center to the villages; the building settlement planned in organic formations with their gardens due to topography. It is noteworthy that the narrow facades of the houses are directed towards the north in order to protect the adobe buildings to rain and to provide climatic comfort for the householders (Figure 1). In the villages, houses are clustered along the road and access to the houses is provided through the gardens. In the village settlements, mosques are usually located in the center of the village and schools, which built with also adobe, in a large garden. The gardens of the schools are used as gathering areas of the villages.

The adobe houses in Central Anatolia and in Gölpa-zarı, are generally designed with square and rectangular plan. The entrances of the houses reached through the gardens are generally arranged on the southwest and west sides. In the gardens, some barns arranged adjacent to the houses (Figure 2). The barns which was also built with adobe is not used due to the decrease in animal husbandry. It is noteworthy that, the parcels of the houses were not surrounded by a continuous garden wall; there are wooden or wire fences around the houses, some parcels are only limited by roads.

Figure 1. Büyükbelen Village site plan.

3 TRADITIONAL ADOBE HOUSES

3.1 Architectural Features of Adobe Houses

The village houses are important living and gathering places. The entrances of the buildings, which are constructed as single or double storeys, are provided from the west or south facades. There are semi-open porch spaces, which called "hayat", on the southern facades of the houses have stone pavement. People make summer and winter food preparations by "imece" (together), the cauldrons are boiled in the garden to make products such as molasses and tomato paste, and people come together in the evenings around a fire. With these features, gardens are open spaces used as living spaces of houses.

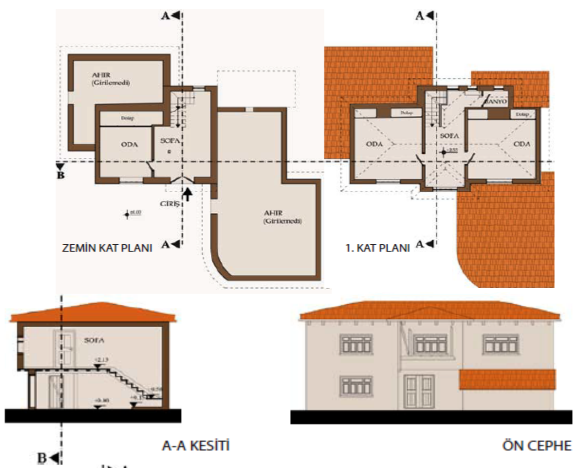

Figure 2. A house planning from Tongurlar village

The adobe houses in Gölpazarı have sofas where are directly related to the gardens. Some rooms are organized adjacent to the barn walls so that they get warm (Figure 2). In these houses the sofas were planned on the edge; in the single buildings the plan type with the middle sofas is widely used (Figure 3). In the downstairs sofas, there are usually kitchen niches to serve in the garden, and staircase leads to the upper hall (Figure 2 and 3).

Service spaces are usually located on the ground floors. In some houses there is a guest room in this floor. On the upper floors, the bedrooms open to the hall (sofa) and there are cupboard niches inside the rooms as traditional (Figure 3). In the middle sofa plan type, the sofas carried out and the projection of the sofas become an eave on the entrance doors (Figure 3). In the plans, symmetrical order was created according to the sofas and reflected also to the facade. The main entrance door and the sofas on the first floors are emphasized with a bay window or balcony. In the houses which planned with the barns on the ground floor, have irregular facade organization in this level floors, besides that first floors have symmetrical order (Figure 2). The windows of the rooms are usually arranged on the east and west facades; it is avoided that planning a window on the north facades, the northern facade of the buildings is generally deaf.

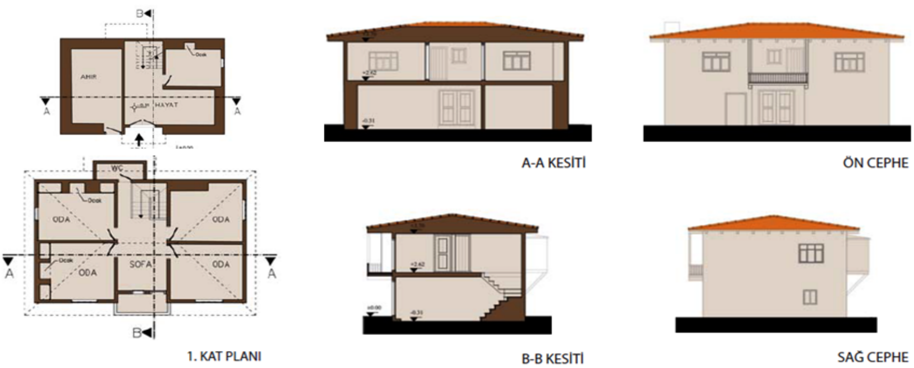

Figure 3. A house planning from Aktaşlar village

3.2 Construction Techniques and Materials

Adobe was used in three different structural systems. The first one is the load bearing system which consists of adobe blocks with adobe mortar, the second one is the wooden carcass with adobe block filling system and the other one is the mixed system. In addition to these systems, in the center of Gölpazarı there are houses which have completely wooden skeleton with bagdadi slat and adobe plastered.

3.2.1 Adobe buildings with load bearing system

In this structural system, adobe blocks put (almaşık) side by side and one on top of the other (Figure 4). In some of these buildings, stone masonry walls were built to the plinth wall and adobe blocks were raised on them. The dimensions of the adobe blocks used in barn and warehouse differ; it is seen that the blocks were not poured on molds in similar dimensions. The outer wall thickness of the buildings is composed of 2 rows of adobe blocks and is approximately 50-60 cm. in depth; while the interior walls are about 30 cm. thickness. All wall surfaces were plastered with adobe plaster. Because of the weather conditions, plasters of some buildings has been lost and deformations have occurred between the blocks (Figure 4).

In the barns, roof structure was made in order to wooden truss because of the large opening. The woods were not chipped and like as logs. The ceilings are not covered, the roof construction can be seen from the inside. In these buildings, a regular wooden rafter is not used and wooden boards are placed on it. This and the other building types have alaturca roof tiles (Figure 5).

Figure 4. A house with load bearing system

Figure 5. A barn with load bearing system

In order to protect the buildings from rain, the eaves are carried out and the lower surface of the eaves are not covered. The roof construction can be seen from under the eaves, some of the eaves have wooden forehead. There is no rain pipe system on the roofs, which are designed as hipped or gable roofs, and the woods used on the roof is not planed and only simply shaved.

In the two-storey houses, the floor beams are placed in short direction on the masonry walls. The length of the wooden beams generally does not exceed 4 m.; as a result the space measurements were determined. The wooden floor beams were placed on horizantal beams which were placed along the walls and were connected to each other on the outer body walls to strengthen. The bottom of the wooden floor beams was covered with wooden ceiling boards in the houses; it is seen that the wooden flooring is not exposed in the barn structures and warehouse spaces (Figure 5). The floor covering of the first floors of the houses is made of wood and the ground floors are made of stone pavement so as not to be affected by water.

On the windows and doors, wooden lintels were used. On the arched windows were constructed in a similar way to brick arched windows; by using molds, the adobe blocks were placed in an upright direction of the arch, the molds were removed and then window openings were formed (Figure 4).

3.2.2 Wooden framework with adobe filling system
In this system, which is called "Hımış", adobe blocks were filled between the wooden framework. The buildings were built with stone masonry to plinth wall level, from this part, wooden carcass system was established. The door and window openings were formed by wooden vertical and horizantal supportings. On the walls wooden vertical supports were connected to each other by timber diagonal and horizantal brackets (Figure 6). The adobe blocks were prepared to fit one in the spaces between the brackets; the blocks were filled diagonally or horizontally between the wooden carcass (Figure 6a and 6b). In both systems, the building facades were plastered with adobe plasterFigure 4 and 6).

In this structural system, the woods were carved but not grated. The floor was arranged in the short direction of the spaces as kagir system. In the roof level the same system was made, the eaves were extended outwards and covered with tiles. No flat-roofed housing was found in the region due to climatic factors. On the wooden floor beams timber flooring was applied. The ceilings are completely covered with wood; flooring or beam systems are not seen. The floors of ground levels have stone pavement.

Figure 6a. *Wooden framework with diagonal..* **Figure 6b.** *..with horizantal adobe block fillings*

3.2.3 Mixed structural system

In this system, buildings were constructed in a similar way to the load bearing system; wooden beams are used to distribute loads between the floors, wooden pillars were used as structural support at the corners of walls and wooden frames on the window and door edges (Figure 7). The wooden beams on the walls connected to each other and reinforce the structure against compressive and tensile strength. In this system, the buildings were placed on a stone foundation and the floor and roof constructions were solved like wooden carcass structures.

According to the results of physical, chemical and mechanical tests that performed in the laboratory condition, on the adobe blocks, adobe plaster and wall mortar samples which were taken from houses of the villages. According to the results of the tests it is determined the clay soil and straw were used in samples. It was found that 4 mm soil material gronulometry was used to increase the strength of adobe blocks and filler mortar, while in thin gronulometry soil was used in plaster mortar (the material passing through the sieve was less than 2 mm). The rate of clay was found approximately 67-80% in adobe blocks, 56-58% in plasters and 10% to 5% ratio straw [3].

Figure 7. Mixed structural system

Energy efficiency and comfort level analyzes have also been conducted on approximately 50 houses in the region. As a result the houses have provided appropriate values for energy efficiency.

4 CONSERVATION PROBLEMS OF ADOBE HOUSES

Adobe is affected by rainwater and temperature differences, because of that adobe material must be protected against to climatic conditions. Therefore, regular maintenance of the adobe buildings is important. However, there are conservation problems due to migration from rural areas to urban areas and the benefits of adobe and earth are not known sufficiently.

- The adobe material which is weak to climatic conditions is severely affected by the water coming from the roof and floor. The adobe buildings which constructed with load bearing system are more sensitive to wooden carcass structures. First of all, the plasters of the buildings are damaged and fall down then due to external weather conditions, the filling mortar between the blocks have been lost and deformations occur between the blocks. The moisture also gives harm to the wooden framework.
- Local people often see continuous care as a diffuculty and do not want to make. Buildings that are not regularly have conservation are exposed to external weather conditions and their damage is increasing.
- Because of changing living conditions, production in rural areas is decreasing, production activities that took place in open and semi-open spaces have lost their importance; sofa, gardens, barns are not used.
- Due to the excessive consumption brought by modern life, comfort conditions change, and people do inaccurate restoration works, wrong arrangements on buildings, deteriorate the original architectural features of the buildings. Also, these arrangements are not suitable for the structural system of buildings so structural damages occur.
- Migrations are increasing in rural areas; the house holders are moved from their homes and the buildings are abandoned and damaged. Instead of the demolished buildings, concrete structures are made, and rural areas become unidentified and our adobe architecture have begun to lose.
- In addition to the migration, on the other hand, people get away from the cities due to crowded city life and rural tourism is in demand because of need natural life. This situation, which increases the interest in rural areas, has both advantages and disadvantages for the protection of these areas. Unconscious interventions caused by urban people starting to spend time in rural areas for weekend vacations cause loss of people because of their easy access as in many rural areas.
- With inheritance, new users have houses in rural areas and want to demolish them not to provide comfort conditions. Instead of the adobe houses, the buildings with reinforced concrete system are constructed, the parcels and gardens sorround with high walls and alienation have began.

5 PROTECTION OF ADOBE HOUSES AND CONCLUSIONS

Adobe porous, natural, ecological material that provides heat and sound insulation. However, its benefits are not sufficiently known.

- In order to ensure its sustainability, continuous maintenance and climatic conditions should be taken.
- The house holders are unwilling to make periodic maintenance works. Because of that, it is recommended to obtain a more durable adobe on repair works with improved adobe that suitable admixtures should be used in order to ensure the long life of the adobe structures and to provide optimum conditions by the user [3].
- The use of adobe is very important in the buildings to be repaired or reconstructed. In the production of adobe material, the soil must be screened well; straw and fibers to be used as additives must be thoroughly chopped and comminuted. The adobe blocks should be compressed by hand pressure into the wooden molds and allowed to dry.
- Traditional buildings cannot provide today's comfort conditions, but rather, they will be abandoned completely; these buildings should be protected. The characteristics of rural architecture must be

examined and developed with the knowledge of today's industrial age to get more healthy and comfortable structures.

- Traditional heating systems of rural buildings are stoves and each room could not be heated in same way. In this case, a radiator system could be integrated in stoves for thermal comfort; local materials continue to be used as fuel. Hot water can also be supplied by installing a solar energy system in adobe houses.
- With reducing production activities in rural areas barns and warehouses is now nonfunctional. These spaces could be reuse with convenient arrangements.
- In order to increase the energy efficiency of the buildings to be reconstructed, it may be recommended to have water and heat insulation on the floor, roof. New adobe production can be achieved by adding water repellent additives to the plaster material and wall blocks. This will extend the time required for periodic maintenance. In order to provide thermal comfort of the houses, it is recommended to replace the windows with double glazing wooden windows instead of inappropriate PVC windows.
- Narrow sofa spaces in traditional houses can be rearranged depending on the needs of the users in the houses to be reconstructed, but the traditional architectural plan should not be changed.
- Cultural policies should be developed to preserve vernacular architecture; conservation projects should be organized and encouraged. Rural tourism should be supported.
- Reinforced concrete buildings in rural areas should be restricted and local regulations should be prepared.
- National economic policies should be developed for rural areas to reduce migration, increase the production activities and contribute to national production.
- In order to ensure the sustainability of our adobe architectural heritage, academic studies should be supported.
- Adobe is a recyclable and natural material, this should be considered as an advantage. New adobe materials can be produced by reusing the adobe soil by utilizing the construction residues of demolished or collapsed structures. The continuity of the material and architecture can be achieved by reconstruction with these materials with low production cost.

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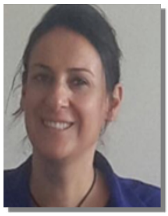
Traditional Adobe Architectural Heritage in Diyarbakir and Conservation Problems

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ABSTRACT

The historical city center of Diyarbakir and its close surroundings have been built on basalt rocks that spread over a very large area. For this reason, basalt was used as the main construction material in the historical buildings of Suriçi (the area on the inside of the city walls). However, especially in the areas near the city walls, adobe houses have been built by low-income families. As moving away from the city center towards the villages where the stone material is hardly found, it is observed that the main construction material is soil since it is found widely and easily. The archaeological excavations carried out in Diyarbakir and its vicinity revealed the usage of adobe material in the constructions since the early ages. To date, houses made of adobe have been built in an almost unchanged way, owing to the flow of information across the generations. The construction of adobe structures is learned in the traditional master-apprentice relationship and therefore, they are the products of the folk architecture. However, with the decrease in adobe production in rural areas, the number of builders who have knowledge about adobe construction techniques has also decreased. Within the scope of this research, the adobe construction types that are existed in the Alabal (Kefnecar), Karacali (Tilalo) and Erimli (Simaki) villages in the northeast of Diyarbakir were investigated, the houses, barns and dovecotes (*boranhane*) which their main building material is adobe were identified. Documentation studies were performed by giving information about the architectural features of these structures and conservation problems in these days.

Keywords: Adobe Architecture, Dovecote, Surici, Village, Diyarbakir

1 INTRODUCTION

The adobe, which was known to be used in Mesopotamia in 10000 BC, is known as the oldest building material in the world [1]. The adobe findings found in the archaeological excavation sites in Diyarbakir and its surroundings which were located in Mesopotamia region confirm this explanation. It is known that the structures of adobe were built on stone blocks in the canalized structures phase in Cayönü Settlement which is dated 9000 years ago [2]. According to examination of Üctepe Mound, Hibermerdon excavations, Aluc Settlement [3], Girikihaciyan [4], Müslüman Hill [5], Salat Hill, Kenan Hill [6] and Kavuşan Mound [7] excavations near to Diyarbakir, it is seen that the adobe material is used intensively.

The tradition of adobe construction has reached to the present day with using same method to be done which has continued for thousands of years.

It was observed that adobe was used in building types such as housing, barn and dovecote[1]. By the scope of this study, the adobe building tradition in the historical city center of Diyarbakır and the adobe structures in the villages of Diyarbakır countryside were examined. The aim of this study is to protect the adobe structure types and to ensure that the plans are taken with the surveying technique and transferred to the future with the documentation method.

2 THE ADOBE USAGE IN THE TRADITIONAL BUILDINGS OF DIYARBAKIR SURICI

Basalt is greatly found in the historical city center of Diyarbakir. Therefore, basalt is the basic material of traditional houses and monumental buildings. In timber walls of the houses, adobe material was used as filling material or in the upper parts to reduce the load of the wall. A minimal number of adobe houses are seen in the Surici of Diyarbakir. The minimal number of adobe houses which have been preferred by the low-income people since their construction is easy to implement and low in cost and survived until today, have been built near the city walls away from the city center [8-10] (Fig. 1, 2).

Figure 1, 2. Adobe houses in the Surici of Diyarbakir

The adobe material used in the buildings in the city center and villages of Diyarbakir was usually made with clay soil provided from the location of the structures. Sifted clay soil was mixed with straw in the ratio of one third, then circle was formed with a hole in the middle. Water was added to the hole, the straw-soil mixture slowly absorbed the water and was kneaded by foot until a homogeneous mixture was obtained. The new mixture, which was well blended with water, was poured into wooden molds, stepped on and compacted. The shaped mixture was removed from the molds and was provided to dry with waiting in the sun for 7-10 days. The adobes were made in two different sizes. It is called *Ana* (mother) and *Kuzu* (lamb). Approximately, most widespread dimensions for these blocks are, for *Ana*, 30x30x10cm and for *Kuzu* 15x30x10cm. These dimensions vary according to the thickness of the wall where the adobe will be used.

Dogan Erginbas gave the following information on the construction of adobe in Diyarbakır form his study published in 1950 [11]:

"…In the traditional houses of Diyarbakir, adobe walls are made. The adobe masonry is 28-30 cm square blocks. Half of them are also available. It is known as Ana (mother) and Kuzu (lamb). Thicknesses are 8 and 10 cm. While the construction of adobe, a person digs the soil, sieves and mixes straw and takes it into molds as shapes of main and lamb. The molder shapes the mud

[1] Pigeon fertilizer used in watermelon cultivation in Diyarbakir was obtained from dovecote. These structures are known as pigeon houses.

according to the mold. The molded mud is provided to dry. The mud mortar is used again when timber walls in rooms or bay windows is made of adobe filling and plastered…"

Figure 3. Adobe House in Diyarbakir

The number of adobe houses reached to the present day is very few. Many were destroyed in time (Fig 3).

3 ADOBE BUILDINGS IN THE RURAL AREA OF DIYARBAKIR

Adobe material was used limitedly in the historical city center of Diyarbakir, however it was used extensively in the villages. The main building material of the houses, stables and dovecotes in Alabal (Kefnecar), Karacali (Tilalo) and Erimli (Simaki) villages of the district of Sur is adobe.

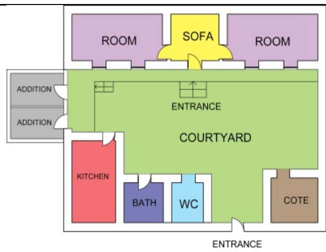
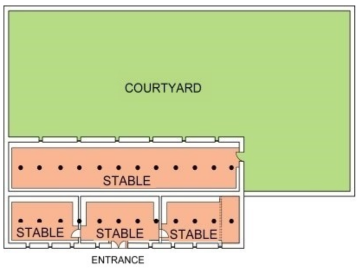
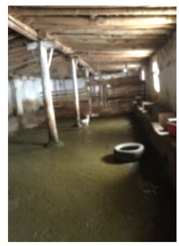
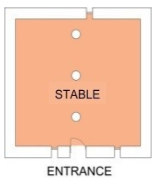
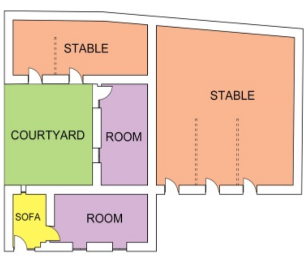
3.1 Alabal (Kefnecar) Village

Alabal, formerly Kefnecar Village, is located on the Silvan road to the northeast of Diyarbakir, 32 km away from the center. The village with 52 households has a population of 320 people.

There is a small square in the village with an organic settlement landscape (Fig. 4). In the past, most of the village consisted of adobe structures, however few adobe structures have survived in today (Fig 5). In this study, samples of adobe building types, which retain the originality of Alabal village, were examined. The adobe houses are one or two storey. The buildings consist of living spaces (room, sofa), wet spaces (bathroom, toilet and kitchen) and service rooms (cote and stable). All the spaces are lined around the courtyard. Long span spaces were created by separating ovine and bovine sections in the stables (Table 1).

Figure 4. Alabal Village Satellite Map [12]
Figure 5. General View of the Village [13]

Table 1. Adobe Houses and Stables in Alabal Village

Building Type	Plan	Photo
House		
Stable		
		
House + Stable		

3.2 Karaçalı (Tilalo) Village

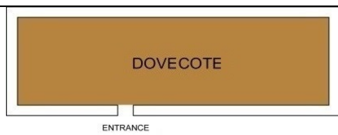
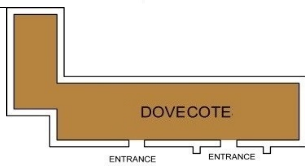
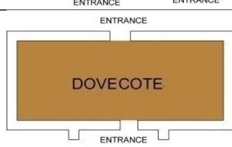
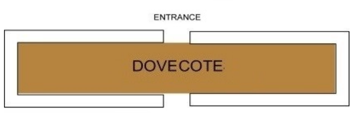
The village of Karaçalı, formerly known as Tilalo, is in the northeast of Diyarbakir on the Silvan road, 10 km away from the center. The population of the village is between 750-800 inhabitants. Watermelon is cultivated in the village which is located on the slope of the Tigris River (Fig. 6, 7).

In the village of Karaçalı, the adobe dovecotes (pigeon houses) attract attention. The local name of the wild pigeon is "*boran*" in Diyarbakir. For this reason, pigeon houses are called "*boranhane*" (dovecote) in Diyarbakir area. Plan of the dovecotes are rectangular; they are distinguished by their simple forms, the internal structures designed for pigeons and the pigeon entry holes in various arrays on their surfaces [14].

Pigeon fertilizer is picked up in dovecote which is gradually decreasing. Nowadays the number is seven. These fertilizers are used in watermelon cultivation (Table 2).

Figure 6. Karacali Village Satellite Map [12]
Figure 7. General View of the Village

Table 2. Adobe Dovecotes in Karaçalı Village

Building Type	Plan	Photo
Dovecotes		
		
		
		
		
		

Ayhan Bekleyen gave the following information on the construction of dovecotes in Karaçalı [15]: *"The walls of the dovecotes are made of sun-dried bricks and have a height of four meters with an average thickness of 55 cm. An old craftsman interviewed by the author stated that formerly 7,000 sun-dried bricks had been used to build one-partitioned dovecotes (300x1100x400 cm). The* *inclined walls are thinner at the top and thicker at the bottom. The dimensions of the sun-dried bricks used for the construction of the walls are 35x16x10 cm. In some buildings, supporting pillars are added to the internal or external parts of the walls in order to provide extra strength. ... The interior sections are connected by passages that are lower and narrower (approximately 80–120 cm high by 60 cm wide). Local craftsmen stated that in earlier times the doors of the dovecotes were completely closed every year with sun-dried bricks after the collection of bird manure."* (Fig. 8,9).


Figure 8, 9. A dovecote in Karaçalı (Tilalo) Village

3.3 Erimli (Simaki) Village

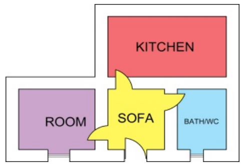
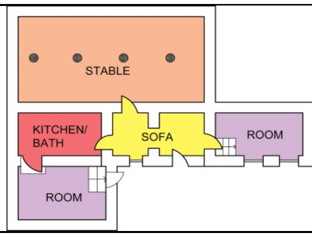
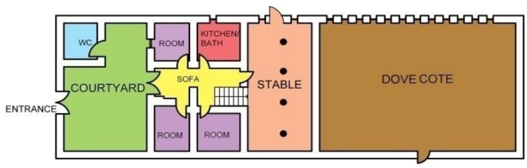
The village of Erimli (Simaki) is located in the 21 km north of Diyarbakır. The village of about 1000 inhabitants, has 250 households (Fig. 10, 11).

In the village of Erimli, which is one of the villages where adobe structures are seen intensely, different types of buildings are seen where housing, housing-barn or housing-barn-dovecote are together (Table 3).

Traditional houses have one or two floors. The houses consist of indoor and outdoor spaces. At home; living spaces - courtyards, rooms, sofas, wet spaces - kitchens, bathrooms - and service places such as stables, cotes, tandoor, takes place if any. The sofa is in the center of the house and the access to the rooms is via the Sofa. In the examples where the house and the barn are together, connection is provided from the sofa to the stable. Generally, the upper floor of the traditional two-storey houses has the same plan as the ground floor. Room sizes are between 250-350 cm. Top cover is timber beamed roof. The wall thickness is around 45-50 cm. Exterior doors of the buildings are single or double-leafed. The entrance door leads to the sofa.

Figure 10. Erimli Village Satellite Map [12] **Figure 11.** General View of the Village

Table 3. Adobe Samples in Erimli Village

Building Type	Plan	Photo
House		
House + Stable		
House + Stable + Dovecotes		

4 CONSERVATION PROBLEMS OF THE ADOBE ARCHITECTURAL HERITAGE

The adobe buildings in the city center of Diyarbakir were destroyed in time and very few of adobe houses survived. Today, adobe houses are also used by low-income users due to poor comfort conditions. The lack of expert craftsmen during the restoration applications caused faulty applications. The use of contemporary materials instead of adobe materials caused the original texture of adobe building elements to be lost. In recent years, the number of adobe houses built in the rural areas of Diyarbakır is almost negligible. The existing adobe houses are demolished and replaced by reinforced concrete houses.

The difficulty of maintenance of adobe structures and the necessity of regular maintenance and repair have led to the abandonment or demolition of many adobe houses. Especially the negative effects of climatic conditions and the lack of maintenance after heavy rains accelerated these devastations. In the past, earth-sheltered buildings were compacted after every rain. Today it is an application that is hard for users to make regularly. The fact that adobe building is less conservation against insects and pests, as the main construction material is soil, intense plant degradation accelerates the degradation even further. Daily and seasonal cleaning of adobe structures is more difficult than concrete structures. It was observed that living in adobe houses was considered as a negative status among the people in the villages examined.

All the negative factors mentioned above have led to the preference of reinforced concrete houses instead of adobe. For this reason, it is seen that few adobe owners also plan to demolish their houses. The dovecotes, which are densely located outside the houses, lost their old functions due to the discontinuation of fertilizer production and the decrease in the number of producers. Dovecotes, which have an important place in our cultural heritage, are not used because they do not maintain their original functions. Many were destroyed due to neglect and misuse. These structures, which cannot be adequately conservation in the Diyarbakır region, are now in complete danger of extinction.

5 CONCLUSION

Adobe has been an economic building material that has been used in Anatolia since the first settlement. In the past, features such as local and easy accessibility and low construction costs have led to the intensive use of adobe in the Diyarbakır countryside. The environmentally friendly material, which does not spend much energy during its construction adobe does not harm the environment during use.

The adobe houses examined in the villages of Diyarbakir are in adjacent order. The houses are generally in the north-south direction. The entrance gate of the houses is generally directed to the south. Main doors of the houses are never opened directly to the street, are always opened first to the garden and then street. Usually close relative houses are made adjacent or close to each other. For security, approach distance of privacy and rain and snow cleaning is considered to place the houses. Spaces are arranged around of the sofa in adobe buildings. No samples were found without sofa in the buildings examined. It is generally seen that rooms are located on the right and left flank of the sofas and rooms such as stables and poultry houses are located opposite them.

While most of the adobe houses in the villages were demolished, the use of adobe stables fragmentarily continued. Knowing that the compressed soils and adobe building elements are important for animal health has big fluency to make this situation happened. Preservation of heat and moisture balance in adobe structures has provided a cleaner and healthier air in the structure. For these reasons, it is thought to be better in terms of animal health than reinforced concrete structures.

The adobe architecture, which is common throughout the country, needs to be conserved and documented in order to be transferred to the future. When the examples of the adobe structures we consider in the rural scale of Diyarbakır were examined, it was seen that the buildings became worse due to lack of care and indifference. Within the scope of cultural heritage, documentation studies should be carried out to conservation and transfer these structures, especially bird houses, to the future.

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The Tale of a Building Material: How can Prehistoric Past Shed Light on the Martian Future in Terms of Earthen Architecture

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ABSTRACT

This paper investigates the journey of earth as a building material, side by side with the human's path to civilization. Even in the prehistoric ages, while humans left caves to maintain a sedentary life, from perspective of architecture, the earth was always the handiest building material found in plenty in almost every climatic region. And in terms of abstract meanings, Stone Age people constructed residences with earth while their public structures were heavily of stone. Besides being one of the four classical elements, earth always maintained its importance especially in the tangible culture of humankind. Until current era, it is used in both formal and vernacular architecture. For formal use, the prefabricated products as bricks and tiles must be named. And for vernacular use, which is closer to both prehistoric and historic roots, several building techniques must be mentioned. First usage of earth in architectural history was in terms of plaster on twigs. This technique, named "wattle-and-daub", consists of weaving a basket of branches and plastering this frame with mud. Second technique was the use of hand-made mudballs named "pisé". Yet another technique was the use of rammed earth with the help of molds. Later in time, right during the middle of the Stone Age -the "Pre-Pottery Neolithic B" era, the adobe brick was invented in Near East. It must be one of the most practical inventions through the architectural history. Since, even today, in the rural areas of mentioned Near East, bricks with same dimensions are still in use. On the other hand, humanity has a brand-new agenda recently: colonization of planets. Mars is the first target, since its healable conditions. Several entrepreneurs promise to carry volunteers on Mars surface in late 2020s and early 2030s. This is an extensive civilization project and needs to be studied by different disciplines in details. Architecture's duty in these terms is the solution of urgent shelters in first phase. Companies in charge keep telling us that transporting building material from Earth is quite expensive for them. Therefore, reddish Martian soil, the "regolith" must be evaluated as building material. Thanks to our experience on Earth, we have already known the physical features of earth. Indeed, high thermal mass of earth material can even be the only clever solution while dealing with the radiation problem through the healing process of planet Mars.

Keywords: adobe, earthen architecture, martian architecture, neolithic architecture, vernacular architecture

1 INTRODUCTION

Middle East is one of the oldest geographies on planet Earth that architecture emerged and one of the several spots that agriculture and sedentarism were born. At broadest sense, these Neolithic achievements were the beginning of the civilization. On the other hand, as of the end of the second decade of the new millennium, human civilization has a brand-new agenda: settling on the planet Mars. And according to hierarchy of needs, there are two basic challenges awaiting while colonizing the red planet: agriculture and architecture, same civilization milestones achieved in the Neolithic. Biologists still search ways of cultivating plants on Mars. Sheltering, on the other hand, seems a problem that architects need to solve. As transporting building parts from Earth is something we cannot afford, we must introduce Martian soil, known as regolith as building material. Interpretation of earth as a building material, dates back as old as the Neolithic. Therefore, the building techniques in the Neolithic have a lot to teach, while human civilization is at dawn of breaking the cosmological border. Aim of this paper is to figure out the solution for the most primitive architectural shelters, when the first manned shuttle lands on Mars. As accepting climate as the main challenge of architecture, this study's methodology is to investigate Martian conditions, and to determine the most accurate building technique for regolith material matching up with the earth material techniques used in the Neolithic.

2 ORIENTATION: THE LINK BETWEEN

Mankind is the only race, as far as we know, gifted with the ability of abstract thinking. What we collect around these abstract ideas, both in concrete and metaphysical aspects, are called culture; and the sum of cultures is called civilization. Australian archaeologist and philologist Gordon Childe has determined the milestones of human civilization and called them **revolutions**, in his sensational work Man Made Himself [1]. According to him, these breaking points were the Agricultural Revolution, the Urban Revolution, and the Industrial Revolution; and in order to be a revolution, any progress should have changed the previous human life permanently. If this study was processed today, both the Internet Revolution and the latest Mars Colonization Revolution should be added on this list [2]. The Internet has totally changed the information and the storage systems of knowledge. Mars Colonization, on the other hand, is going to introduce a multi-planet civilization, for the first time ever.

Sailing out to space was mankind's biggest dream since they started observing the sky. For a long time, we have been familiarized with the idea of space travel by space operas, as a sub-genre of science fiction, like Star Wars, Star Trek, The Martian, and StarCraft[1]. Through the process, both Russian cosmonaut Yuri Gagarin's first journey into outer space and American astronaut Neil Armstrong's first walk on the Moon were great achievements for the purposes of this dream. Since 1960s, where these goals were accomplished, government space agencies like NASA from United States, Roscosmos from Russia, and European Space Agency struggle for the conquest of the space. Several numbers of satellites and landers were sent out for research and communication purposes. However today, private entrepreneurs have larger economies than state agencies and they carry on the space race, dragging the track into a new ground: colonizing the planets, beginning with the Mars[2]. Serious scientific projects also laid down the time limit; people are going to walk on Mars by **2030s**.

Colonization of planets is an insurance policy. Scientists predict that we cannot live on Earth forever. There are serious threats against the survival of life on this planet, beginning with the human itself. We have significant impact on Earth's geology and ecosystem, especially since the Industrial Revolution[3]. Yet another threat of human origin is the possibility of a global disaster, like a nuclear war or something. There also is a possibility of an external threat, like an asteroid crash into the Earth once again. Hence, the life on Earth is on knife-edge and an alternative must be prepared. Those projects, in this case, accept Mars as a border post for extending our civilization to other planets and even other solar systems.

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[1] One of the first non-fictional scientific works about the subject was Das Marsprojekt [3]. Even two decades before Apollo 11, a German rocket physicist detailed the Mars colonization idea.
[2] One of the private foundations aims to market the broadcasting rights in order to create an even larger amount of funds.
[3] Known as the Anthropocene, it is a proposed geological epoch including the current era [4].

According to American psychologist Abraham Maslow's well-known **hierarchy of needs**, there are two basic challenges awaiting while colonizing the red planet: agriculture and architecture [5]. Biologists still search ways of cultivating plants on Mars surface. Building shelters, on the other hand, seems an architectural problem. Private organizations in charge of Mars colonization, like SpaceX of Elon Musk and Mars One of Bas Lansdorp submit that transporting all building material from Earth is something they cannot afford. Each extra pound means extra need of energy and they want to takeoff as light as possible. Despite all these facts, we are still not hopeless, - **Don't Panic** (the motto of another popular space opera, The Hitchhiker's Guide to the Galaxy) [6]! Several studies were put forward for interpretation of Martian soil, known as **regolith** as a building material [7], [8], [9]. Usage of earth, on planet Earth, as a building material dates back as old as the Neolithic, together with the first agricultural attempts. In other words, when the first **small step (or the giant leap?)** is going to be taken, the Neolithic age of Mars is going to begin.

3 INPUT: THE NEOLITHIC AGE

Prior to Neolithic, sedentarism was not common. The Paleolithic hunter-gatherers first sheltered in caves, and later they created temporary camps for seasons. Lifetimes of these camps increased with the constant ability of food around. Totally sedentary villages began with the agricultural cultures, in the beginning of the Neolithic. Although the vast majority of the studies on Neolithic period were processed on the agriculture topic, there still are beneficial architectural studies. According to them, buildings in Neolithic villages are basically divided into two categories: residences and the public structures [2] (Fig. 1). Public structures were an outcome of collective living in a common environment. Mistakenly called temples [10], these buildings were designed for communal functions, not only as religious purposes but also as socializing venues as councils, areas for fests and feasts, and even dance parties. A common feature of these public structures was their noticeable identity within the Neolithic village, with their architecture. They were greater in volume and specially treated both in building material and technique. However, for Mars, public structures are non-urgent initially, at least for the earlier phases.

Figure 1. Structure types (residences on top) from Neolithic[4]

[4] [11]

Residences, on the other hand, are more important for the time pairing with Martian structures. Houses in Neolithic were in circular plantype in the beginning of Neolithic and transformed into rectangular during the progress. This metamorphosis is explained with the social organization of either extended or nucleus families and the transfer of production to indoors [12]. On the other hand, all these houses were not only structures built to live in but were decorated with mystic cult objects, displaying the world of thought of its inhabitants [13].

However, more than these abstract design concepts, the concrete structural features of the Neolithic houses are going to be helpful with the Mars. At the beginning of the era, when they were in circular plantypes, houses were of wattle and daub technique. That means weaving the branches like basket and plastering this frame with mud. This was the first time, the earth used for construction purposes. Second set of efforts with mud was the methods either molding superimposed earth or using handmade mudballs, known as **pisé**. Both techniques were decelerating the construction. Finally, in the middle of the Neolithic, the sun-dried adobe brick was invented as the earliest prefabricated building material [14][5]. Use of earth in bricks increased the expertise and eased the forthcoming invention of pottery. In archaeology, absence and existence of pottery in excavation levels are both regarded as they divide the period into two: Pre-Pottery and Pottery Neolithic.

Since mankind left caves and modified their own environment, climate became the main challenge of architecture. For instance, when a modern structure does not work with climate the architect at least faces with an unsatisfied client, but in ancient times the builders faced an unforgiving nature. Hence, inspirational solutions were figured out throughout the history. Even the Neolithic people were cleverer than we depict them, in this case. Very first dome shaped wattle and daub huts (Fig. 2, upper left) were an outcome of an intelligent design. Sphere (the hemisphere in this case) is the best example of prime geometry for the minimum surface area to volume ratio. Another solution for decreasing surface area to minimize heat loss is the adjacent placement of individual volumes. This creates a compact entity that people walk on flat roofs and use a ladder to access interiors through the holes on the ceilings. This way of design, which is known as honeycomb, is the unique architectural feature of Neolithic Central Anatolia (Fig. 2, lower left). And in both samples, the earth is known for the best ratings in heat insulation as a building material. As the modern counterparts of both samples, the igloo from circumpolar region (Fig. 2, upper right) and the pueblo from North America (Fig. 2, lower right) are observable. The concepts behind their forms are almost identical with Neolithic samples in terms of design mechanics mentioned. What we learned from all those individual samples, in terms of both material and technique, are going to support the creation of civilization on Mars.

[5] Despite playing with mud since the Paleolithic when small cult statues known as figurine were made and using it as mentioned building materials, mankind figured out the brick at a very late stage [15].

Figure 2. Neolithic architecture and modern counterparts[6]

4 OUTPUT: THE MARS SHELTERS

For the Mars, climate is once again the main challenge of architecture. And this time, the mankind is going to face with very unfamiliar conditions. As far as we know, Mars is at 1/10 of Earth's mass and 1/2 farther from the Sun. Mars day, known as **sol**, is 40 minutes longer than an Earth day and a Mars year is about 689 Earth days. As also the Mars has an axial tilt quite close to the value for Earth, there are four seasons, but longer than Earth to spread over the Martian year. Similarities continue with the existence of polar ice caps and observable presence of weather patterns. However, the main difference coming front is the structure of the Mars atmosphere. It is thinner and 100 times looser than the Earth and composed mostly of carbon dioxide, 96% approximately [16] (Fig. 3)[7]. More, the dusty structure of Mars atmosphere paints the sky in an orange-brown color observable from the surface. These features result great diurnal temperature variation and leave the surface vulnerable to both solar and cosmic radiations. It is believed, Mars also had rivers and lakes, and even large oceans a few billion years ago [17]. Long-term plan is to heal Martian habitat with re-activating those now frozen waters. When atmosphere is going to become breathable without helmet, that means availability of food production by both plant cultivation and animal herding, in other words the Agricultural Revolution.

[6] (upper left) [18], (upper right) [19], (lower left) [20], (lower right) [21]
[7] Who knows, this fact can be beneficial with the plant cultivation at first.

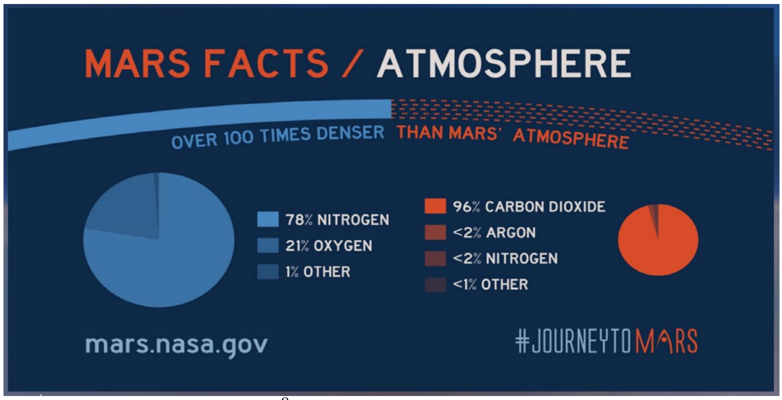

Figure 3. Facts about Mars atmosphere[8]

Since the main threat architecture needs to solve is the climate once again, here the radiation problem must be handled until the atmosphere is healed. Some suggestions were creating prefabricated building materials on Earth and build them up on Mars (Fig. 4, lower left). However, now we know that those much elements cannot be transported. Another of the earlier suggestions was using balloon- like inflatable structures (Fig. 4, upper left). However, it is obvious that they are not going to work with mentioned radiation conditions. As another solution, wattle and daub can be offered. This time, frame material can be transported from the Earth, which must be lighter in weight (not to annoy those fuel-obsessed private organizations). However, preparing mud is going to be unavailable at first, since the water scarcity. Cutting bricks out of the regolith here seems once again the cleverest solution, not only for availability but also for the high-rate performance predicted against space radiation [22] (Fig. 4, right). These double advantages make Mars colonization even more available and realistic[9].

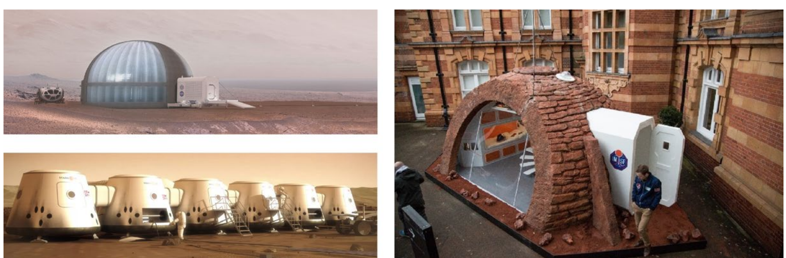

Figure 3. Mars architecture proposals[10]

For the building techniques, once again the different solutions were offered. One was creating underground volumes; however, it causes a need for giant workforce to dig up all the dirt. Another solution can be cutting bricks on one place and pile up them on another, to create the structure. This one also seems disadvantageous in terms of both workforce and the time. The best advices are the from what we have learned from early Neolithic and the construction from the igloo sample. In this case, the builder stands on the center of the circular plantype, cuts out the bricks from the floor and piles up them around. Structure becomes partially underground which is known as pit-house in history of architecture [23]. This recommendation is the most beneficial in terms of either time or

[8] [24]
[9] The first settlers may shelter in the caves just like their Paleolithic ancestors, temporarily for first a few days after the landing and then start the construction, or at least preparing the bricks.
[10] (upper left) [25], (lower left) [26], (right) [27].

workforce, for the urgent need of shelters**.** When these first huts shielding radiation are in use, modifying the other structures of the built environment becomes much easier. Even Rome was not built in a day.

The **honeycomb** design language can also be tried later. There going to be need for much workforce and time in those setting, but the earlier huts mentioned above will provide them. As we know about the axial tilt and the seasons, there can be two bases in both hemispheres of Mars [8]. And as we know about the weather patterns, honeycomb design can be more beneficial in one of the either parts. And inhabitants of Mars may begin a seasonal nomadism, known as **transhumance**, just like their ancestors lived once[11].

5 RESULT: WHAT MUST BE DONE

Mankind left Africa 60,000 years ago and kept exploring new horizons until they spread all the globe. The reason behind those discoveries was the tendency to survive. The number of English naval fleet arrived America continent in the first campaign was one. By a few centuries, the number increased to hundreds. New World was hope, so is the Mars. The goal is settling 50,000 inhabitants into red planet in a few decades after the first arrival. First settlers are going to be supported by shipments from the home planet and soon they are going to be vegetarian, as herding animal is a lot more difficult in first step. Later, when Mars environment is healed for agriculture, frontier colonies may become self-sufficient[12].

As we have time about one decade for getting ready for the journey, we must think about each little detail carefully. Scholars from different disciplines must assume responsibility for preparing this civilization project. Astronomers must collect more information about Mars, geographers must calculate Mars conditions more accurately, mechanics must study for higher performance rockets, and biologists must figure out the certain flowchart of horticulture on Mars. The architects, on the other hand, must plan all the architectural chapter of the colonization campaign in detail, regarding those climatic facts, much before the shuttles set sail.

And as the last thing from a reverse perspective; watching Earth from a distance may help with understanding how we corrupted it. Although it is an insurance to survive, healing Mars conditions and recreating the civilization may give an idea about repairing both the Earth and the lifestyles we maintain on its surface.

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Intangible Values of Earthen Building Culture of Konya

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ABSTRACT

Intangible values of building culture mainly express cultural expressions embodied in traditional craftsmanship which has mostly carried out by the local master builders and transmitted from generation to generation throughout tradition. Of these expressions, beside the knowledge, know-how and the skills of builders, there are also specific practices related to local building tradition carried out by local people and the shared meanings attributed to them. The specificity of building culture of contexts is mainly sourced from these hidden meanings. These intangible values carried in the minds of the builders through local building tradition are embodied in the architectural language of historic environments.

The knowledge and practices that have continued in local building tradition in the rural settlements of Anatolia are a significant part of intangible cultural heritage. For the conservation of intangible cultural heritage, the documentation and the continuity of practices by practitioners, namely, local building craftsmen, is a most significant requirement. The documentation and transmission of know-how, skills, techniques and methods of the masters as the practitioners of the building tradition is compulsory for the continuity of tradition.

Konya's earthen building culture is so specific as the embodiments of both the activities, knowledge and know-how of local building masters on mud-brick construction techniques; and the practices of maintenance, renewal and ornamentation of traditional buildings carried out by women. This study aims to investigate the intangible values of Konya's earthen building culture considering their interrelations with tangible values to develop a holistic conservation approach. As the method of study, the data obtained from the architectural surveys of the traditional buildings, observations, photographic documentation, and the in-depth interviews carried out with peasant women, building masters and local authorities carried out in July 2017 and September 2018 during the site surveys in Çavuş and Değirmenaltı Villages in Hüyük, Sarayönü and Kadınhanı will be evaluated.

Keywords: Earthen building culture, intangible values, building craftsmen, conservation, Konya

1 INTRODUCTION

Building culture, as an expression type of culture on built environment, includes certain 'structuring structures' and the intangible values in it (Karakul, 2011a, 2011b). The structuring structures in building culture, namely the technology and knowledge of the local builders, have the formative power on cultural expressions. It actually means that the intangible values concretized mainly on the building technology and vernacular architectural language in a historic environment (Karakul, 2011a, 2011b, 2014). It is composed of technology comprising of techniques, technics

(Pultar, 1997, pp.27-32) and methods and knowledge comprising of skills (Ito, 2003; Akagawa, 2005), craftmanship (Akagawa, 2005), measuring units (Ito, 2003).

Intangible values in building culture are mainly related to cultural expressions in traditional craftsmanship carried out by the local master builders within tradition (Karakul, 2014, 166). These cultural expressions are mainly related to the cultural structure of the region which reflect on various meanings shared by both local people and builders. Of these meanings, there are certain meanings about significant aspects of the inhabitant's lives that are expressed through the forms of places maintained within the transformation process of formal characteristics of buildings. Specificity of contexts can be understood through analyzing these meanings in them. These intangible values carried in the minds of the builders are embodied in architectural language of the traditional buildings.

In historic environments, the intangible values in building culture, namely, cultural expressions embodied in the buildings have been transmitted to the present time especially by the information flow between master craftsman and apprentice (usta- çırak). Hubka (1979, p.28) investigates the methods of study of folk builders in the production process of traditional buildings. According to Hubka (1979), folk design method is carried exclusively in the mind of builders and continued by tradition- the handing down of information by word of mouth, observation, replication and apprenticeship. Rules and traditions in folk design method are in the minds of its builders as a kind of highly abstracted architectural grammar, or schemata. Certainly, the transmission of the knowledge of masters to their apprentices assures the continuation of the local building tradition.

Intangible values of building culture need to be investigated as an element of traditional craftsmanship which is a domain of intangible cultural heritage in in the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage adopted by UNESCO[1]. This study examines Konya's earthen building culture as a genuine tissue to identify the intangible values carried on tradition by builders and villagers for long years and their interrelations with tangible values to develop a holistic conservation approach. Among the intangible elements of Konya's building culture, knowledge, skills and practices of the inhabitants of rural settlements, besides the knowledge and skills of the building masters, are investigated focusing on special techniques and tools used by the building masters for construction and the peasant women for the maintenance and decoration of the traditional adobe buildings are examined within the scope of the study[2].

2 KONYA'S TRADITIONAL ARCHITECTURE

Konya which has been a settlement of different civilizations since ancient times, presents a rich variety of architectural forms formed by the interactions of different cultures including the Neolithic settlement of Çatalhöyük, monumental buildings from Seljukid Period and traditional dwellings. The traditional residential architecture of Konya, the capital of the Seljuk Period, was built by mud-brick masonry walls covered with earth roof (Arseven, 1952: 2078). Traditional

[1] The UNESCO 2003 Convention defines "intangible cultural heritage" as "the practices, representations, expressions, knowledge, skills-as well as the instruments, objects, artifacts and cultural spaces associated therewith- that communities, groups and, in some cases, individuals recognize as part of their cultural heritage"; and, emphasizes the domains of intangible cultural heritage as (a) oral traditions and expressions, including language as a vehicle of the intangible cultural heritage;(b) performing arts; (c) social practices, rituals and festive events;(d) knowledge and practices concerning nature and the universe;(e) traditional craftsmanship". See the Convention for the Safeguarding of the Intangible Cultural Heritage. 32nd Session of the General Conference. September 29- October 17. Paris. from http://unesdoc.unesco.org/images/0013/001325/132540e.pdf)

[2] This study was prepared by using information obtained from field surveys carried out in the Çavuş and Değirmenaltı villages of Hüyük District within the scope of Scientific Research Project (BAP) numbered 17401071 conducted by Özlem Karakul with a researcher, Neriman Şahin Güçhan, in Selçuk University since 2017.

dwellings in rural settlements in Konya and its surrounding areas had been built with mudbrick masonry technique, which has been widely used in Anatolia since the Hittites, depending on the material facilities in the region (Kömürcüoğlu, 1962, 8, Naumann, 1975).

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In the mountainous and rainy regions around Konya, the buildings have usually been constructed by stone masonry systems, whereas, in the regions which has flat topography and low rainfall, the traditional buildings are generally constructed by mud-brick masonry with timber bonds (Önge, 1991: 138). The spatial organization of Konya's traditional architecture is constituted by courtyard, semi-open space, called *Çardak*, a multi-purpose space located between the rooms called *mabeyin* and rooms in single-storey houses (Karpuz, 2000). In two-storey traditional dwellings, in ground floor, the courtyard or an entrance space called *Hayat* and service spaces, like, barn, haystack, woodshed, warehouse are located; on the first floor, spaces used for living and production activities, like mabeyin, Hayat and semi-open space, *Çardak* and rooms.

2 INTANGIBLE HERITAGE OF KONYA'S BUILDING CULTURE| KNOWLEDGE, SKILLS AND PRACTICES EMBODIED IN LOCAL BUILDING TRADITION OF KONYA

Focusing on the intangible values of Konya's earthen building culture, this study mainly discusses knowledge, skills and practices embodied in local building tradition. These practices can mainly be grouped into two as the knowledge, skills and practices of building masters and inhabitants embodied in local building culture.

2.1 Knowledge, Skills and Practices of Building Masters

The knowledge and skills of building masters are mainly embodied in local mud-brick building tradition of Konya.

2.1.1 Construction Techniques of Walls in Adobe Architecture

Adobe masonry walls are composed of mud-brick blocks used as masonry materials and earth and mortar mixtures used as binder material. The adobe is obtained by soil and an organic binder material, such as hay or animal hair, by mixing them in blocks and drying in the sun.

The preparation of adobe blocks consists of three stages as the preparation of sludge, molding-cutting-casting and drying. The cutting process of adobe blocks is mostly carried out in the which are located near the water, in a dry period, usually at the end of May or in June, in order to come out the mudbrick blocks smoothly in flat terrains or threshing fields (Karakul, 2019). For the preparation of the mud to be used for adobe blocks, the loamy soil is continuously mixed with the addition of big straw called *kesmik* and water until it becomes thick; and, then, soaked and softened and left for one day. After two or three days, water and straw are added and mixed well, it is expected to become more complete, waiting for another day, when fermentation and consistency is achieved, then adobe cutting process is started.

Starting the cutting of the adobe blocks the next day, the mud was poured into the wooden molds with four compartments, called *gelif*, to produce two large blocks called *ana* and two small blocks called *kuzu*, after being corrected with a tool made of wood called *sürtegeç*, it was removed. The molds were wetted every time so that the mold could be drawn easily. The adobe blocks were laid out in the open space in such a way as to take sunshine for drying, after 3-5 days at the place where they are dried; by turning it sideways and inverted respectively for a while, drying process is completed.

The external walls of traditional adobe buildings are usually constructed by stone masonry technique up to 50-60 cm height from the ground level. During building up the masonry of the mudbrick walls, the large blocks and small blocks are placed side by side and the gaps between them are filled with mud mixed with the fragments of mud bricks.

2.1.2 *Construction Techniques of Floors and Roofs in Adobe Architecture*
According to the information obtained from local building masters, in the villages examined in Konya, wooden beams are firstly placed under the slab beams on the adobe walls during the construction of flat roofs (Karakul, 2019). Round wooden beams are placed on them, depending on the economic situation of the host, the mat layer obtained from Beşer, Akşehir or the vicinity; and, a reed layer is laid on the mat. Over the reed layer taken from the regions where the lake is located, the soil is spread in different thicknesses depending on the region, and after soaking, either salt or a soil type called çorak is laid to prevent water permeability by compressing the soil surface and becoming rugged. After laying salt, earth layer is compacted by using a cylindrical stone, called yuvak.

2.2 Knowledge Skills and Practices of Local Inhabitants
The knowledge and skills of local inhabitants are connoted as local practices mostly carried out by peasant women related to building activities, specifically, maintenance and decoration practices in adobe architecture (Karakul, 2019). For the purpose of maintenance, renewal and decoration of adobe structures built by the building masters in the rural settlements of Konya, like Hüyük, the knowledge and practices carried out by the traditional building masters and peasant women have specific values related to the techniques, materials and tools used, required to be documented and protected as the elements of intangible cultural heritage particular to the region.

After the completion of the construction process of the traditional buildings by the building masters, women who are the practitioners of the tradition of maintenance and decoration, play an important role in preserving and maintaining the intangible cultural heritage in terms of the materials, tools and techniques used. In the region, the knowledge and practices through the tradition of decoration and maintenance, continued by peasant women for centuries have been sustained by transferring from mother to daughter. The practices of maintenance and decoration continued for centuries prove the role of women in building culture beside building masters particular to the region.

2.2.1 Maintenance Practices in Adobe Architecture
Regular maintenance is of great importance in the protection of adobe buildings as is in all historical buildings. The renewal of the mud plaster applied to the wall surface, which is built from the mudbrick, which has a lower degree of water resistance compared to stone and wood, extends the life span of the buildings. In the Çavuş and Değirmenaltı Villages in which the investigations were carried out, the maintenance practices in the traditional mudbrick houses are a three-stage process consisting of the construction of soil plaster, application of sludge application called *yalabıtma* by local people, and painting.

The first stage of maintenance applications is the application of mud plaster by the building masters in the final stage of the construction process of traditional mudbrick buildings. According to the statements of the building masters in Çavuş Village of Hüyük District, the soil brought from Söğütlüdere Region was mixed with straw and water and then it was kept on the first day, then, during three days, the mixture is mixed from time to time, and, then on fourth day, after being normal consistency, the mixture is used as plaster[3]. It is taken into consideration that the soil used in the preparation of the plaster is cored and the straw is thinner than those used in the mudbrick building blocks.

Following the completion and drying of the plaster made by the craftsmen, a second process is carried out by the peasant women with a sludge plastering process after storing the soil mixed with

[3] Interviewer: İbrahim Can

straw and water for three days and resting and trampling[4]. The sludge is easily adhered to the wall surface when it is hit. Then, the plaster surface is corrected and fixed with a wooden trowel. During this plastering process, men plaster the upper levels of the buildings, and, women plaster the ground floor wall.

After the plastering, in the Çavuş Village, the process of applying sludge in a more liquid state by adding water is applied over the mud plaster. The sludge mixture, which is prepared by mixing the red cored soil taken from the center of Hüyük with water and flour bran, is applied to the surface of the plaster by means of a cloth or felt[5]. The red cored soil used without sieving is also used as a filling material for the repair of the broken and broken parts of the wall by adding flour bran to the mixture.

As the last stage of maintenance applications in adobe houses, after finishing the suldge plastering process, painting process starts. In some buildings, using the lime, in some buildings, using the special white soil taken from the Kıreli region mixed with water and sometimes with the fine straw, the paint is applied to the wall surface[6]. This renewal and maintenance process, the so-called Aklama within the region, is carried out twice a year in spring and fall by peasant women. This special white soil type is also one of the basic materials used for the decoration of the wall surfaces which will be explained in detail below using different tools and techniques besides painting of mudbrick walls. In the painting process, besides white soil, red soil and brown soil obtained by mixing red and white soil is also used.

2.2.1 Decoration Practices in Adobe Architecture

The tradition of mural painting in the Neolithic Period Çatalhöyük settlement in Konya (Hodder, Meskell, 2010; Çamurcuoğlu, 2015) and its immediate vicinity, despite the variations in the motifs and symbolic meanings, has still continued in the tradition of Çavuş and Değirmenaltı. The decoration practices examined within the scope of the study express the process of applying different patterns and motifs made by using the plaster and paint on the wall surfaces of the peasant women by using different tools and techniques. Since the ornamentation practices that have been carried out for centuries in the tradition as an element of intangible cultural heritage need to be documented, they are examined with regard to different methods, materials and techniques used by the practitioners in the fields of study.

As mentioned above, the paint obtained by mixing the special white, brown or red soil in the Çavuş Village and Değirmenaltı Village is also used for the decoration of the walls beside for the painting of the walls of the buildings. In traditional houses, mostly in the front façade, in the vicinity of the entrance door, on the walls of the interior spaces, on the walls of the entrance space and in the courtyards, on the walls of the semi open spaces, including the tandoor, different patterns and motifs in different shapes and colors made by using different techniques and materials, specifically, brown and shades, red and white soil, can be seen. Peasant women, said that the practice of ornamentation was given more importance by the villagers in the past, and that this practice has still continued to be applied on the wall surfaces.

[4] Interviewer: Kerime Çelik
[5] Interviewer: Kerime Çelik
[6] Interviewers: İbrahim Can and Cüneyd Ülvan

Figure 1. The earth based patterns around the main entrance door (Source: Cüneyd Ülvan Archive)

After the application of the soil plaster described above and the application of the sludge and paint applied after the application, the special white soil, the brown or red soil obtained from different regions, is used for the decoration and pattern applications. For the mixture prepared for the making the ornaments, firstly, in the terracotta pots, by mixing the soil and water, a homogenous mixture is obtained. During the preparation of the mixture, the white soil produces a unique fragrance that the villagers love. The prepared mixture is applied to the wall surface by different techniques and methods by the peasant women by using tools like, finger, hand, cloth, sheep wool, broom made from heath. According to the interviews carried out with the villagers, the most common techniques used are "sprinkling", "splashing" and "finger press" techniques. By using different techniques and tools, different patterns and motifs can be created on the wall surfaces. Ir Sprinkling and splashing techniques are applied by using broom made from heath, wool or cloth, and, finger pressing technique is applied mostly by immersing three fingers or hand into the mixture and pressing on the wall surface in different directions. Among the special meanings attributed to the decoration practice by peasant women, there is a common belief about the sprinkling and splashing technique. According to this belief, during the application of the sprinkling and splashing technique, young girls need to be able to apply the paint to the wall surface without spilling as a precondition for getting married and being admired. According to peasant women, the secret of this work is about the consistency and manual dexterity of the manually adjusted mixture. Because the patterns on the walls disappear in time with the effect of severe climatic conditions, peasant women renew this process once a year or twice a year, in spring and fall months providing cultural continuity of practice in tradition.

Figure 2. Different techniques used for making patterns by peasant women (Source: Cüneyd Ülvan Archive)

3. CONCLUSION

Konya's earthen building culture is so specific as the embodiments of both the activities, knowledge and know-how of local building masters on mud-brick construction techniques; and the practices of maintenance, renewal and ornamentation of traditional buildings carried out by peasant women. Investigating the intangible values of Konya's earthen building culture considering their interrelations with tangible values, the study put forward a holistic documentation approach. The building tradition of Konya is constituted by the activities of building masters and the maintenance and decoration practices of peasant women which have significance as the elements of intangible cultural heritage to be documented with the tangible values of traditional buildings. In this respect, it is very important to document and protect the building tradition with its tangible and intangible aspects, like technique, materials and tools, for the conservation of the cultural history of Konya. In this context, the preliminary documentation method put forward by this initial study need to be repeated in the other rural settlements of Konya; and the knowledge and practices within the building tradition need to be documented for future generations.

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Structural Study of Twin Yakh-chals of Sirjan in Iran

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ABSTRACT

Adobe ice-pits (Yakhchals in Persian) are one of the functional and structural buildings in urban architecture. Since wide regions of Iran have hot-arid climate, the need for cool water in the past was the main reason for creating Yakh chal in such weather conditions. The main three elements of an ice-pit are shading walls, ice reservoir and dome, which shows the genius of old Iranian architects to utilize mud, adobe, and native facilities. Considering the enormous structure of Iranian Yakh chal and the use of Adobe, as the main utilized material, in this paper we attempt to study the construction technology as well as force transfer pattern in Iranian stepped Yakh chal. Data gathering was a combination of observation and library studies and also the general method of this research is descriptive analytical. Yakh chal in most regions of Iran are single-dome, however, as the main contribuation of this paper we studied the static and structural aspects of twin Yakh chal of Sirjan with the exclusive feature of two domes, ice reservoir, and arch shaped shading wall between two domes.

Keywords: Iranian Yakh chal, Stepped dome, Strautural analysis, Twin yakh-chals of Sirjan.

1 INTRODUCTION

Climatic condition is one the main elements in traditional and native architecture. Considering the large regions with hot-arid weather in Iran, the architects have tried to benefit from natural conditions. Ice was produced in the coldest periods of winter and people would use the preserved ice during long and warm summers. It was a reason to build Yakh chal (Yakh-chals in persian) nearcities and villages [3]. Geometry of physical elements is one of the effective factors in general form of Yakh-chals specially the form of it's shading wall and dome shaped structure. Past architects have designed and constructed the elements of a building by using their experiences and skills. Nowadays, the use of Yakh-chals is completely expired but this kind of buldings and their construction process with large span will provide many suitable solutions to construct buildings with cumulative spaces. As the main questions of this research we like to answer the folowing three questions: I what are the principles of forming dome shaped structure and it's meted of construction? II.what was the solution of architects to increase the resistance of dome shaped structure and shading wall? III. How loads and forces are transferred in this structure. These questions are answered through using library documents, interview with old skillful masons of Sirjan, and performing a case study of twin Yakh chal in Sirjan.

2 LİTRATURE REVİEW

The historical background of Iranian Yakh-chals is not exactly clear before the Safavid era. Although, the word "Ice" can be seen in different texts before the Safavid era but there is nofmention about how it is produced. Some researchers have studied the historical aspect of Yakh-chals. Constructive parts of Yakh-chals generally are described in some references

[8],[6],[1],[4],[5] Yakh-chal in Persian literally means "ice-pit" that illustrates that ice is kept inside a pit[13] Yakh-chals of Iran are located in regions with hot summers and winters with at least 20 frozen days (south cities of Alborz and north of desert, north of Khorasan and south of desert). Furthermore, Yakh-chals can be found near the mountains, lut desert, and Kavir desert[13]. Some researchers have studied the structure and constructive elements of Yakhchals [8],[7],[1],[9],[3]. In these studies, Yakh-chals have been categorized according to their general form and number of components into the folowing types: Yakh-chal in the warehouse, a simple Yakh-chal, a Yakh-chal without a arch, a semi-complete Yakh-chal (without a wall of shading), a full Yakh-chal, underground Yakh-chal, and tunnel Yakh-chal. The research has been done so far the structure of the Yakh-chal has been underestimated. In this research, we are trying to explain the structure of the Yakh-chal.

3 YAKH-CHALS AND THİER COMPONENTS

The building of Yakhchals has no particular complexity. Main components are: main shading wall, secondary shading wall, provision pool, ice reservoir, entrance, and Yakhchal-guard room. These components are diffent from oneanother. In general, shading wall, provision pool, and ice reservoir are main parts of Yakhchals [2] (see Figure 1).

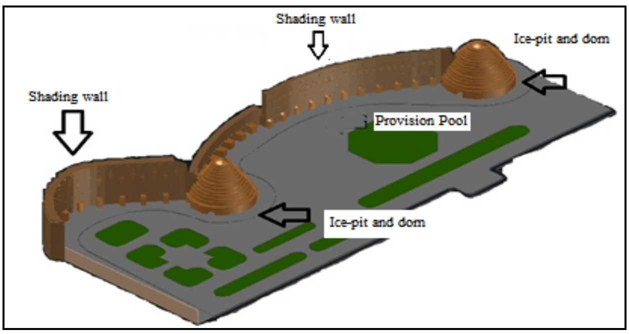


Figure 1. Main components of Twin Yak-chal of Sirjan

3.1 Shading Wall

The shading wall is a long and great wall that stretches from the east to the west. The enormous height of this wall comes up to almost 10 m. Therefore, the enormous height prevents the sun shine on the frozen water in the ponds.

3.2 Provision Pool

A rectangular shaped pit that is dug parallel to shading wall in its north part with a bit longer length. This pit was a place for ice providing during cold winter nights. There is no material used in building these pools [8]In areas like Isfahan, they made green lagoons after the end of work and warm weather. So, the product was passed straight to the consumer .This was done in twin Yakh chal of Sirjan in the same way.

3.3 Ice reservoir

Includes ice storage pit and its cover. The main pit was a place where ice was stored and grounded on a flat ground. The walls of the pit were usually lined with Sarouj, and there was a duct on the floor that ended in a deeper hole. The water from the melted ice was poured into this well and away from the main pit. The building on the main pit had a dome and tunnel formation. In most parts of Iran, Yakh chal have been dome-shaped with a cape or hinged rack [9].

4 TWİN YAKH-CHALS OF SİRJAN

Sirjan is located in the southwest of Kerman. This city was called Sirgan in Sassanian era because of its many aqueducts. The city was very rich in terms of kariz. Sirjan is located in a warm and dry climate. with minor rainfall and unthearing heat in summer. Architects used extreme cold wether as a way to preserve foods and drinks in summer. Cone-shaped building that was transported by steps to several underground floors made the conditions of today Yakh-chals.

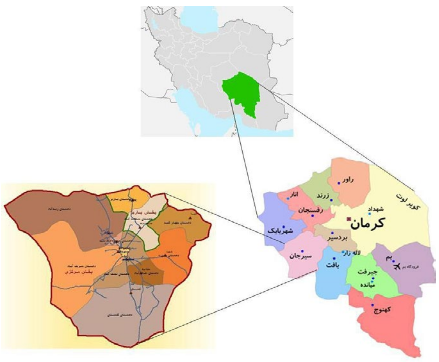


Figure 2. Location of Sirjan city
Figure 3. The position of the twin Yak-chal of Sirjan

Figure 4. Twin Yakh-chals of Sirjan (taken from the ISNA site)

5 CONSTRUCTİON TECHNOLOGY OF TWIN YAKH-CHALS

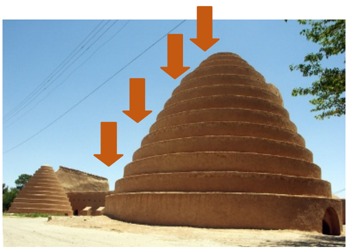
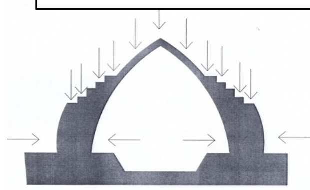
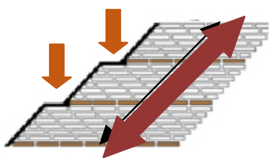
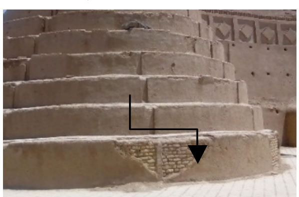
In construction Proccess, The first stage is construction of dome shaped structure as well as ice reservoir and the second one is shading wall construction.

5.1 Dome shaped structure of Sirjan Yakh-chal

Firstly, architects implemented the plan on the ground and proceeded to lay a foundation. in the next stage, they dug an ice reservoir pit with the height of one meter. Furthermore, the extracted soil from digging was utilized to construct dome shaped structure. To construct the stepped form of dome, architect would be settled on outside the dome shaped structure to make an adobe row. After one or two adobe row, next row was taken toward the inside. This was done for five to seven rows until the thickness was decreased as small as an adobe that makes a stepped look from outside veiw of dome. Numbers of steps and rows were in a reverse relationship. The ultimate thickness of the wall reached 1.5 times of adobe lenght[10]. Reasons for stepped form of dome shapedstructure are as follows: I. Cutting down on numbers of used adobes which results inlightweight construction. II.To avoid thrust that leads to a thicker base. III. Create a place outside the dome structure to facilitate the architect's work. IV. To avoid plaster from being washed off by rain. V. decreasing sun radiation.

In the case of twin Yakh chal in Sirjan both domes are designed as a stepped structures with 13 steps. The height of each step would be decreased from down to top. Table 1 illustrates the loads in the dome. The outer cover of the dome is plastered by a cobb layer to insulate Yakh-chal.

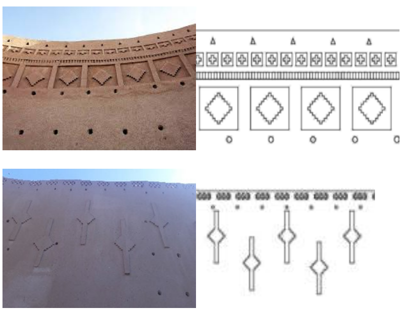
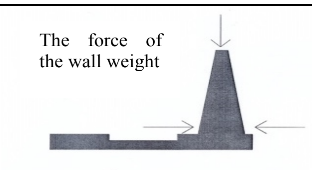
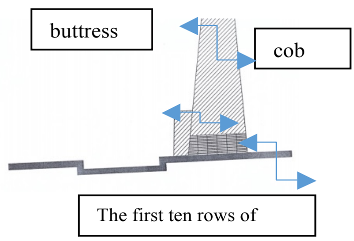
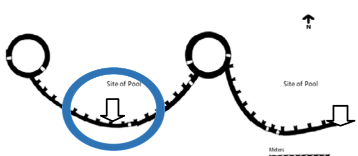
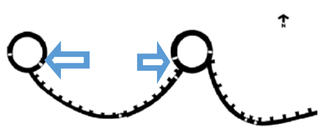
Table 1. Analysis of dome structure

Dome Image	Structural analysis	Dome profile
	Force dome weight 	Height: 11.5 m Diameter of dome No. 1: 15/5 meters Dome number 2: 14 meters Number of steps:13 Dome Type: Staircase High dorsal thickness at the bottom of the dome for preventing thrust. Stair step form due to weight loss of materials.
How to transfer forces 	Driving force at the bottom of the dome  Diameter:14m Diameter:15/5m	
	Adobe with plated lace	Materials

5.2 Shading wall of Sirjan Yakh-chal

After building the dome, they built a shading wall. The shading walls were mostly made from straw in most cities. But in some cases it was made with adobe. To create the wall, they first set the wall direction. The walls faced the cold winter winds. The width of these walls varies from 1.5 to 3 meters. The structure of these walls, like the wall of gardens, There was no foundation. And in rare cases they also have lime. After making the wall dimensions on the ground, if necessary, to create a foundation, the width of the wall, along with 0.3 meters from both sides, was depleted to a depth of 0.6 to 1.2 meters, and then filled with lime to fill it. [12] There are two shaded walls in the twin Yakh-chal. One is located in the distance between the dugnobud and the other on the eastern side of one of the domes. The position of the dome and the angle of sunshine on the form of the wall of the shading has been affected. The shading wall in the Sirjan Yakh-chal is curved and u shaped And the domes are covered. The shading walls are very long in this building And According to the old architects of the region, this building is without foundation. Therefore, in order to stabilize this wall, the wall is divided into two sections by placing the dome in the main shading wall. A dome is a suitable support for the stacking of a shading wall. The height of the shading wall in the Sirjan Yakh-chal is 11.5 meters, The thickness of the wall at the lowest part is 2.5 meters, In the middle of the wall is 1 meter and at the top it is about 0.30 meters. The thickness of the wall has a significant effect on the static structure. The construction of the wall is in the form a multi-layered conical shape. As the height is increased, the thickness of the wall decreases and decrease in materials has led to the stability of this shading wall. For a more stable wall, the buttress is used from the backside at the bottom of the wall and on the north side. buttress, in addition to the structural role, helps to reduce the temperature of the space of ice shelves. In the upper part of the shading wall, a geometric ornament has been used, which, in addition to the beauty in the wall's structure also affects the top. The method of connecting the shading wall to the dome is straight and stepped and has been used in the dome for better wall stacking. One of the reasons for using two domes, according to local architects, may be a Structural reason for the wall.see table 2

Table 2. Analysis of shading wall structure

Shading wall Image	**Structural analysis**	**Shading wall profile**
The decorations are geometrically, for the sake of beauty and styling above the wall 	 	Height: 11.5 m Thickness at the bottom: 2.5 meters Medium Thickness: 1 meter Thickness at the top: 3 meters Cone wall execution due to reduced material and wall styling 
 		**Buttress:** Height: 2 m Number: 28 Thickness: 1 meter Use a backing to prevent the wall from rolling
	 Dome as a reliance on structural wall	Connecting the Wall to the Dome: Stair and straight

5.3 Ice reservoir of Sirjan Yakh-chal

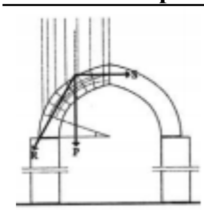
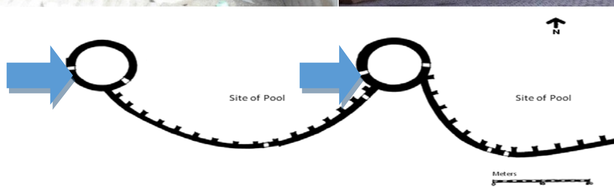
The place of ice storage is below the space of the dome. Materials used in Yakh-chal were adobe and Sarouj mortar. In the first few rows of the first reservoir rock was used with a sarooj mortar that prevents the moisture from from penetrating through the stone to the top of the dome. The soil that was removed from the pit was used to build dome adobe.

5.4 Entrance of Sirjan Yakh-chal

The entrance of ice tanks through the eastern and western parts of each dome. These entrances are available in all seasons and in the shade of the wall. There is a type of arch in this entrance Which is known as Roman arch. In fact, an arch is a curved shape for a covering whose span size is greater than its depth. Although the execution of an arch starts from the starting point on the wall or grapple, but at the end, we have a structure in which the weight of each segment or row of bricks is transferred from its highest point, that is, and this transfer of force is a force line that Creates a curved shape. The sum of the forces arrive at the starting point and then are transferred to the ground.It is a desirable force that decomposes into a horizontal or vertical component.

Inside the dome, in order to reach the icebox, stairs were constructed either directly (along the wall of the reservoir downward) or rotating (in a circular axis) to the end of the reservoir. In the twin Yakhchal, due to the large spans of the domes and the sufficient space of access stairs, they are rotated around the dome.see table 3

Table 3. Yakh-chal entrance Analysis

entrance Specifications	Force analysis
 	Yakh-chal entrances are in the shape of the arch with the Roman method   

6 CONCLUSION

This study was carried out to perform a static analysis of Yakhchal's structure as one of the great structures made of adobe in the past, and to document the benefits of the vernacular architects' solutions in the construction of these structures and use of it in today's architecture based on lasting and vernacular materials. Several factors, such as static and climatic conditions affect the form and the shape of the Yakhchal. through the structural analysis of the Yakhchal, these results have been obtained:

Because of the dome's large dimensions and for better balance and stability of it at the time of the construction, vernacular architects have made the dome's form by the help of offsetting each layer of adobe compared to the below layer and made it's stepped form. Due to the lightness of the materials at the top of the dome and the use of thicker materials in the lower parts, it Restrains the horizontal and vertical forces and causes this huge structure to be very stable even thought it is made of low strength materials. for the stability of the shading wall, the walls are usually curved and become thicker as the height increase. For more stability in the Sirjan twin Yakhchal, the dome is located between its shading wall and works as a support for the wall maintaining its

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