United Nations
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kerpic'18

Back to Earthen Architecture
Industrialized, injected, rammed, stabilized.

6th International Conference

1-2 June 2018
Gaziantep, TURKEY

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HASAN KALYONCU UNIVERSITY

PROOCEEDINGS
For the Sixth International Conference

Kerpiç'18
Back to Earthen Architecture:
Industrialized, injected, rammed, stabilized

1-2 JUNE 2018
Organized by
Hasan Kalyoncu Universty
Kerpiç Network

Proceedings for the
6. International Conference kerpic'18

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Edited by Dr. Bilge ISIK

Published by
iBoo Press, 26 Sep. 2018

3rd Floor
86-90 Paul Street
London, EC2A4NE UK
t: +44 20 3828 7097
info@iboo.com II iBoo.com

e-ISBN: 978-1-64181-232-0

Themes Of The Conference:

1. Solving the huge demand for housing with earthen architecture
2. Social, cultural, touristic reuses of earthen architectural heritage
3. Commercial development on earthen architecture
4. Changes in traditional heritage value of society
5. Advanced construction techniques with earth
6. Standards and guidelines for earthen houses
7. Advances in researches

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Dear Colleagues,

6. International Conference www.kerpic.org/2018 will take place at Hasan Kalyoncu University Gaziantep, 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.

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 6. international conference on kerpiç’18 “Back to earthen architecture: industrialized, injected, rammed, stabilized” and the workshop on production: 1-2 June 2018 Organized by Hasan Kalyoncu University - Gaziantep and Kerpic Network

The conference scope will focus on using earth for housing, “Back to earthen architecture: industrialized, injected, rammed, stabilized”, 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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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
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Seismic Assessment of the Architectural Heritage in Fatih District of Istanbul

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ABSTRACT

Istanbul, a 2500-year old city, is under the threat of a devastating earthquake. Reflecting past experience, a very high probability of occurrence has been postulated for an M7 or larger earthquake during the next quarter century. The Metropolitan Municipality of Istanbul has committed itself to an ambitious program that targets urban rehabilitation, part of which involves seismic loss mitigation. The building stock includes many irreplaceable historic buildings of different ages. The city's long history is reflected in the architectural heritage of its urban texture. While the current size and population of the conurbation have spread over a large area, the historic buildings are situated mainly in the area known as the "Historic Peninsula". Here they are confined to two administrative districts (Fatih and Eminönü) that are bound by the estuary Haliç (the Golden Horn) to the north, the Strait of Istanbul to the east, Sea of Marmara to the south, and the ancient city walls to the west. The administrative district Fatih alone boasts some 5,000 registered historic buildings under protection. This paper describes the procedure for measuring, recording and assessing the seismic vulnerability of historic masonry buildings in Fatih. A sample group, comprising 223 buildings, was surveyed as part of field and office work that lasted one and a half years. Of these, 20 buildings will be subjected to further stress analysis and detailed assessment.

Key Words: Istanbul, Fatih District, Survey, Historic Buildings, Seismic Vulnerability

1 GEOGRAPHY AND SEISMICITY

Istanbul sits astride the 30 km-long eponymous strait that connects the Black Sea with the Sea of Marmara (left frame in Figure 1). An engraving from the 16th century shows the Historic Peninsula from the east in the right frame of the same image. The walled city is separated from a smaller settlement on the north side of Haliç. A current space image is given in Figure 2.

The city was visited by well-recorded major earthquakes in the past, and experienced major destruction. The M7.4 earthquake that occurred in Kocaeli in 1999 was only 80 km from the historic city core, but several districts on vulnerable sub-grade witnessed building collapses and loss of life. There is reason to expect that the segment of the North Anatolian Fault traversing the Sea of Marmara at about 15-20 km south of the city proper may well rupture in the near future, causing damage in many buildings, modern as well as historic (Parsons, 2004; Griffiths et al., 2007). During the last 2000 years or so 55 reasonably well documented earthquakes have occurred in the Marmara Sea region. Many have been felt in the city proper and caused damage (Finkel and Ambraseys, 1997; Mazlum, 2003).

Figure 1. View of Istanbul Strait and Fatih (Circled, Left) and Historic Engraving (Right)

Figure 2. Historic Peninsula Comprising Fatih District

2 HISTORIC BUILDING STOCK CHARACTERISTICS IN FATIH

The urbanization in Fatih region goes back to the time of Constantine the Great (4th century). In the fifth century, by the construction of the Theodosian Wall, the city was enlarged in the western direction. The Theodosian Wall is a 7 km long defensive structure that suffered from several earthquakes and had to be repaired to defend the city through the Middle Ages. Along with some other parts of the historic city, it is included in the World Heritage Areas of Istanbul. Other Byzantine buildings, like the Church of Studious and Church of Monastery of Christ of Chora make up a rich legacy of religious architecture. These are monuments of high historical and artistic importance. Due to their exceptional architecture and decoration, they must be protected from further deterioration (Ahunbay, 2006).

The churches from early Christian and Medieval Period have alternating wall construction, with brick courses acting as bands uniting the wall structure. Walls were constructed of local limestone, well baked brick and good quality mortar consisting of slaked lime, crushed brick aggregate and powder and sand. Some of the walls also had timber runner beams, providing reinforcement to resist earthquakes. Yet, the fragile sections, such as the tall apse windows suffered from tremors and needed to be repaired many times. Vaults and domes also had structural failures and had to be reinforced or reconstructed.

Fatih region also hosts a large number of important Ottoman buildings dating from the second half of the fifteenth century up to the early years of the twentieth. These are monuments with different functions. Small size timber and masonry houses do not present serious problems from the point of earthquake risk, but mosques with designs incorporating major domes in their composition have been facing serious problems. Due to their long life span, monuments in Istanbul have resisted several earthquakes; those of 1509, 1766 and 1894 caused serious damages to these masonry structures. Vaults are usually made of brick, which is lighter than stone. Yet lack of tie bars or their deterioration caused failures. Arcades were also the weak parts of the mosques and religious colleges which had small sized domes in their design.

Ottoman architects were clever not to build oversized domes that would collapse during strong ground motions. The most vulnerable part of a mosque is the minaret. Their construction was reinforced by using clamps and dowels, aimed at fixing the blocks horizontally and vertically. However, the uppermost part of tall minarets usually suffered from earthquakes; the balconies and caps collapsed and had to be rebuilt.

Public baths were important in Turkish society. Many baths were built to meet the demand in the residential and commercial parts of the town. Some baths stand out with their impressive dressing halls, with domes measuring as big as those of medium sized mosques, reaching 16-18 m in diameter. Such big sized domes suffered severely from earthquakes and the baths had to be restored to continue their service. Otherwise, they were out of service and fell into neglect.

At the moment most of the historic buildings in Fatih are in poor state of preservation. The expected earthquake will affect these buildings to a greater extent if they are not retrofitted carefully. The repairs demand careful analysis of the vulnerabilities and minimum intervention to maintain the authenticity of the historic buildings.

3 REMEDIAL ACTIONS

In recognition of the impending earthquake, Istanbul Metropolitan Municipality has started an action program that has a component for seismic assessment of historic buildings in Fatih as part of a wider urban renewal undertaking. These buildings are mostly masonry; many serve devotional purposes, with ages often spanning centuries. The categories fall into mosques, theological schools, tombs, convents for religious orders, libraries, baths, fountains, churches, synagogues, cisterns, historic public kitchens, remains of fortified walls and cemetery appurtenances. The municipal administration developed an inventory with information for location, architectural features, historic or artistic significance, legal ownership status and whether repairs or modifications had been done on them. This detailed information that had been collected as a result of lengthy field work was useful in its own right, but provided little information on the vulnerability of a building. It was clear that, owing to time and resource limits, a smaller subset of the thousands of buildings could be considered for seismic assessment. We resolved to develop an additional information database with regard to the structural features of each building's load resisting system. This implied a complementary phase of field work following a generic procedure:

- Do survey drawings exist? If not, create these with total station or other scanning

technology, noting any structural defects or deviations from original state. Use 1/100 or 1/50 scale as necessary.
- Create electronic building-condition forms. Note building materials.
- Measure GPS coordinates, assess environmental conditions and site geology. Create a GIS database.
- Define seismic hazard at site.
- Create a photographic record file.

Thus, the record for each building contained all of the information required in the ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites. Additional information related to the following items is provided:

- Plan areas and total areas
- Section areas for vertical load-carrying members, and information on openings or material losses in them
- Characteristics of the structural walls and diaphragms for horizontal load resistance
- The foundation system

Fatih, shown in Figure 3, is a living city. Ancient, old and modern are intermixed, urban functions bustle. Many of the buildings are currently being actively used, or are guarded by their custodians even if they are idle. It was not easy to gain access and do lengthy measurements. Removal of material samples for testing required additional permit so it was not attempted at this stage. The program objectives did not include developing a building-specific information database for each building; such an undertaking would have been overwhelming because of the sheer number of buildings. Of the original inventory we first developed an 800-building subset, which was finally reduced to 223 entries listed in Table 1 covering a representative sampling. Even with this modest number, the Fatih Seismic Assessment Project represents a comprehensive attempt to assess the earthquake performance of the historic buildings in the historic core of Istanbul. The procedure is only a preliminary stage for ranking the buildings. Even detailed and lengthy analyses are beset by uncertainties; our objective was to create two bins, one for buildings that would likely survive and the other for those that would likely fail to achieve that objective. The dividing line can be a vague one.

The seismic assessment of selected buildings was done for an M7.2 earthquake occurring on the Marmara Sea Segment of the North Anatolian Fault closest to the city. For this purpose, a building inventory system was developed to record the structural features of the buildings.

As detailed stress analysis of each building is unfeasible, a two-tiered rapid survey procedure was developed. In the first stage, a simplified model of the building was created from laser scan measurements and wall stresses were computed for comparison with limits. The second stage comprises detailed stress analysis for a typical subset of about 20 buildings. The last stage will incorporate the rehabilitation measurements and typical strengthening details. This paper emphasizes the initial stage, and illustrates the assessment procedure through a sample.

4 ELEMENTS OF HISTORIC BUILDING EVALUATION

With the complete information set comprising structural (materials, wall thicknesses, and state of cracking as opposed to architectural or conservation-relevant) features, local geology, estimated ground motion we built simplified SDOF models for each building in the inventory in the style shown in Figure 4. Ground motion was assumed to act in one of two principal horizontal directions, and separate stress analyses were made in- and out-of-plane wall capacities. Openings in walls were taken into account in estimating their stiffness, and roofs or domes were assumed as inert masses. Site-specific response spectra adjusted for distance to fault rupture and local soil characteristics were tools for estimation of the spectral acceleration. No force reductions were allowed, so wall stresses or out-of-plane strengths were based on values from limited coupon tests or triple their code allowables. This elementary exercise yielded good vulnerability estimates. A sample sheet is shown in Figure 5.

Figure 3. A Section of Fatih Viewed from the North

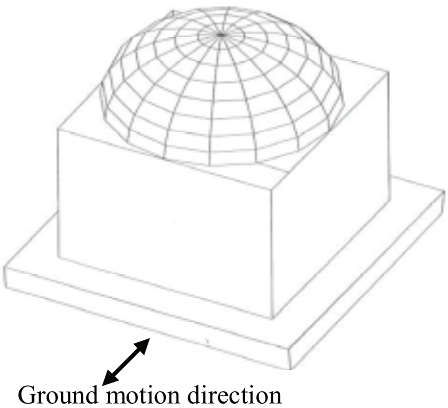

Figure 4. Simplified Model of a Historic Building

The building stock comprised disparate architectural forms and construction styles. Their variability is reflected in the numbers in Table 1.

Table 1. Breakdown of the Buildings Included in the Survey

Mosque	91	School	15	Convent	18	Church	32
Tomb	23	Seminary	14	Annexes	5	Public Bath	3
Unity Room	1	Koran School	3	Private House	8	Institutional	1
Museum	1	Hospital	2	Public Kitchen	1	Fountain	1
Library	1	Timing House	1	Oil Press	1	Cistern	1

Application of performance criteria to existing masonry buildings is not meaningful. We chose instead to estimate the shear stresses in the in-plane walls of the buildings by modeling them as simple one-degree-of-freedom systems. Openings in the walls and translations caused by rotational effects were accounted for. The strengths of out-of-plane walls were estimated by checking whether cracking was likely to occur under the postulated roof level acceleration (assumed as 2.5 times the ground acceleration) and the gravity loads. Not surprisingly, the most vulnerable parts for mosques were the minarets. The churches in the stock are mostly broad and one-story buildings without any belfries. We estimated that their resistance would be sufficient in many cases.

Spreadsheet calculations for each building were enabled by the known dimensions of the walls and their masses. While this is a gross simplification for assessment of the stresses in intricate components such as vaults and transitions from curved to straight surfaces, this was left for the next phase when sample detailed stress analyses will be run for the subset of 20 of these buildings.

5 SUMMARY

According to the recommendations, we have submitted to the Metropolitan Municipality nearly all of the buildings that are not likely to be destroyed by the postulated earthquake. This result is compatible with the knowledge that all of these buildings have experienced at least one major earthquake, the last of which was the estimated M6.8 event in 1894 (e.g., Finkel and Ambraseys, 1997), and what we have examined in this study are the buildings that have survived. The set of simplified calculations that have been made for the buildings belie the correctness of the fundamental and conservative approach that we have developed for the assessment of these more than two-hundred buildings. The procedure should be construed as a first tier method for a rapid survey of historic buildings. Its accuracy is similar to that of methods developed for buildings. In many cases, the estimates for the gross shear stresses in the walls agreed well with the average stresses in those walls derived from the next tier of analyses. The exception to this was for re-entrant corners and walls with irregular plan views. In many mosques, the minarets are likely to be destroyed.

6 ACKNOWLEDGMENTS

The work described in this paper was carried out with the support of the Metropolitan Municipality of Istanbul under the project package "Urban Renewal Planning and Preparation of Local Action Program and Initiatives in Fatih District Guiding Reconstruction, Rehabilitation and Strengthening as Part of Enhancing Earthquake Safety." The project managers for the Municipality were L. Altun and A. Gökbayrak with A. Ağırman and M. Turna in direct charge of program activities on behalf of BIMTAS, Inc..

Fatih İlçesinin Depreme Karşı Güvenli Kılınması Projesi
Anıt Eserler Yapı Stokunun İnceleme ve Değerlendirmesi

Bimtaş

TARİHİ YAPI DEĞERLENDİRME RAPORU

Anıtın Adı : **DAVUD PAŞA TÜRBESİ**				Blok Adı:
İmar	Pafta No. :	Ada No. : 1157	Parsel No. : 53	Kadastro No. : Harita No. :
Adres	Mahalle / Mevkii : Davutpaşa		Cadde / Sokak : Davutpaşa Medrese Sk.	Kapı No :
Yapım	Yapım Yılı : Vakfiye : --- Kitabe : 1485	Yaptıran : Derviş Davud Paşa		Özgün İşlev : Türbe
		Yapan / Mimarlar : ---		

F. Hasar ve Mevcut Durum Tespit Bilgileri

Tespit Edilebilen Deprem Kayıtları :	Tarihi: 1509 Bilinen Hasar :		Tarihi: 1766 Bilinen Hasar :	Tarihi: 1894 Bilinen Hasar :		Tarihi: 1999 Bilinen Hasar :	
Yapının Halihazır Durumu :	İyi Korunmuş ☐ Orta ■ Kötü Korunmuş ☐	Taşıyıcı Dış / İç Duvar :	Hasarsız ■ Az Hasarlı ☐ Çok Hasarlı ☐	Döşeme Taşıyıcı Sistemi :	Hasarsız ■ Orta ☐ Yüksek ☐	Döşeme Sehimi :	Yok ■ Orta ☐ Çok ☐
Binada Oturma :	Oturma Yok ■ Kısmen Var ☐ Çok Fazla var ☐	Oturmadan Kaynaklı Gözlenen Hasar :	Var ☐ Çok Az ☐ Yok ■	Çatıda Sistem Hasarı :	Hasarsız ■ Orta ☐ Yüksek ☐	Nemden Kaynaklı Hasar :	Yok ■ Orta ☐ Çok ☐
Malzeme Deneyleri :	Yapıldı ☐ Yapılamadı ■	Sonuçlar Özeti : Açıklama :					
Mevcut Durum İle İlgili Diğer Gözlemler :							

G. Vaziyet Planı

KAGİR YAPILARDA BASİTLEŞTİRİLMİŞ HESAP METODU İLE PERFORMANS DEĞERLENDİRMESİ			
Referans No:	FA263	Anıtın Adı:	DAVUD PAŞA TÜRBESİ

Tavan İzdüşüm Alanı(m²) =	78.62	Döşeme x_{ark}(cm)=	490.9	$G_{kaplama}$ (kN/m²) =	2
Tavan Döşeme Kalınlığı (cm) =	70	Döşeme y_{ark}(cm)=	483.1	Q_{kar} (kN/m²) =	1.5
w_{kubbe} / h_{kubbe} (m) =	7.43/4.27	Kubbe x_{ark}(cm)=	490.9	Varsa İlave Yük +(G+n*Q) (kN) =	
Döşeme Özgül Ağırlığı (kN/m³) =	20	Kubbe y_{ark}(cm)=	485.0	Hareketli Yük Katılım Katsayısı=	0.6
TOPLAM BİNA AĞIRLIĞI ΣW(kN)=			7673.35		

DEPREM HESABI PARAMETRELERİ			
$M_{kütle}$ (ton) =	388.72	a_g (m/s²) =	1.339
Sax (m/s²) =	2.32	Tx (sn) =	0.7145
Say (m/s²) =	2.37	Ty (sn) =	0.7016
Deprem Yükü Fx (kN)=	903.3	Deprem Yükü Fy (kN)=	919.9

Duvar Malzemesi ve Emniyet Gerilmeleri	
Taş duvar	
σ_{em} (MPa) =	0.9
τ_{em} (MPa) =	0.18

TAŞIYICI DUVAR HESAPLARI

Duvar No	Malzeme Özellikleri		Yükseklik	Duvar Plan Yerleşim Bilgileri					Düşey Yük Hesabı			Rijitlik Hesabı		Kritik Duvar Parçası Özellikleri		Düzlem İçi Etkiler		Düzlem Dışı Etki ve Dayanım		Eleman Kontrol
	E_{duvar} MPa	γ_{duvar} kN/m3	h cm	X col-alt cm	Y col-alt cm	Lx/Ly cm	Lnet cm	Açı derece	A_{etkin}	Ek Yük (kN)	ΣP	kx kN/m	ky kN/m	k kritik / k kesit	A kritik cm2	τ MPa	σo MPa	Md kN-m	Mr kN-m	
1	450	20	876	290	0	405/97	310	0	97839		547.5	8118	0	0.53	14259	0.09	0.20	-	-	Yeterli
2	450	20	876	695	0	404/105	300	44	96544		569.0	3573	3235	0.54	15750	0.05	0.19	-	-	Yeterli
3	450	20	876	874.4	279.5	105/412	310	0	97404		577.8	0	9361	0.54	15750	0.09	0.19	-	-	Yeterli
4	450	20	876	619.4	902.4	402/100	296	-45	97211		553.2	3203	3203	0.54	15000	0.05	0.19	-	-	Yeterli
5	450	20	876	280	867.7	406/101	311	0	97953		561.3	8716	0	0.54	15150	0.09	0.19	-	-	Yeterli
6	450	20	876	0	679.3	104/402	297	-45	95668		562.1	3331	3331	0.54	15600	0.05	0.19	-	-	Yeterli
7	450	20	876	2.3	280	103/400	313	0	96254		558.7	0	8598	0.54	15450	0.09	0.19	-	-	Yeterli
8	450	20	876	289.6	0.9	103/401	302	44	96158		559.3	3117	3444	0.54	15450	0.05	0.19	-	-	Yeterli

Figure 5. Selected Sheets for Assessment of a Tomb

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Preserving the Earthen Architecture, Building the New with Earth: Challenges and Hopes


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ABSTRACT

City of Yazd, with a history of many thousand of years, has hosted the history of the people of Iran living in the desert climate and fairly pure cultural development through the ages. The historical city has been well kept and the social life is active. About a year ago, the historical city of Yazd was registered in the UNESCO world heritage list, which is one of the most prideful events for Yazd and Iran.

This paper is about the value change of the people toward the earthen architecture and the challenges resulting from the failure to accept the new earthen architecture as a new form of construction from the society value systems.

Many planning and practical activities were carried out by the authorities, university academics, professionals and students to provide the documents and conditions for the UNESCO registration, but the main objective is to follow all the rules and the requirements set by the world authorities. Building new earthen architecture is the most important challenge for Yazd to prove that this material is still the way of sustainable construction.

Yazd University, School of Art and Architecture cooperated with Yazd Cultural Heritage Organization in many ways to preserve the historical city and educate the people to understand the values of the earthen architecture. The paper will explain some of the restoration and preservation activities. It will also explain the results of the new research- design and construction of a "Green Guest Suite" Being built with earthen material in Yazd University main campus.

Keywords: Earthen architecture, Historical city, Value system, Society

1 INTRODUCTION

As an original Iranian city at the heart of the Iranian plateau, Yazd has 700 Hectare old texture built in thousands years by certified masons. Historical texture of Yazd has been preserved for years. In 2017, Yazd old city was registered in the UNESCO world heritage list of the historical cities. After Yazd old city was registered in UNESCO, many earthen houses were restored and adopted for different uses such as hotels, hotel- restaurants, restaurants, cafes, galleries, shops and etc.. So, the property value of the buildings increased and people became more interested in keeping their property or returning to live there.

Unfortunately, after modern architecture was achieved in Iran, certified masons were rejected, and they started to operate under the supervision of the assigned architecture with an academical background. Thus, Iranian old architect was negatively affected. After this time some, architecture schools such as Tehran University architecture school, Meli University architecture school, etc were established to raise young modern architects. From this time until certified masons were no longer licensed, new buildings were built with modernism aspect and one 'Green Small Suit' was built in Yazd university main campus by the author and his students under the supervision one of the best master masons Memar Kamali Ardakani.

This paper aims to reveal the challenges and hopes of the new construction with earthen material in Yazd contemporary developed areas like Safayieh. The process started when Yazd University and Yazd electrical company decided to have a joint research project to build a "Green small suite" in Yazd University main campus.

The present author, as the manager of this research project, proposed to study, design and build this 45 square meters green suite as a research project. This paper will explain the design process, difficulty of finding the masons and the master masons, the construction challenges and the education opportunities provided for the students and other professionals involved in the construction.

Following the Green LEED criteria was another main aspect of the research from the site selection, material and technological alternatives, environmental issues and using the resources, especially water, during the construction and occupancy.

Emphasizing on the role of Yazd University School of Art and Architecture as a pro- environment institution, pro-vernacular and earthen architecture education and research, is also an important issue that will be explained below related to the objective of this research proposal.

At the first, I will describe Yazd Art and Architecture School and its vision about Preserving, Society and earthen architecture and some project that has been done and then describe "Green Guest Suite" and its design.

2 YAZD UNIVERSITY, SCHOOL OF ART AND ARCHITECTURE

Yazd University is located in Yazd since 1989 at Safaie district over 300 hectare area, and from the beginning, the school of Art and Architecture was decided to be located in historical fabric of Yazd. The location of the Yazd University School of Art and Architecture is outside of the walled city (Historical city) called Godale Mosalla and very near to Amirghaghmaq Square, located in the old city. Yazd architecture school consists of 12 old houses, which were renovated. These houses are over 150 years old and a majority of them were allocated to university.

Being an architecture school in old area has some advantages for students, schools and the neighbourhood. One of these advantages are the importance of teaching, research and training of the students of the art and architecture school and the capability of the historical fabric of Yazd as the context for the program and the foundation of the school as the forth school of architecture in Iran and the first school outside Tehran. The school of art and architecture was founded in the old city in 1990 with donations from Rasoulian House, and after that school has been developed by allocations and buying traditional houses.

Since its establishment, Yazd architecture school has played an active role about preservation of old city of Yazd and students of this school have been taught about preservation and trend of contact with old building. Some graduated students of Yazd architecture school have tried to preserve ancient monuments in Yazd province and Iran. Some of these preservation and restoration projects are described in the next paragraph.

(1)rasoulian 1989
(2)Taraghi 1990
(3)Mirza taghi rasolian 1992
(4)Kasmayian 1994
(5)torkzade 1995
(6)Mortaz 1996
(7)Kermani 2002
(8) Pirnia 2002
(9) Lariha 2002
(10) Nikbin 2002
(11)Sima Rasoulian 2007
(12)Shafipour 2010

3 REUSE OF RASUOLIAN WIND CATCHERS

One main vision of Yazd Art and Architecture School has been preserving the old city of Yazd and rehabilitation of this site, which is also one of the biggest ambitions for its school. Therefore, these goals were tried to be reached.

One of the biggest goals is using all wind catchers in Yazd historical city that were abolished although Yazd city is well-known as a wind catcher city. But one wind catcher located in Rasoulian House was rehabilitated in 2005 by the author. In 2005, the author described the reuse of Rasoulian wind catcher research project to Yazd International Center for Living with Desert (YICLD). Rasoulian House Wind Catcher is connected to Kolah Farhngi room with its office of Yazd Art and Architecture School's Dean. This project reached its goal by creating one hole to connect Kolah Farhangi room to cellar and use humidity and low temperature of cellar air. When wind catcher starts to draw air out of Kolah Farhangi room, it suppressed the air from the Cellar to Kolah Farhangi room. This reuse eliminates mechanical equipment for cooling and uses natural ventilation.

This project enables a new vision on rehabilitation in the Yazd society and it is continued by students with dissertations on adaptive reuse.

4 DEVELOPMENT OF SIMA RASOULIAN

Roya Rahimi was one of the master students whose master degree's thesis is about development of Sima Rasoulian under the supervision of the author. She focused on Social and Economic aspects for her thesis. This thesis is one of the theses in Yazd School of Architecture focusing on the development of School of Architecture and its Neighborhood. The development process is based on the true needs of the target population, reviewing the academic institution. Intention of this project is to connect students with neighborhood and society as well as tourists. Thus, she chose some space for this idea. At this time, Sahne Rasoulian was constructed four month ago.

For the next part, I will describe the "Green Guest Suit".

Design Intent and Criteria
Design intent of this project is to have a 45 square meter green suite with a focus on low cost and underground. One of the objectives of the Yazd electrical company, as a partner client, was to utilize the advantages of building underground and follow the passive solar cooling and heating strategies.

Design criteria are necessary to have benchmarks to measure the success or failure in meeting the design intent. Design criteria for this project were set to achieve a LEED Silver certification. LEED certification does not have an office in Iran at the present and by following the credits given to different items, the silver grade will be calculated for obtaining the actual certificate for the project. The project will have been completed by August 2018, and then occupancy will start for measuring data about thermal comfort.

Design Process
Design process will be explained from all the pre-design activities (programming), to conceptual sketch, conceptual design, schematic design and design development. Coordinating efforts to bring together the two different organizations with different expectations to agree on the design intent were one of the most important aspects of the pre-design activities especially when their first joint research failed and Yazd electric company chose to agree on the similar research proposal with Tarbiat Modares University.

Research-design and construction contract with the present author was singed on July 2016, but the project started about the end of the year. The clients agreed for the construction site to be at the Yazd University main campus, so the students from all different majors, the academic members and the ordinary people have the opportunity to visit an example of a Green suite. In the design process, team decided to use earthen architecture for project, and then another intention was added by the team. This intention was to preserve the ancient architecture by building with earthen materials.

4.1. Site Selection

Yazd University main campus with an area of more than 300 hectares of land has many hectares of undeveloped land and is reserved for future development. Five potential locations were selected and according to LEED accreditation criteria (figure 1), location number 2 (Figure 1) was selected. Close distance to the main ring road of the campus and the use of university and public transportation, suitable microclimate, good outside and inside condition, close distance to solar panels, site potential to become a part of Echo park, site potential for the construction of more prototype samples of green buildings, possibility of east west orientation instead of south east- north west orientation, good location for bicycle parking and many other advantages in comparing to other locations were the reasons for the site selection.

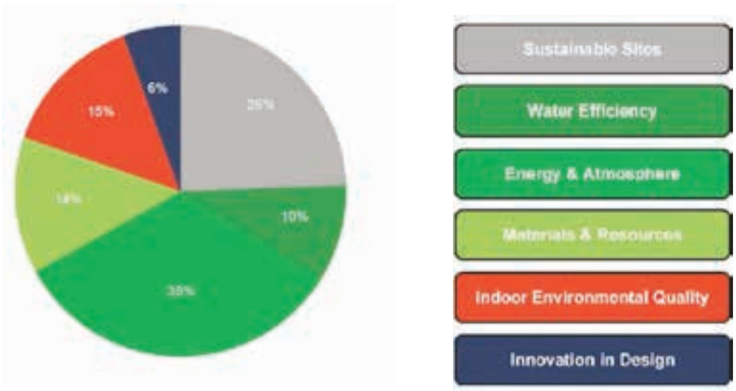
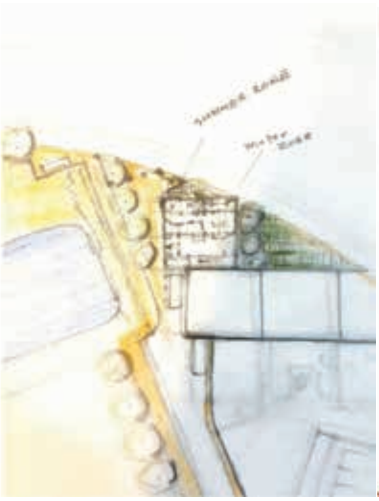


Figure 1. Selected site in Yazd University main campus

4.2. Conceptual sketch and schematic design

Site analysis to understand all the forces of the site at micro and macro level is the first step toward conceptual sketch. Being able to repeat the project with different strategies and materials was one of the goals of the research. Designing an Echo park has also been discussed with the university officials. Design by the present author or another research team became another factor to be considered during the design process. The humidity of the trees and the reservoir pool were important factors to be used and developed for passive cooling. All the process of the conceptual sketch, considering the orientation and other alternatives, was tested by simulation tools.



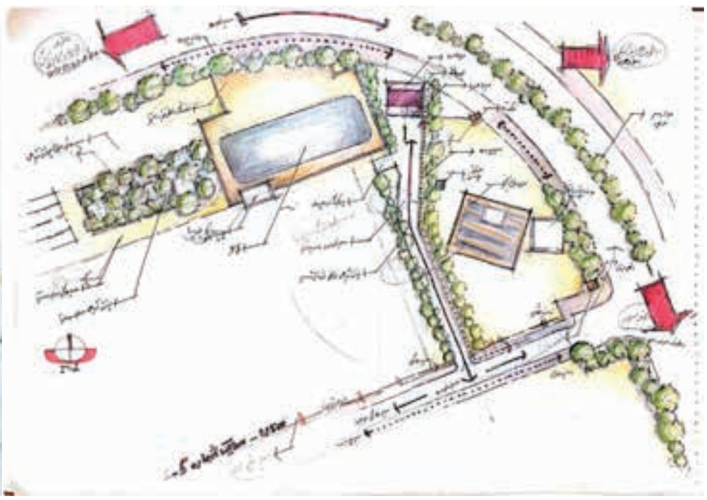


Figure 2. Conceptual design
Figure 3. Conceptual design of the site

Designing the green suite in a 10 by 10 meters lot required enough land for hot court yard and cold court yard. The concept of cold-hot yard was first proposed by the present author during the design of his passive solar house about 17 years ago, which was chosen and elaborated from the traditional houses of Yazd historical city. Cold yard in the solar house is about 30 square meters and has a sunken small yard and a small pool of water, which is the optimum means for cool air inlet to the house by the use of solar chimney to produce negative pressure.

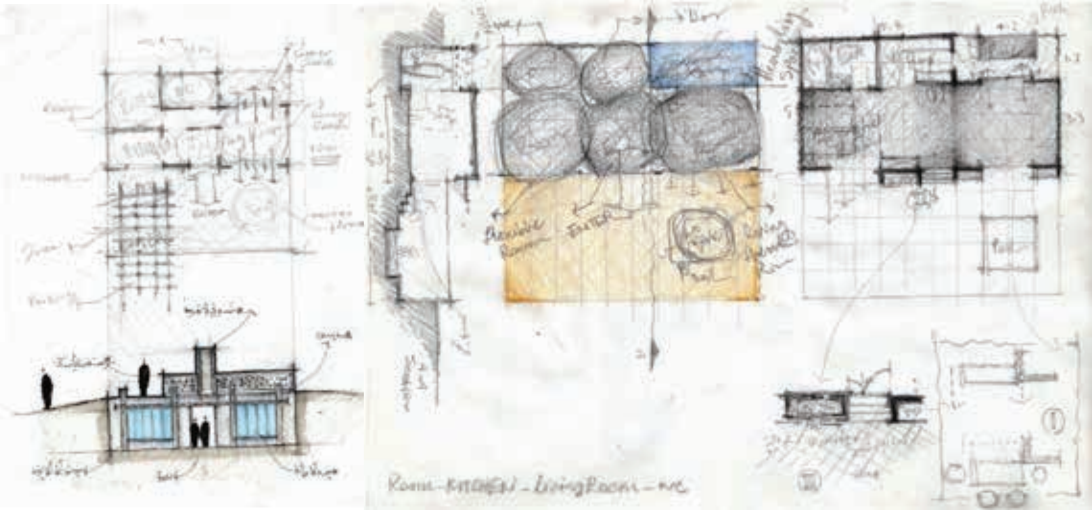


Figure 4. Schematic design. Plan and section

During all the design process, many students were active and the present author tried to provide them the opportunity to present their ideas and the team experience of brain storming and, especially follow the "Value based programming" introduced by Robert Hershberger in his excellent book "Architectural Programming and Design Manager" (R.Hershberger-1999). The main decision of project was checked out by Memar Kamali (master mason). Almost all of the Memar Kamali ideas about structure and detailing were employed.

Most of the programming and design process occurred at the school of art and architecture and a private office near the student's dormitories and the present author's house. About half of the students that were part of the design team were actually working on their master program under the supervision of the present author.

As the schematic design process developed, many decisions were made and many alternatives were presented and consulted with the structural team and mechanic professors.
What kind of structure and materials were to be selected was the most challenging decision. Even the use of "Straw Bale Construction" was one of the alternatives. It was the best opportunity to build with "Earthen Material", especially in the university campus. So, Yazd University became the pioneer to reintroduce the earthen material to construction techniques for new buildings.

By going semi under ground, using the adobe bricks (Khesht) with more compressive strength, implementing vertical posts and some kind of mesh to make the construction more resistant to different forces and searching for very professional workmanship by master masons, the team and the clients gained enough confidence to use the earthen material similar to the traditional ways of construction. Therefore, the design alternatives focused gradually on the earthen material and structure with thick walls and traditional vaults. Study models were made and different roof structures with different plans were suggested to gain more free space as much as possible.

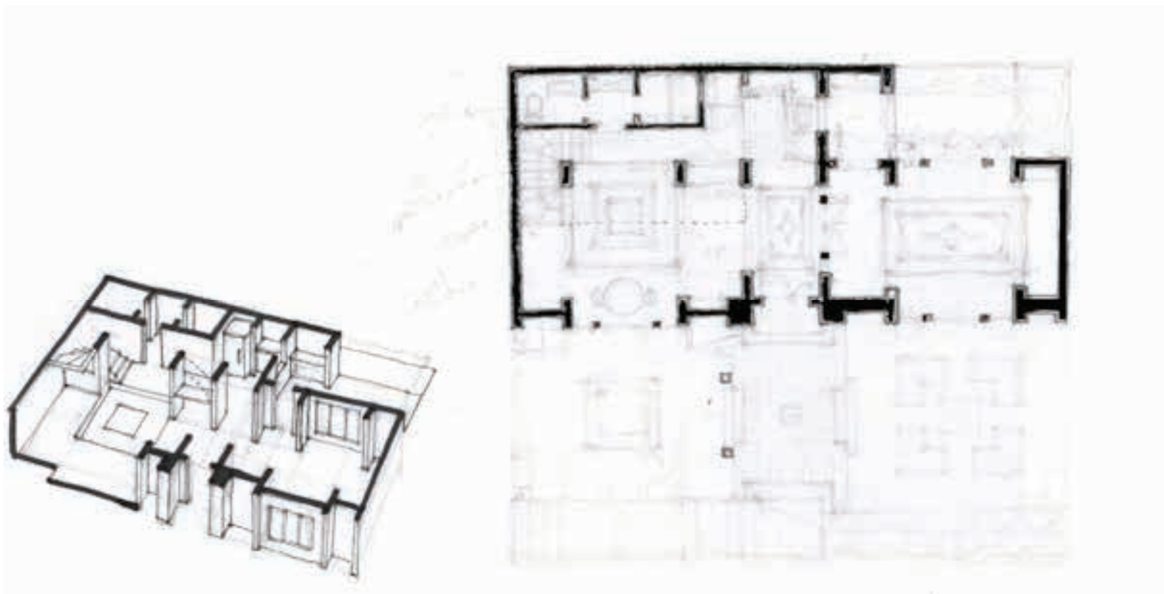


Figure 5. Design alternative with masonry walls

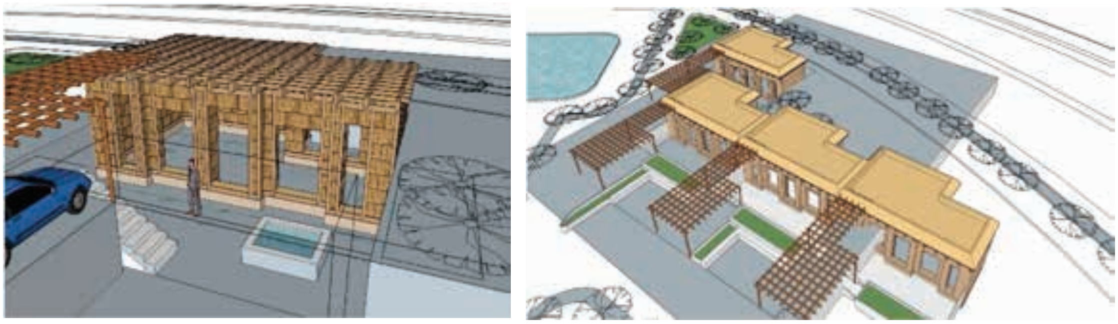


Figure 6-7. Design alternative with straw bale walls

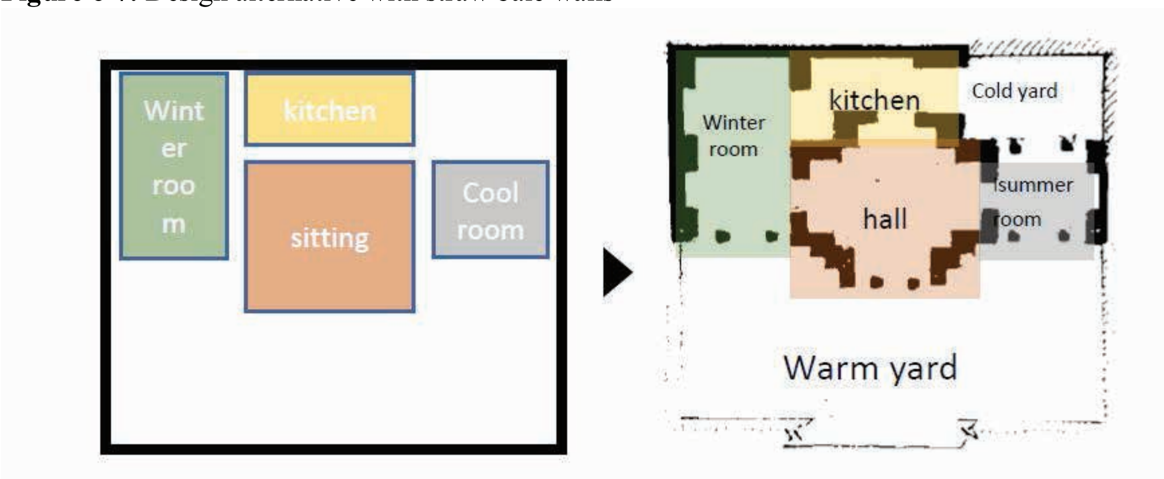
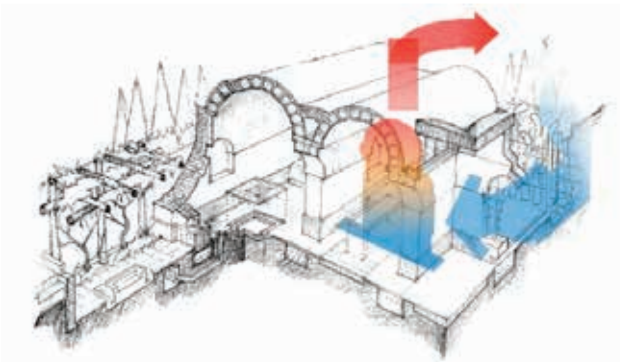


Figure 8-9. Earthen material and structure alternative

Figure 10. Exterior view of the earthen alternative



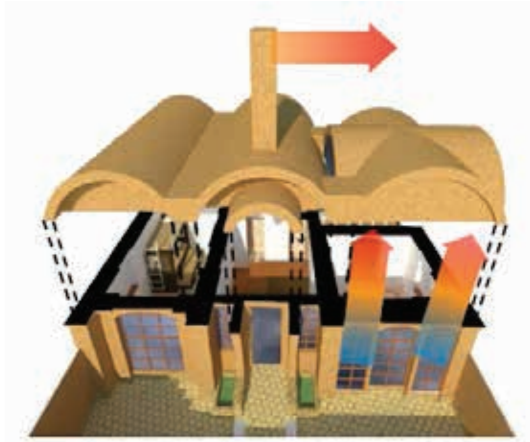


Figure 11-12. Section perspectives to show the ventilation

4.3. Design Development Phase

During the design development, the plans and other drawings were finalized and the construction phase was started. Most of the drawing details were for passive strategies and structural additions. To be able to obtain silver LEED certificate, 35 percent of the points are for energy and atmosphere and passive heating and cooling strategies were designed for this project. Direct gain and indirect gain are both used to collect, store and distribute solar energy during the cold season. The most challenging design details are for controllers such as window shades, operable windows, operable shutters, operable interior curtains, exterior operable night insulation curtains and etc. needed to operate manually and easily during the day or night.

Wind catchers have been the best means for natural cooling during the hot dry summers in the desert regions. It was a very good opportunity for the present author as the head of the Wind- Catcher International Research Center to search for new and innovative solutions to design a double act of wind- catching and wind suctioning. This portion of the design is still in progress, but the location of it is ready to be installed.

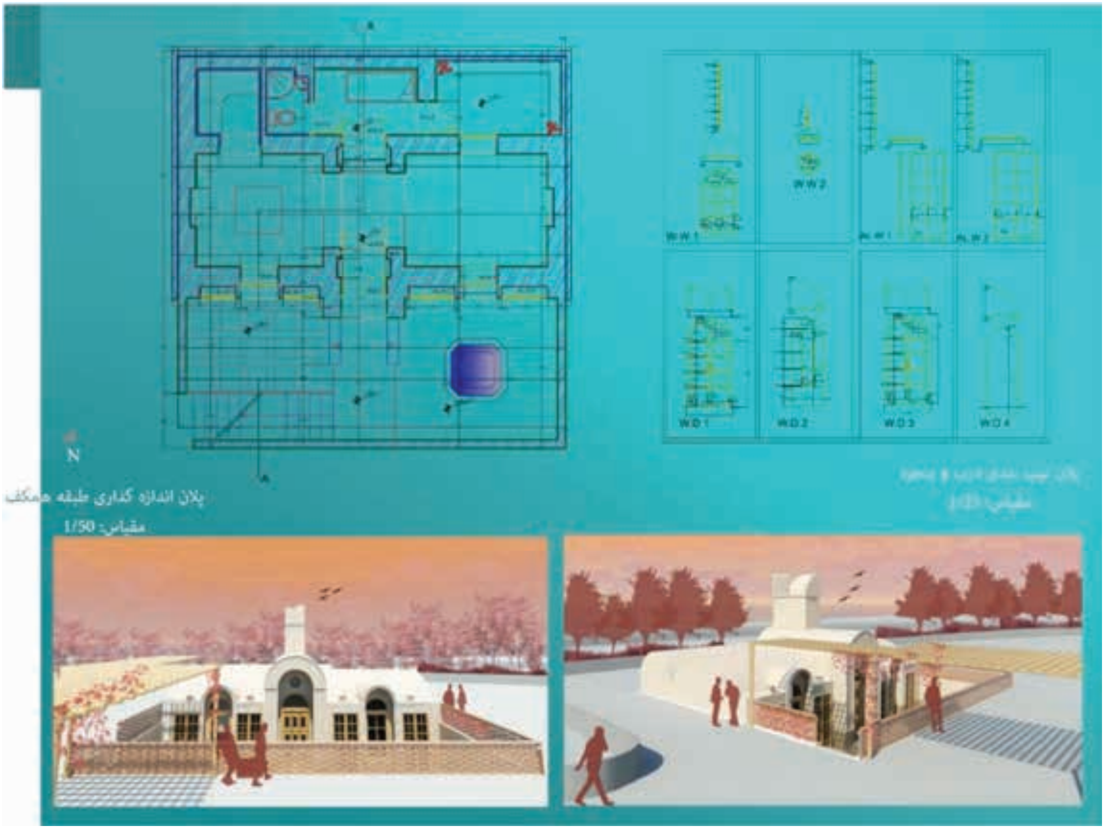


Figure 13. Plan, Perspectives and windows details

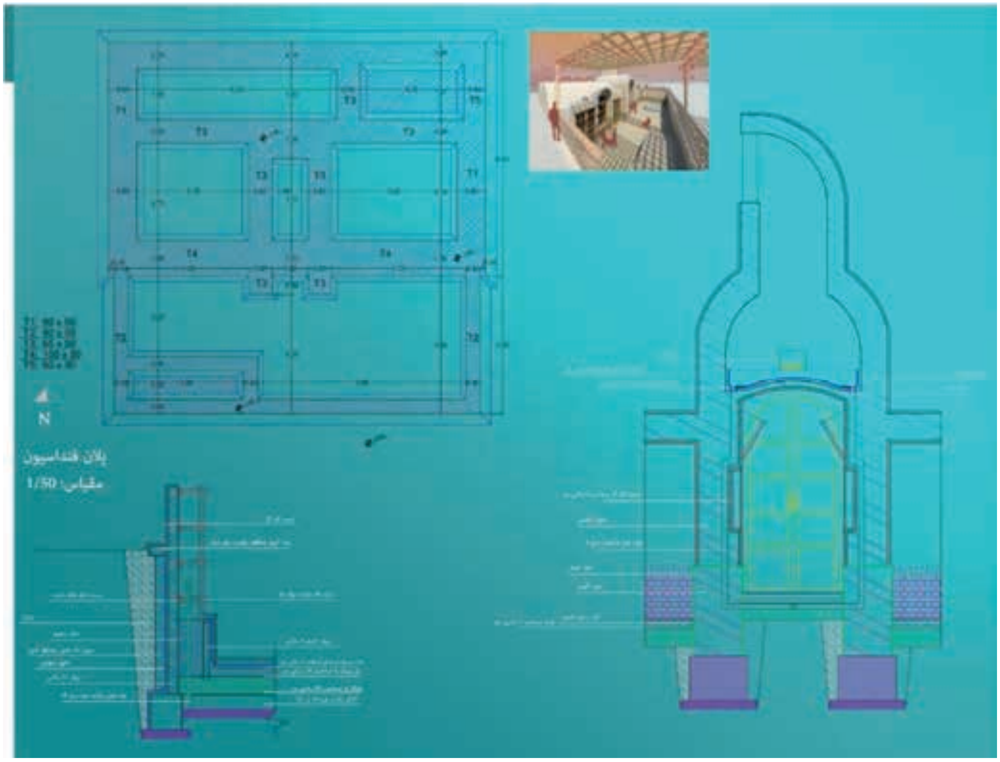


Figure 14. Foundation plan, wall section and wind catcher section

5 CONSTRUCTION AND SUPERVISION

During the entire construction process, there were two structural engineers and one master student of architecture named "Arman Sedighian", who all were supervising the project. Arman's input was great and very constructive. He almost supervised the project every day from the design process until the present time. He took care of selecting local materials from the nearest shops to gain the green LEED points for "using the local materials and energy for transportation- 2 points".
One of the best ideas was to use abolished material of Yazd University in Green Guest suit. For example, we used one abolished bus to function as the main office of workshop.

He also made some innovative on site design decisions details that gave a good touch of taste to the project and gave him more joy and motivation for his supervision. He became part of the project that could transfer all the site information to Memar Kamali and the design team.

It became a great opportunity for Arman to learn and give input during all the process so far. It is possible for him to handle a similar project with greater confidence and he gained so much motivation to start a new project.

Three different masons were selected during the project with a different range of skills for traditional earthen architecture as recommended by Memar Kamali. The last person, who proved to be a great chance for us, was the master mason "Ostad Mashallah".

Figure 15-16-17. Innovative on site details by Arman

6 RESULTS AND DISCUSSION

Building an earthen building in continuation of the traditional architecture by two governmental organizations was the best and most important result of this project. More than 30 professionals and academic members and students were actively involved during the design and construction phases of the project. Some of the results of this research- design and construction project are as follows:

- Bringing together Yazd University and Yazd Electrical Company was a challenging and important task that was mainly accomplished by the cooperation of mechanic, electric and architecture departments headed by the Yazd University Vice Dean of research and the passive research center of Yazd Electrical Company.
- The construction of an earthen green small suite and semi underground is a very promising outcome after Yazd historical city, which was registered in the UNESCO list of historical

cities, since building a new structure with earth was one of the subject of interest of UNESCO officials during their supervisions.

- Trying to build a real green building with a clear intention and criteria rather than imitating the face of this valuable concept. Earthen material that is returned to nature easily and without any threat, using waste materials such as reed for reinforcement, wood, wrecked bus for site meeting place and tools storage, using the least amount of water and energy during construction, using local materials with the least amount of embodied energy, practical sustainability education for the student and ordinary people, training the traditional techniques of earthen construction, using new technology and knowledge for evaluation and many other efforts are the advantages and results of this research and building project.
- Close cooperation among different disciplines to think and work together to solve the problems of the community as a whole and practice team work.
- Author decided to hold a meeting with Yazd Province politicians to present Green Guest suit to them..
- Using abolished materials of Yazd University: such as bus, Ney, etc.

Since the project is not completed and some details such as mechanical and electrical, water saving arrangements, passive cooling controlling devices and etc. are still under construction, firm evaluation can not be reported. Post occupancy evaluation is part of the design team objective to follow the results and compare the expected outcome with the actual outcome.

Figure 18-19-20. The wrecked university bus as a meeting, storage place and main office of workshop

7 CONCLUSION

Traditional earthen architecture of Yazd historical city has been preserved and restored since the Pahlavi period, but the people have not shown any interest in building new earthen buildings because of the cultural value change and the influence of modernity coming from the western countries. The necessity to build new earthen architecture became much more apparent when Yazd historical city was registered in UNESCO heritage list of historical cities and Yazd University School of Art and Architecture was chosen to be located in the central fabric of the historical city, which is the best government institution to serve to the purposes of this idea.

As discussed above, the green suit research- design and build project served many purposes such as showing and proving that earthen material is the most sustainable material that is rooted in the life of the Iranian culture and civilization and with research and application of the new technology can become a major material for low cost and sustainable eco-friendly buildings, following the LEED criteria based on simulation software tools and methodology and also showing that building with earthen material with passive solar heating and cooling techniques, it is possible to reach silver LEED green criteria and use under 50 kwh of energy per square meters; providing the opportunity of teamwork with different disciplines; providing an opportunity for the students to learn, train and practice with earthen material and also allowing a master of architecture, who have been a part of the design team, to supervise the construction process from the start.

The present author hopes that similar projects are implemented to continue the traditional earthen architecture of Yazd. Another hope is to obtain positive results from the post occupancy evaluation to be certain about all the predictions and actual use of energy, water and resources and this project becomes a starting point to design and build many more earthen buildings, using the traditional and modern technology.

8 ACKNOWLEDGMENT

The authors of this paper would like to express their deepest thanks to Yazd University and Yazd Electrical Company's officials, all the academic member colleagues, all the students and all the workers, all the masons and the master masons, that allowed this project to be built. Our especial thanks to Dr. Lotfi and Dr. Tavanayie from Yazd University, Mr. Engineer Sharif yazdi and javedani from Yazd Electrical Company, Mr. Engineer Tabatabayie and Dadvar, Ostad Memar Kamali and Master Mason Ostad Mashallah and finally Arman Sedighian for their support and help during the project.

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Kerpic'18 — Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized 6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Göbeklitepe Visitor Center


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ABSTRACT

Göbeklitepe archaeological site is located 15 km away from Şanlıurfa city center. It is understood that the history of Göbeklitepe dates back over 12.000 years. A group of 20 buildings in circular form, formed by arranging stone columns side by side in "T" form, were discovered. It was fathomed that the building groups were built for worshipping. So, earning the title of being the first known temple of the world is not surprising. Today six of these temples have come to light and can be easily visited.

In this paper, we will try to outline the design story of the Göbeklitepe Visitor and Exhibition Center, for which we became entitled to work as architects after winning the architectural design competition. You will be witnessing how the figurative design story was constructed and how the adobe (earthen wall or rammed earth) construction system was incorporated into this fiction.

Key Words: Göbeklitepe, visitor center, earthen wall, rammed earth, adobe

1 INTRODUCTION

Architecture is a discipline which allows incorporating a new dynamic into an existing system. That is to say, what architects create affects the location. Considering the existing design environment, it is essential that the building is a part of the strong historical area. The strong existence of the Göbeklitepe archaeological site is an important phenomenon and thus, even little touches on the site has enormous effects for humanity and archaeological identity of environment. Therefore, with careful consideration of the archaeological characteristics of Göbeklitepe ruins, the needs of Göbeklitepe Visitor Center must be met as a responsibility for the future.

2 LOCATION

Göbeklitepe is about twenty (20) km away from the city center, located on the north-east of Şanlıurfa. It takes about fifteen (15) minutes to drive from the city (figure 1).

The excavation area, the archaeological site and the visitor center (point) are shown in Figure 2. After you reach this point, you can buy tickets from the visitor center and get on the ring shuttles to visit the excavation area.

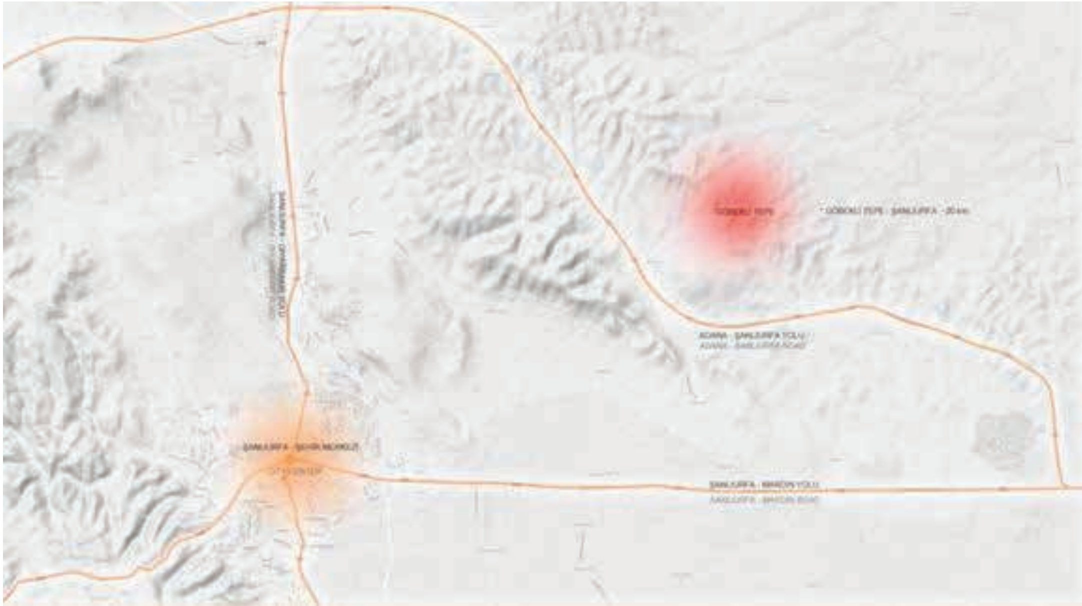

Figure 1. Location

Figure 2. The excavation area

3 HISTORY OF GÖBEKLİTEPE

The first archaeological excavation started in 1995 with the cooperation of German Archaeology Institute and Şanlıurfa Museum. Prof. Dr. Klaus Schmidt manages the excavations. After the first excavations, it is understood that Göbeklitepe is a series of circular and oval shaped structures situated at the top of a hill. Archaeological researches prove that these installations were not used for domestic purposes. They were discovered to be twelve thousand (12.000) years old temples.

This makes Göbeklitepe the oldest temple in the history. In other words, it is the zero point in time.

4 PARTICIPATION IN THE GÖBEKLİTEPE VISITOR CENTER PROJECT

Ancient archaeological elements constitute an important heritage for humanity. In order to exhibit those historical ruins to the public, Doğus Holding sponsored for the Göbeklitepe Visitor Center Project and a competition was held where creative architects were invited. This valuable project needed to be handled carefully. Given the internal and external factors, conceptual design was developed step by step. Doğuş Holding announced the winner and thus, Kreatif Architects was chosen to use their creative skills for the Göbeklitepe Visitor Center Project.

5 ACCESSIBILITY AND LEGISLATION OF GÖBEKLİTEPE

Figure 3. Google Earth view of the site

The main access to Gobeklitepe from Urfa is shown below (figure 3). How visitors could reach to the site was planned according to the existing transportation system. On the site, primarily one circular block was designed as a visitor center on the main road from Urfa. Both individual and public transportation systems were considered to allow the visitor to access to the main archaeological site. Therefore, parking lot and bus stops were planned near the visitor center building. Shuttles to the archaeological site and shaded pedestrian path were also planned. Finally, the existing visitor block had to be protected and at least the permit to change the facade of the building was granted.

6 CONCEPTUAL PROCESS OF THE PROJECT

Göbeklitepe served as a temple in ancient times. The floor plan of temple is in circular shape (figure 4) which is the main characteristic of Göbeklitepe urban pattern. Kreatif architects utilized those existing circular shapes for the design in order to create a relation and harmony between the site and the visitor center. Visitor center is not only a building, but also offers some outside space which reflects the relation between indoor and outdoor, old and new, building and surrounding. It has a transparency between the site and new facilities planned for the location. Therefore, when visitors come to visit it, they feel a unified system between the archaeological zone and the visitor center.

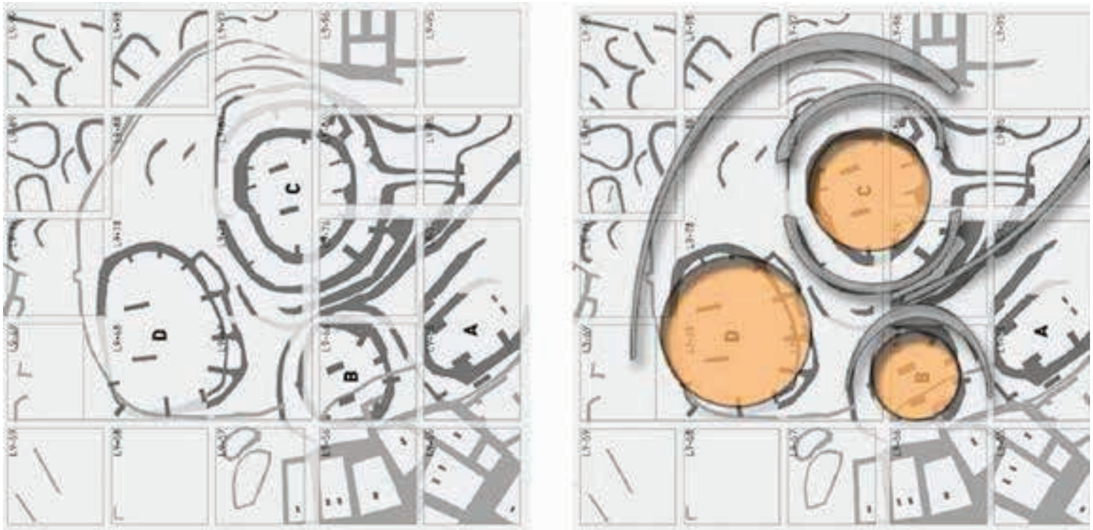

Figure 4. Conceptual Diagrams

For visitor center complex, three circular shapes were defined, i.e. main visitor area, exhibition hall and multimedia and amphitheater. Between these functional points, according to surrounding landscape, these functions were connected to the earth, which determines the circulation between them.

Another design step was to prepare a physical 3D model (figure 5) to experience the relation between mass and void and between built and un-built. Next to the archaeological site, the legibility of main identity of landscape was a key to respect the existing environment in order to design a successful architectural building. Based on the landscape, organic lines flow between buildings, and the building should give the feeling that it is a part of the earth. Both the building form and materials used are important for architectural elements and landscape design.

Figure 5. Conceptual

7 ARCHITECTURAL DETAILS OF THE PROJECT COMPLEX

On the master plan (Figure 6), the functional distribution, including exhibition center (also referred to as multimedia hall), visitor center and amphitheater, is shown as supported by parking lot and bus parking area for easy access by visitors. Circulation paths and stops of shuttle that transports visitors to the archaeological ruins are also shown. This complex is in service and landscape elements are highlighted.

Figure 6. The site plan of project

According to the floor plan, circulation outside was reflected into the interior circulation. Materials used on façade were also used for interiors. In other words, the project complex is a full complex with its interior and exterior elements. Upon entry, tourists and visitors are directed to the visitor center blocks. Based on its floor plan (Figure 7), interrelated functions such as entrance hall, offices, restaurant, ticket desks, shop and technical, prayer room and WC are available.

The architectural plan of the exhibition center (Figure 8) was planned based on the same principle. Multimedia exhibition is located at the center of building, which has less light than the outside. The outside of the building has natural light, which creates a favorable condition for the exhibition hall, including administrative area and circulation. Lounge and kitchen are also embedded to enhance the quality of venue, considering the lack of social areas surrounding Göbeklitepe archaeological zone.

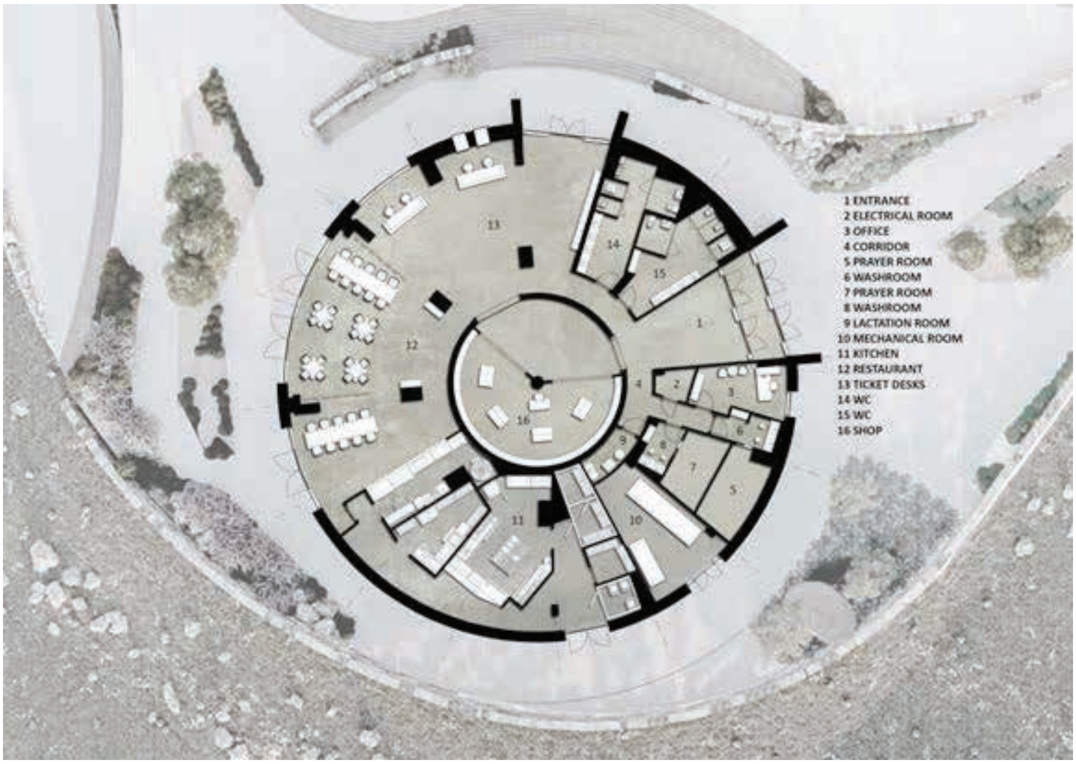

Figure 7. Visitor center architectural flor plan

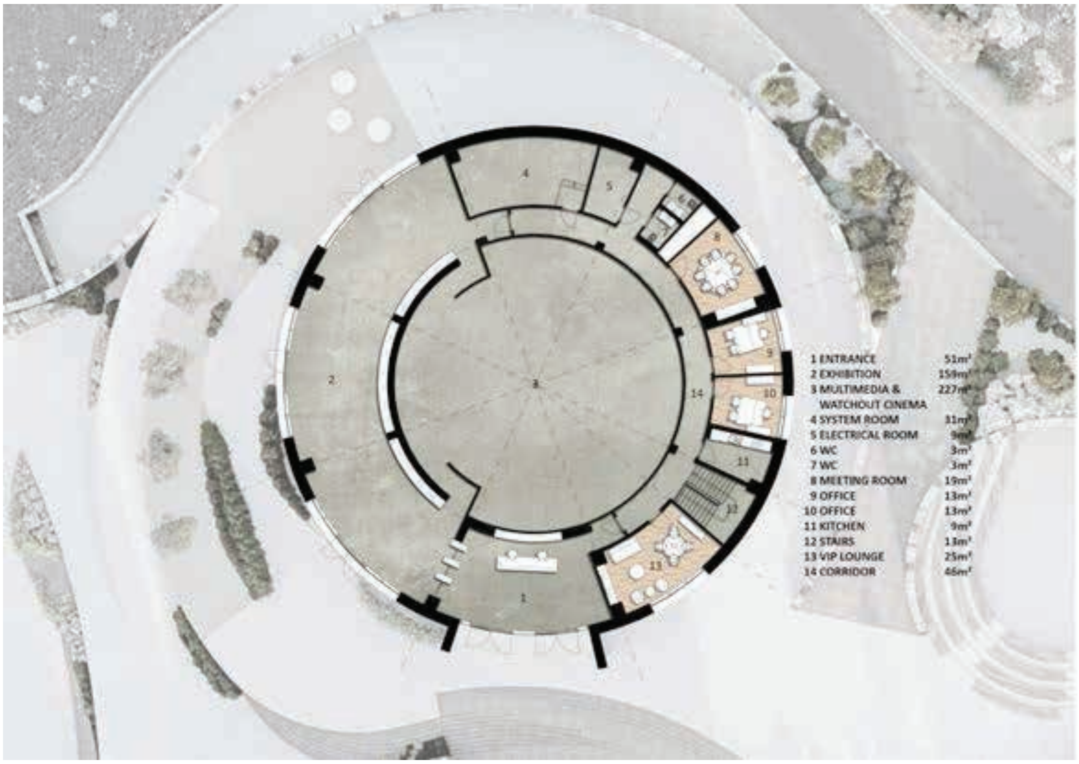

Figure 8. Exhibition center architectural floor plan

As for the conceptual approach of the project, Kreatif architects decided that the design had to be connected to the earth as an identity of landscape, thus, respecting the existing environment. It is a sustainable approach since the material is locally available, natural and eco-friendly and long distance transportation is not necessary. The building structure is formed by both steel and reinforced concrete. Earthen wall is used as building envelope as well as for the interior walls.

Rammed earth walls are constructed by ramming a mixture of selected aggregates, including gravel, sand, silt and a small amount of clay, into place between flat panels called formwork.

Traditional technology was used to ram the end of a wooden pole into the earth mixture to compress it. Modern technology has replaced the pole with a mechanical ram.

Stabilized rammed earth is a variant of traditional rammed earth that adds a small amount of cement (typically 5-10%) to increase strength and durability. Stabilized rammed earth walls need a slight added protection but are usually coated with an air-permeable sealer to increase the lifecycle of the material — it depends on the circumstances. Thousands of unsterilized rammed earth buildings around the world have given good service over many centuries.

Most of the energy used in the construction of rammed earth is spent in quarrying the raw material and transporting it to the construction site. However, use of on-site materials can reduce energy spent in construction. Rammed earth provides limited insulation but excellent thermal mass.

Rammed earth walls are sometimes known as pisé walls — from the Latin origin *pisé de terre.* First used in Lyons, France, in 1562, the term applied to the principle of constructing walls at least 500mm thick by ramming earth between two parallel frames that were then removed, revealing a completed section of compressed earthen wall. While 500mm thick walls may still be constructed, optionally with or without cement, most modern rammed earth walls in Australia are built using cement as a stabilizer and are typically 300mm thick for external walls and 300mm or 200mm for internal walls.

4 CONCLUSION

Consequently, Göbeklitepe Visitor Project is located adjacent to extremely important archaeological ruins. Therefore, designing a building on the existing environment, especially adjacent to historical ruins, is a huge responsibility for architects.

Figure 10. Göbeklitepe visitor center

Both the form of design and materials used in the project are vital. This project primarily aims to create a design that respects the existing landscape and environmental elements. The use of round shaped blocks reflects the identity of the place and using earthen walls provide a visual and physical connection between the building and the landscape.

5 ACKNOWLEDGMENTS

Earthen wall application is novel for Kreatif architects. In line with the request for assistance from Doğuş Holding, the sponsor, Prof. Bilge Işık, who is profoundly experienced in the field of earthen wall/adobe, was recommended. She played a key role in earthen wall application/concept of the project.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Recommendations for Çanakkale-Ayvacık Post-Earthquake Housing Needs and Solutions

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ABSTRACT

A number of housing units were rendered uninhabitable when an earthquake struck Western Turkey, centered in the Ayvacık district of Çanakkale province in February, 2017. The local inhabitants have been living in shipping containers. Thus, the mass production of emergency housing is urgently needed in order for these people to regain healthy living conditions. The objective of this study is to examine the causes for structures that were damaged in the villages and to recommend housing production that is earthquake-safe and appropriate for the region. The region's traditional structures are made of stone and adobe material. Adobe material is recommended for new buildings. Earthquake safety of modern adobe building technology as well as contemporary production technique are summarized in the declaration. The construction period with the traditional 'adobe' technique blended with straw lasts the entire summer season. While constructing 3-5 m^3/day with a labor team using the 'Sledgehammer' technique is possible, the construction duration can be accelerated by producing walls with a tunnel mold by using a 'Shotcrete' machine, which has an output of 40 m^3 rather than 5m^3 per hour. New adobe construction technologies for solving emergency housing needs in the Ayvacık area will be summarized below.

Key Words: Çanakkale Ayvacık Earthquake, Adobe Production Technique, Adobe Material Additives, Rapid Adobe Construction Production

1 INTRODUCTION

The province of Çanakkale is located in a 1st degree earthquake zone and tremors that have struck the tectonically active region during recent centuries show the area is still seismically on shaky ground. Situated over one of the world's most active faults, the region is known to have been hit by 15 major earthquakes along the Northern Anatolian Fault (KAF) over the past century. On 6 February, 2017, an earthquake measuring 5.3 struck the population center of Çanakkale, Ayvacık, destroying many of the structures in the region, and rendering most of the homes in the surrounding villages uninhabitable, which forced the local inhabitants to take up temporary dwellings. An acute housing shortage has since emerged in the region. The containers in which the homeless locals dwell do not provide the necessary thermal protection and have rendered living conditions here even more deplorable.

The damage assessments and building construction technologies of the villages in the region were examined in this field study, whereas recommendation was made for an adobe production technique that can be produced with rapid technology in order to meet the need for emergency housing, which emerged in the region's severely damaged villages. The recommendation was followed through the implementation of a rapid adobe construction technique with the participation of the mayor of Ayvacık and his personnel. The study was planned to include materials to be used in the adobe construction production, the type of mold to be applied and production technology and an exemplary building was constructed for the municipal staff.

2 REGIONAL CHARACTERISTICS & DAMAGE ASSESSMENT

Damage sustained from the earthquake that struck the Çanakkale Ayvacık district, the earthquake's properties and the region's construction characteristics were touched upon in this chapter of the study.

2.1 The Region's Earthquake Properties

Turkey is situated in a zone with active earthquake belts. Given the geography of Turkey, our field study region, i.e. Çanakkale, has high earthquake-generating energy and seismically active fault lines. Although the exact times of such earthquakes cannot be scientifically predicted, the regions are categorized by the degree of risk (Figure 1). The fault line of Çanakkale province, the focus of our study, is shown in Figure 2.

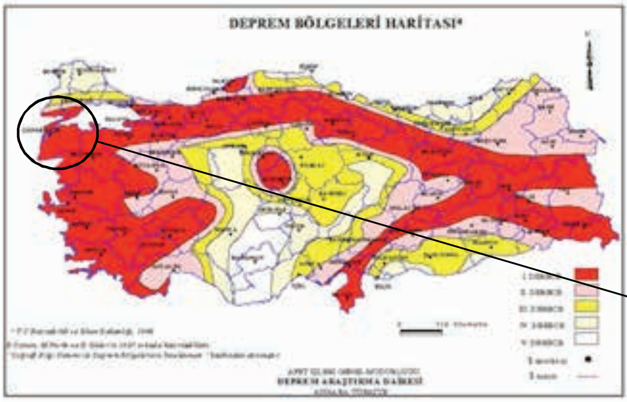

Figure 1. Map of Turkey's Earthquake Regions [1]

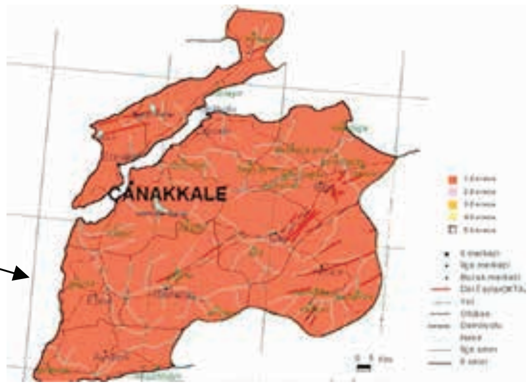

Figure 2. Fault lines of Çanakkale province [2]

Two active fault lines exist in the region. The first line is the Yenice-Gönen Fault Line (the continuation of the Northern Anatolian Fault Line) as well as the Saroz-Gaziköy Fault Line, which passes beneath the Gelibolu (Gallipoli) Peninsula and into the Aegean Sea. The second line comprises of Etlil fault and Çan-Biga fault, which have sufficiently high energy to generate earthquakes [3]. From a seismicity aspect, Çanakkale region is situated in a 1st degree earthquake zone. The focus of our study, Çanakkale province's Ayvacık district, is the westernmost tip of the Marmara region, known as Baba Burnu.

Several earthquakes of various magnitudes struck the Çanakkale province Ayvacık district between 15 January and 12 February 2017. The sources indicate that several structures sustained damage from the earthquakes in Ayvacık district as well as the villages of Tuzla, Çamköy, Yukarıköy, Babakale, Taşağıl and Bademli and luckily, any loss of life was not reported [3]. The 5.4-magnitude earthquake that struck Çanakkale's Ayvacık/Gülpınar region on 6 February, 2017 caused severe damage to the region, whereas the 4.5- and 5.4-magnitude aftershocks that occurred on 15.01.2017-16.02.2017 rendered the damaged buildings uninhabitable [4].

2.2 The Typology of the Region's Structures

Ayvacık is situated in a mountainous rocky terrain. From the aspect of convenient supply and economics, a great majority of the structures are built from materials such as locally produced stone, soil and bricks. Generally speaking, the structure of the materials used constitutes simple construction systems.

The single- or two-storey floors, comprising of four-edged body walls of latticework-style rubble using a binding adobe mortar, were placed on top of each other without containing them in a certain system (Figure 3). In some buildings, the roof-wall was erected without using any binding material.

a  **b** 

Figure 3. a, b, Using soil as a binder in masonry works.

When we examine the wall construction technology of the uninhabitable structures, it seems that masonry systems do not meet the required standards. Binding stones (keystone) were not available in the masonry work that would intertwine with each other. While the staggered masonry technique was assumed to be applied, in the grout joint intervals of the stone masonry work, wall systems were installed in these damaged structures without binding these stones, which did not offer heading bond property. The earthquake caused cracks in the regions where the staggered masonry system was not applied as required in the grout masonry (Fig. 4). Reinforcements were made with modern materials in order to rectify deformations that had occurred in these structures. For instance, reinforced concrete lintels, beams, column supported bricks and briquette materials were added to the existing structures, resulting in complicated non-system structures (Fig. 5).

Figure 4. Visible cracks in the building

Figure 5. Example of a complicated system

The masonry that formed the two surfaces of the wall were practically filled with smaller stones and soil filler, whereas stones positioned into the two surfaces of the wall were not connected to each another. For this reason, the stones found on both sides disassociated from each other and collapsed (Fig. 6 a, b). The wall was not stabilized and beam (hatil) elements to protect it against earthquake loads were not in place. This was a crucial drawback that prevented the walls from being stable.

The majority of roof coverings in the region are flat earthen roofs. For this covering, wooden beams and logs were laid as the framework and covered with reeds and soil (Fig. 7). While designing the roofing systems on the buildings, errors were made such as keeping overlapping margins at the wooden beams and wall connection points too short and the failure to include connecting lentils, which resulted in the collapse of the earthen roof covering.

a b

Figure 6 a, b. The stone masonry of the two surfaces was not mutually linked and slipped off the surface.

Figure 7. Example the roof covering type commonly used in the region

Structures that were damaged or destroyed throughout the region were constructed without complying with or observing the applicable construction techniques and technologies. The structures where wall paving techniques were implemented more carefully and straighter were observed to remain intact.

3 ADOBE PRODUCTION TECHNOLOGY AS AN ALTERNATIVE FOR RAPID HOUSING PRODUCTION

A substantial housing shortage has emerged as a result of the earthquake that struck the region. Adobe structures, which are healthy, offer thermal comfort and humidity balance and are economically viable, have been recommended as a good solution for the region. The ADOBE obtained by adding hay to suitable soil is a building material that balances humidity, can be easily obtained, does not require high production energy, offers high thermal insulation, is environmentally friendly, recyclable and natural. It takes a long time to construct building with straw-added mudbrick.

Obtaining the material, allowing it to settle once hay is added to the soil in the pool, producing the adobe blocks individually, spreading them out over a wide area to dry, turning them over for proper drying, transporting them to the construction site, the paving process itself, and the foreman/worker procedures can all take several months.

As a result of research conducted at ITU by Prof. Ruhi Kafesçioğlu, soil mixed with gypsum and lime proved to be water resistant. This material, which is a combination of the Turkish words for gypsum and lime, 'alçı' and 'kireç,' was named 'ALKER.' In terms of mechanical and physical characteristics, adobe with gypsum and lime additives (Water 20%, Lime 2% and Gypsum 10%) produced some favorable results for construction in experiments conducted [5].

3.1 Rapid Adobe Production Technique/Method

In terms of construction time, the traditional straw-blended 'adobe' technique is not suitable for meeting the current needs. Techniques have been developed to shorten construction times of modern adobe structures. 'Rammed' and 'shotcrete' may be considered amongst these accelerated techniques. A team of workers can construct 3-5 m^3 per day utilizing the knocking technique. If the "Shotcrete" machine with a production capacity of 40 m^3 instead of 5 m^3 per hour is selected, and tunnel molds are used in the walls, the speed of one structure per hour can be achieved.

Rammed technique: Mortar mixed with soil-gypsum-lime additive is poured into a reinforced concrete mold. Depending on the type of soil used, 20 cm of soil poured into the mold is compressed to 14 cm, using a sledgehammer. Using the rammed technique, a workforce of four people may produce around 3 m^3 per day (Fig. 8). Manually mixed soil that is poured into molds may also be mixed with a cement mixer (Figure 9) in order to speed up the process.
Depending on the type of soil to be used in the wall construction,

For every 100 kg of soil,
10 kg gypsum
2 kg lime
and sufficient water (20%) to allow the components to adhere to each other, as seen in the palm, is used (Fig. 10). Cracking may occur during the drying stage if excessive water is used, which may result in a negative impact on the resistance.

Figure 8. Soil mortar is compressed in a steel mold using a sledgehammer

Figure 9. Using a cement mixer to mix the soil to be used in adobe production

Figure 10. Determining the amount of water to be mixed into the soil

Shotcrete production technique: A shotcrete machine is used. By means of a shotcrete machine and compressor, soil is sprayed into the mold using a hose (Fig. 11 a, b). The Shotcrete machine is used to reinforce the internal and external surfaces of masonry walls for earthquake safety by spraying concrete. High-powered, high capacity shotcrete machines are used to reinforce soil surfaces of highway tunnels. As a result, it is possible with this technique to produce any wall from 4 m^3 to 40 m^3 per hour. If the total wall volume of a small house is 40 m^3, the walls of a house can be erected just in one hour by using a shotcrete machine.

a 

b 

Figure 11 a, b. Machine mixed soil is (a) sprayed (b) and placed into molds.

3.2 Principles for earthquake-safe masonry walls

To make a structure earthquake-proof, horizontal forces arising from the earthquake, which may cause diagonal cracks on the wall, must be prevented. If a horizontal force is generated by an earthquake and diagonal cracking occurs, the wall above the crack will slide during a landslide, causing the entire structure to topple. If horizontal cracks, instead of diagonal cracks, occur as a result of force divergence, the structure continues to bears its own weight and will not collapse.

In order to prevent the wall from collapsing due to horizontal cracks during an earthquake, an energy dissipation surface layer is placed from the bottom to the top at 40 - 60 cm intervals in the mold filler. The slip plane can also be a simple plaster wire, such as GEOGRID, which is used to reinforce the fill in highway construction.

The desired type of ceiling covering can be made once the walls are brought up to floor height. However, optionally, wooden roof coverings can also be made. Reinforced concrete joists and slabs are recommended. A joist height of 30 cm. to be used with reinforced concrete flooring over the adobe masonry wall is considered sufficient. A balcony or bay window may be added as suitable for the system applied for flooring or reinforced concrete ceiling covering system.

A reinforced concrete foundation and a footing should be laid down under the masonry walls in accordance with this construction method. As for the building's foundation, a standard reinforced concrete raft foundation produced for modern reinforced concrete structures can also be laid down. The structure can be completed within a short time if the spraying technique is used in the wall construction stage after the foundation is complete and the concrete floor is laid. Steel molds that are used in the construction of ready-made curtain walls are positioned onto the foundation floor for the supporting walls. Depending on the climatic conditions, wall widths should be at least 50 cm.

3.3 Demonstrating an Examplary Adobe Application for Ayvacık Municipal Staff

A "rapid adobe building technique workshop application" was demonstrated before the building management staff of Ayvacık Municipality with the purpose of meeting the housing shortage arising from the Ayvacık earthquake through adobe materials.

For this workshop study, first:

- A steel mold to ensure wall production in a short time was prepared,
- Then adobe mortar had to be mixed to make the walls,
- The proper proportions of materials such as gypsum, lime, sand and soil necessary for making the mortar were added.

All those were dry-mixed in order to ensure a homogenous mixture and then the mortar was formed by adding water. After pouring the prepared mortar into the mold, it was compressed into the mold by knocking it into place. After the compressing process was completed, the mold was opened and the earthen wall was thus obtained. The stages of this process are shown in [Table 1].

Table 1. Pouring the adobe mortar mixture into the mold and removing a finished wall from the mold

		
Dry mixing of sand and soil	Mixing gypsum and lime	Pouring mortar into the mold
		
Compressing the mortar into the mold	Opening the mold	Forming the wall

4 CONCLUSION

The local people have been living in containers since the destructive 5.4 earthquake that struck Turkey's Çanakkale Ayvacık region in February, 2017. The majority of the region's traditional structures are made from stone and partly from adobe materials. At the present time, stone and adobe masters are difficult to find and those who are available do not have higher education credentials. While buildings that were produced with better techniques remained intact, those that were not produced to appropriate technical standards collapsed in the earthquake.

In terms of physical structure, adobe material has a high thermal transfer and a humidity balancing characteristic. At the same time, it is eco-friendly and easily biodegradable.

With the recommended adobe building technique, it will be possible to produce a housing unit in the region just in a few days. This process offers an emergency solution for the region's people who still live in containers. Moreover, adobe has made it back onto the global habitation agenda as a preferred eco-friendly material that ensures thermal comfort.

Considering current emergency housing and economic conditions, adobe buildings are regarded as an extremely favorable construction technique and material for the region. Instead of making single mud bricks, the adobe building technique proposed here pours the prepared mortar into steel molds to build a large number of adobe structures in a short time. This system will be able to meet the need for low-rise village cottages in a short span of time and in a healthy manner. The buildings produced with this system constitute structures that are earthquake-resistant and easily ensure thermal comfort.

Adobe has been proposed as a system which can offer a quick-fix solution for the region's people as a healthy, eco-friendly, economical, non-waste, low-energy heating system that offers protection against humidity for years to come.

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Using a Nylon Rope Mesh as Seismic Reinforcement for Earthen Constructions

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ABSTRACT

This article presents preliminary results of an ongoing research project whose objective is to develop a structural reinforcement system for earthen constructions located in seismic areas. The proposed reinforcement consists of a mesh made of nylon ropes, which envelopes completely all the earthen walls and maintains structural integrity even after the walls have been significantly damaged by earthquake forces. A design methodology was developed to specify the required reinforcement for one-story earthen constructions and was validated via shaking table testing of several large-scale one-story adobe housing models. Recently, four two-story half-scale models were also tested on the shaking table: two without reinforcement and two with rope mesh reinforcement. The test results obtained and the needs for further research are discussed in the article.

It is thought that the use of a rope mesh as seismic reinforcement for earthen constructions has the potential to protect the lives of millions of families which are currently are at risk and the integrity of invaluable earthen historical monuments.

Key Words: Seismic reinforcement, Earthen constructions, Shaking table tests

1 INTRODUCTION

The high seismic vulnerability of earthen buildings is due to the poor structural properties of their walls: earthen walls are dense and heavy, have extremely low tensile strength and, as a result, during earthquakes they fail in a brittle fashion, without any warning. As a consequence, every significant earthquake that has occurred in regions where earthen construction is common has produced tragic loss of life and considerable material damage. For instance, in Peru the Ancash 1970 earthquake killed around 70,000 people. Almost half of them died crushed by their own adobe houses, and the other half was buried by an avalanche. In the 2001 El Salvador earthquake 1,100 people died, more than 150,000 adobe buildings were severely damaged or collapsed and over 1.6 million people were affected (Fig. 1, left, from Dowling 2004;). More recently, the Pisco 2007 earthquake in Peru destroyed around 70,000 earthen houses and caused almost 550 deaths (Fig. 1, right).

Figure 1. Earthquake destruction of adobe houses Latin America.
Left: El Salvador 2001. Right: Peru 2007.

A team of researchers from the Pontifical Catholic University of Peru (PUCP) has been working since the 1970s towards finding simple and economical ways to provide seismic safety to earthen buildings. Reinforcement systems made with different natural and industrial materials were studied: bamboo canes, wire meshed, plastic tubes, and polymer meshes (Vargas and Ottazzi 1981, Blondet *et al*. 1998 and 2011, Zegarra *et al*. 1997 and 2001). In this article, the use of nylon rope meshes is proposed for the seismic retrofitting of one and two-story adobe buildings.

2 REINFORCEMENT TECHNIQUES FOR EARTHEN BUILDINGS

The seismic performance of the reinforcing systems for earthen buildings studied at the PUCP was evaluated via shaking table tests of one-story large-scale models, as described below.

Internal cane mesh reinforcement (Blondet et al. 1988)
The reinforcement consists of vertical cane rods anchored to a concrete foundation and placed inside the adobe walls. The adobe block layout defines the distance between the vertical cane rods. Horizontal layers of crushed canes are placed in the horizontal joints every few rows and tied to the vertical cane reinforcement (Fig. 2). Finally, this internal cane mesh reinforcement is tied to a wooden crown beam.

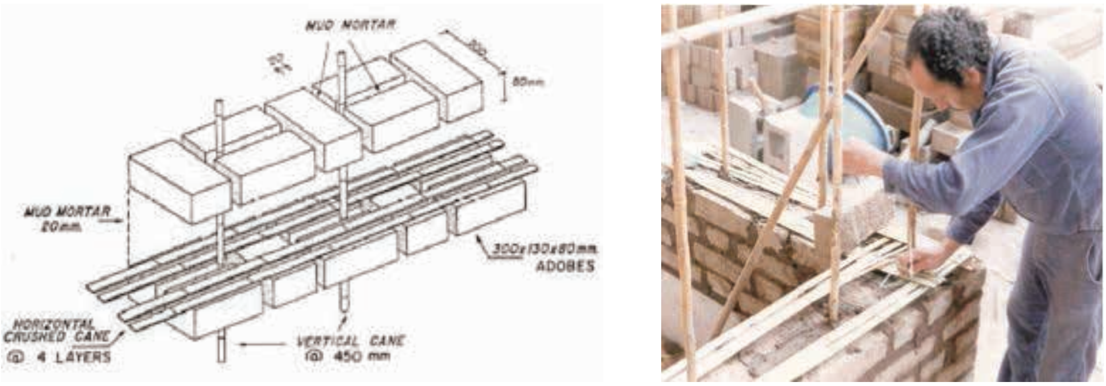

Figure 2. Internal cane mesh reinforcement.
Right: Cane and adobe layout. Right: Placement of horizontal crushed cane.

The one-story roofless models reinforced with this system demonstrated excellent seismic behaviour during intense unidirectional shaking since the internal cane mesh was able to keep the damaged walls together and maintain structural integrity. The main limitation of this system is due to the scarcity of cane in most seismic regions.

2.1 External wire mesh reinforcement (Zegarra et al.1997 and 2001)

This technique consists of nailing wire mesh bands against the adobe walls and then covering them with cement mortar. The mesh is placed in horizontal and vertical strips, following a layout similar to that of beams and columns. This reinforcement system provided significant additional strength to one-story large-scale adobe masonry models undergoing moderate amplitude tests at the PUCP's shaking table. However, the mode of failure was brittle during a strong test, which is considered unacceptable seismic performance (Fig. 3, left). During the 2007 Pisco earthquake in Peru, while surrounding houses were severely damaged or destroyed, houses reinforced with this system did not suffer any damage and were used as shelters, as shown in Fig. 3 right.

Figure 2. Adobe buildings with wire mesh reinforcement.
Left: Brittle failure during test. Right: Undamaged house after 2007 earthquake.

Wire mesh and cement are expensive for the inhabitants of earthen houses in developing countries and exceed their economic capacity.

2.2 External polymer mesh reinforcement (Blondet et al. 2006)

Several similar one-story large-scale adobe housing models with different amounts and types of polymer mesh were tested on the PUCP's shaking table in order to explore the possibility of using these industrial products as seismic reinforcement for earthen buildings. The first models were reinforced with different amounts of geomesh or geogrid (Fig. 4, left). They showed good dynamic response during earthquake simulation tests: although the adobe walls were damaged, collapse was avoided even during very strong shaking. As expected, the amount and spread of damage on the adobe walls increased as the quantity of polymer mesh reinforcement was reduced.

Since geogrid is quite expensive in Peru, it was decided to study also the use of a cheaper plastic mesh, usually employed as a soft safety fence in construction sites. The adobe model shown in Fig. 4 on the right was reinforced with bands of plastic mesh located in the regions where most damage was expected. After a strong shaking test, the adobe walls were broken into several large pieces, which were held together by the plastic mesh. The mesh was deformed and broken in several places, indicating that the amount provided was barely adequate. Although the building suffered significant damage, collapse was averted.

Figure 3. Adobe models reinforced with polymer mesh.
Left: Geogrid. Right: Plastic mesh.

These test results have demonstrated that moderate amounts of strategically placed polymer mesh reinforcement can therefore be used to prevent the seismic collapse of one-story earthen buildings.

2.3 Nylon rope reinforcement (Blondet et al. 2016)

PUCP´s research team is currently working on a technique to reinforce earthen buildings by wrapping all the walls with a mesh made of nylon ropes (*halyard*). This technique can be successfully combined with a mud injection repair procedure intended to recover as much as possible of the original strength and stiffness of damaged earthen walls. The rope mesh reinforcement's main function is to maintain the integrity of the earthen walls after they have been severely cracked by an earthquake, by preventing broken wall portions from overturning and falling off. A one-story adobe masonry model was built in the PUCP's Structures Laboratory and tested on the shaking table to evaluate the feasibility of this technique. The model was first shaken in order to induce representative seismic damage. The larger cracks were then repaired by injecting a liquid mud grout inside them. After the repaired cracks were suitably dry, the model was reinforced with a mesh made of nylon ropes with ½" nominal diameter. Rope spacing was selected according to the adobe blocks layout (Fig. 5, left).

All ropes were tensioned using metal turnbuckles, and then rope ties were placed across the walls in order to join the exterior and interior meshes. The model was then tested again on the shaking table with a sequence of movements of increasing intensity. Its seismic response during the strongest shaking was considered to be excellent because the mesh reinforcement maintained the structural connection between roof and walls, controlled the excessive displacements of the walls and avoided partial collapses, thus preserving the integrity of the structure (Fig. 5, right).

With slight and careful modifications (such as avoiding the drilling of the earthen walls), this repair and reinforcement procedure would fully agree with conservation principles of minimum intervention, compatible reinforcement and reversible solutions.

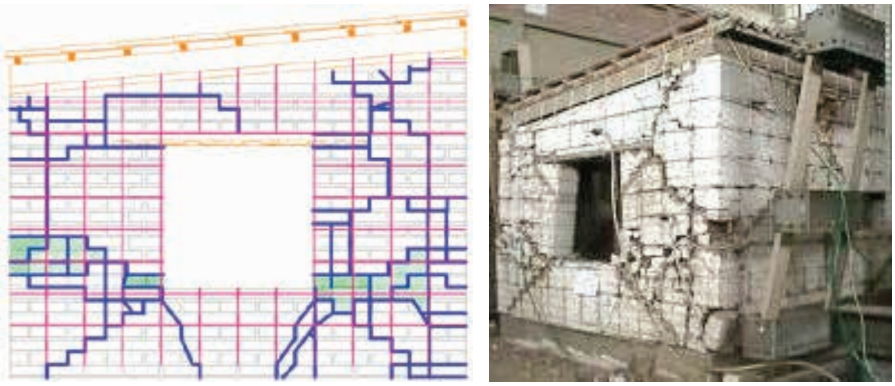

Figure 4. Repaired and reinforced adobe model after testing.
Left: cracking pattern. Right: model after intense shaking table test.

A structural design procedure was then developed to compute the required seismic rope reinforcement for a given earthen structure subjected to seismic loading. The design should specify a rope mesh capable of avoiding the overturning of all possible wall portions. An alternate rope mesh reinforcement was then designed to be provided to an identical one-story large-scale model, but this time with a thinner 5/32" diameter rope. Fig. 6 on the left shows the layout of the resulting, denser mesh. The dynamic response of this test specimen was considered to be excellent, as the rope mesh was capable of preventing the overturning of large wall portions during a single strong shaking. Fig. 6 (right) shows the condition of the model after the test.

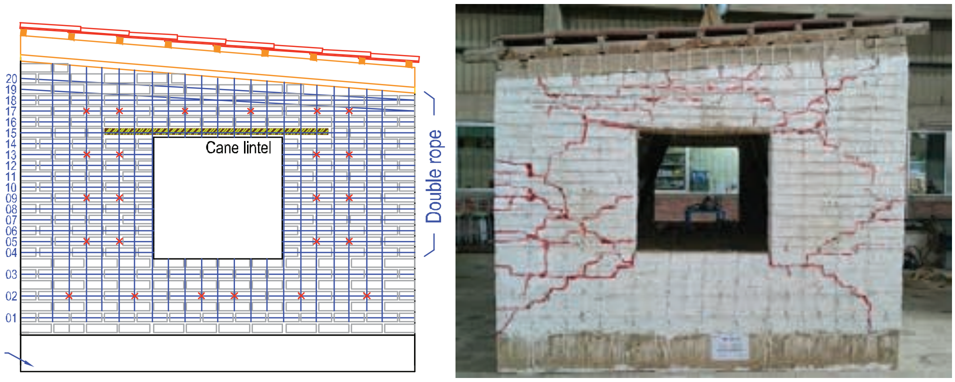

Figure 5. One-story adobe model reinforced with 5/32" nylon mesh.
Left: mesh layout. Right: cracking pattern after strong shaking.

The dynamic testing campaign on rope-reinforced adobe masonry models has revealed that this reinforcing system is adequate to prevent collapse of one-story earthen buildings subjected to strong seismic shaking. However, in Peru (as in many other countries) two-story houses are prevalent, and therefore, it was decided to study whether this system was also suitable to protect taller earthen buildings.

3 PRELIMINARY RESULTS FOR TWO-STORY BUILDINGS

In many cities, towns and villages of the Andean regions, it is common to find two-story earthen houses. For example, Fig. 7 shows a view of the city of Huancavelica, in the South Central Peru, where many two-story houses can be seen.

Figure 6. A view of the city of Huancavelica. Notice many two-story houses. (Photo: Culture Ministry, Peru, www.cultura.gob.pe/es/ddc/huancavelica).

Shaking table testing of large-scale models of two-story earthen buildings is not possible on the PUCP's shaking table, which was designed specifically to perform dynamic tests on one-story earthen full-scale models, with 4x4 m^2 plan dimensions and a maximum weight of 150 kN. The only possibility to perform dynamic testing on two-story models was therefore to use reduced-scale test specimens. It was therefore decided to design and build a reduced scale two-story *model*, which should be able to represent with acceptable accuracy the dynamic response of a typical two-story adobe prototype structure.

3.1 Scaling process

The two-story reduced-scale adobe building *model* was designed by establishing similitude ratios λ between each relevant physical property of the *prototype* and the equivalent property of the *model*.

Due to the dimensions of the laboratory facilities, it was decided to build a half-scale model. Therefore, the length scaling ratio (Prototype/Model) was $\lambda_L = L_P/L_M = 2$, and correspondingly, the scaling ratios for area and volume were, respectively, $\lambda_A = 4$ and $\lambda_V = 8$. Since the model was to be made with the same soil as the prototype, the scaling ratios for mass density, modulus of elasticity and mechanical strength were equal to 1. Therefore, the mass ratio was $\lambda_M = \lambda_V = 8$, and assuming that the applied stress ratio was equal to the material strength ratio (*i.e.* ignoring gravity stresses) implied that the force ratio was equal to the area ratio ($\lambda_F = \lambda_A = 4$). Finally, Newton's 2nd law (F = ma) implied that the acceleration ratio was $\lambda_a = ½$ and therefore, to have $\lambda_L = 2$ the time ratio must be $\lambda_T = T_P/T_M = 2$.

The shaking table displacement command signal used to test the scaled two-story adobe *model* was therefore obtained by halving the amplitude of the *prototype* displacement command signal ($L_M/L_P = 1/\lambda_L = ½$), and by compressing the time scale by a factor of two ($T_M/T_P = 1/\lambda_T = ½$).

3.2 Half-scale test models

Four half-scale two-story adobe building models were built in the PUCP's Structures Laboratory. Two models were unreinforced and represented typical Andean two-story adobe houses. The other two models were reinforced with a mesh made from nylon ropes with 1/8" nominal diameter, thus respecting the scale ratio for linear dimensions $\lambda_L = L_P/L_M = 2$, as a previously large-scale specimen had been reinforced with 1/4" ropes. Figure 8, on the left, shows a drawing of a reinforced half-scale model and, on the right, a photograph of the test model on the shaking table. Some portions of the reinforced adobe walls model were left intentionally without stucco, with the hope of being able to visualize the response of the ropes during shaking.

Figure 8. Two-story half-scale adobe reinforced model.
Left: construction schematics. Right: test model on the shaking table.

As expected, the unreinforced *models* suffered significant damage and were near collapse during moderate shaking. Figure 9 on the left shows the condition of one of the unreinforced models after shaking with peak displacement amplitude $D_M = 41$ mm and peak acceleration $A_M = 1.27$ g. In *prototype* scale, these table motions would correspond to ground motions with peak displacement $D_P = \lambda_L D_M = 2 D_M = 82$ mm and a peak acceleration $A_P = \lambda_a A_M = 0.5 A_M = 0.63$ g. This is consistent with the observation in the field that actual 2-story adobe buildings collapse or are inhabitable after moderate earthquakes.

The rope-reinforced half-scale models showed a completely different dynamic response. Whereas one of the models was subjected to a sequence of motions with increasing intensity, the second model was subjected to the most intense motion that the table can safely provide. In both cases, and similarly to the one-story large-scale models, although the adobe walls broke in several large blocks, the provided rope reinforcement was able to prevent the overturning of these blocks, thus preserving the structural integrity of the models. Figure 9 (right) shows the condition of a reinforced model after a test with peak table motion displacement D_M = 56 mm and acceleration A_M = 1.67 g. In prototype scale, the ground peak displacement and acceleration would be D_P = 112 mm and A_P = 0.83 g, respectively. Clearly, the seismic response of the model is adequate since the structure is still stable after strong shaking.

Figure 9. Two-story scaled models after shaking table testing.
Left: unreinforced, close to collapse. Right: reinforced, with moderate damage.

These preliminary experimental results are encouraging because they indicate that it seems possible to design suitable rope mesh reinforcement to provide safety to the inhabitants of real two-story earthen buildings located in seismic areas.

4 FURTHER WORK CHALLENGES

The immediate research phase will be to attempt to extend the reinforcement design procedure developed for one-story earthen buildings for its use on two-story earthen structures. This is a challenging problem of structural dynamics of multiple interacting colliding blocks joined by strings. After a design procedure is proposed, it would have to be validated with a series of shaking table tests.

The availability of technical solutions, unfortunately, is not sufficient to solve the real problem of the unacceptable seismic risk for the millions of earthen house dwellers. Mitigation of seismic risk will be possible only when the users themselves adopt improved earthen construction systems as part of their own culture.

A main obstacle is, obviously, economic. Without government and private involvement in providing construction training and building materials, it seems impossible to develop and implement seismic protection programs to the communities where unreinforced buildings are traditional.

5 CONCLUSIONS

The extensive research effort developed at the PUCP and other institutions has shown that it is possible to build earthquake-resistant earthen structures. This can be achieved only by provident suitable reinforcement to all the earthen walls in order to prevent their partial or total collapse during earthquakes. A rope mesh which envelopes all walls and connects them with the foundation and a continuous chain at the roof level has shown to be effective to prevent the collapse of one- and two-story earthen models during intense unidirectional shaking. Therefore, it seems that this reinforcement system could be used to provide seismic safety to the families who are actually living under unacceptable seismic risk.

6 ACKNOWLEDGEMENTS

This article summarizes the results obtained during several projects developed at PUCP. Most of the work described here was financed through grants of the PUCP's Research Office, and SENCICO, a Peruvian government institute devoted to construction code development and training. The support of the Structures Laboratory technical staff is gratefully acknowledged. Last but not least, the authors would like to thank our colleague Carlos Sosa, who contributed with many good ideas, and the following students, who worked very hard to make these projects a reality: Qenti Herencia, Hillary Vargas, Lourdes Pando, José Romero, Angely Valle, and Ramiro Yallico.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Evaluation of the Graduate Research done in Turkey on Adobe

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ABSTRACT

In this study, graduate and doctoral studies on the subject of adobe in Turkey are discussed. As a working method, 'adobe' was searched as a keyword for the title of the thesis in the thesis archive on the thesis screening page of the website of the Council of Higher Education in Turkey. As a result of the study, it was seen that 21 graduate studies have been done by different disciplines. Eleven of those are in architectural areas, three in civil engineering field, three in archeology field, one in cytometry field, one in mining engineering field, one in fine arts field and one in technical education field at master's level. It was noticed that doctoral level studies had not been done. In recent years, studies at the master's level heavily concentrated on the fields of architecture and civil engineering.

It can be said that the studies conducted by different disciplines on adobe are not at a sufficient level. In order to increase studies on this area, project support, award-winning competitions, panels, symposiums, presentations, etc. can be organized to withdraw support and attention from different disciplines. In the departments of Architecture and Civil Engineering, undergraduate level courses "Introductory Adobe Course" can be opened as an elective course. In architectural projects, the use of adobe in terms of color, pattern, naturalness, easy availability, easy accessibility, easy reducibility, healthy and natural building material can be preferred. Thus, adobe building material can be used in modern architecture as well as traditional architecture in our country. In order to protect, repair and use adobe structures, especially in rural architecture, necessary researches should be done across the country.

Key Words: Turkey, Adobe structures, Graduate studies, Adobe materials

1 INTRODUCTION

Adobe is a building material obtained by several processes, i.e. adding sandy soil that contains clay of a consistency that binds the particles to each other, adding fibrous additives such as straw, mixing water to turn it into a mortar, pouring the mixture into simple wooden molds, shaping and removing it from the mold and allowing it to dry out in the sun [1, 2, 3, 4].

Adobe masonry structure is a type of building often preferred for housing units and animal shelters since antiquity, particularly in rural areas. Masonry structures have been constructed by utilizing various building materials such as stone, bricks, briquettes, and adobe. The walls in masonry structures both serve as load-bearing elements and surround the building's utilization space. Load transfer occurs between the materials and the mortar used. The load-bearing system elements of masonry buildings comprise of the flooring, the walls supporting them and the foundations of these walls. Masonry structures may exhibit different behaviors according to the ingredients of the construction materials used [5, 6].

Adobe structures provide the easiest and most advanced means of taking advantage of the country's abundant resources as well as the possibility of assessing the people's traditions and customs. Effective energy savings aim to optimize the use of resources deemed necessary for development. In every season, the building offers the occupant the opportunity to benefit from the most suitable living conditions, to benefit optimally from solar energy by using the easiest methods, and apply all types of amenities in the structure deemed necessary for contemporary living. For this reason, modern day earthen structures have achieved the quality of 'Contemporary Structures.' [4, 7, 8].

Adobe material is still widely used in traditional building architecture due to its simple application technique, employment opportunities it creates for rural labor force in non-farming activity, low overhead expenses and readily available clay loam used in the production of adobe. This study concentrates on the inspection of a concentration of adobe structures located in two of five neighborhoods, i.e. Tunceli province, Pertek (Derebaşı and Camiikebir). It draws attention to the damage in adobe structures (Fig. 1).

Figure 1. Damage to adobe structures in Pertek (Pertek, 2017)

2 THE STUDY METHOD

A detailed literature survey on adobe structures was carried out. An assessment of adobe structure damage in Pertek specimens was conducted. Twenty of the approximately 100 adobe structures in the neighborhoods of Derebasi and Camiikebir were examined, photographed and observed. It is aimed to restore these structures back to their original architectural state.

3 DAMAGE ASSESSMENT AND RECOMMENDATIONS

The examination of adobe structures in the district of Pertek revealed that some buildings collapsed in their abandoned state, while other structures sustained heavy damage. These destroyed or damaged buildings need to be architecturally restored. Upon close examination of the adobe structures, frequently encountered problems were noted and recommendations were determined as follows;

1. Adobe masonry structure damage was generally found to be cracks in the walls, settling in the foundation or the deformation or disintegration of materials used.
2. Water-moisture damage was frequently encountered. The required detailed designs for water- and moisture-proofing must be carried out in strict compliance with the rules and these structures must be maintained at regular intervals.
3. Old or dysfunctional detailing materials must be renewed.
4. Lack of maintenance and abandonment eventually led to major damage to the structures. Since dwellers are aware of and focus more on the disadvantages of these type of structures rather than their advantages, they do not prefer these types of buildings.
5. Broken or wornout wooden fixtures should be replaced with impregnated new fixtures.
6. Plaster should be applied to structures that have their exterior plaster peeled off whereas adhesive enhancing materials should be used in the plaster.
7. In structures with cracked plaster, old plaster should be removed and new plaster should be applied.
8. The additive dosage to be mixed with the plaster mixture needs to be adjusted and care should be taken to ensure the necessary dosage is neither too much nor too little in order to prevent cracking in the future.
9. The importance of the wall coping in the adobe garden wall and/or the retaining wall needs to be emphasized whereas material to increase the elasticity of the plaster material should be used.
10. A dripper should be left in the wall coping in order for rainwater to seep from the adobe walls.
11. Collapsed structures without ceilings need to be restored in harmony with the town architecture.
12. Plywood boards should be used to cover the ceiling and other parts inside the structure to counter insect damage or prevent soil from falling from the ceiling.
13. Regardless of the size, gaps should not be left between the plywood material and the wall in structures that need to have their ceilings covered. Care should be taken to ensure that nails do not crack the plywood material when the plywood material is hammered into wooden beams. Nails of the proper length should be used according to the thickness of the plywood material used.
14. Strict compliance with the building rules is required in constructing adobe structures from scratch and labor issues should be considered as well.
15. Wall corner connections should be made in solid fashion.
16. Care should be taken to ensure that the plan's wall arrangement does not lose its symmetry, and the required construction rules are strictly observed.
17. If construction elements of various sizes are used in the construction phase, care should be taken to use the larger elements in the joining spaces as well as the wall covering techniques.
18. In constructing the roof, care should be taken to use materials that are lightweight.
19. As is the case for reinforced concrete structures, workmanship, adequate detailing and quality of construction are extremely important in adobe masonry.
20. Adherence between materials must be strong so that load bearing may be achieved in a sound manner.

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Damages Seen in the Adobe Buildings in Pertek

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ABSTRACT

Pertek is the most crowded district in Tunceli. With a population of 25,000 in 1872 and a considerable decline in 2016, the population there fell to 11,034 people. It is a settlement located on the coast of Keban Dam. Few mudbrick structures exist in other districts of Tunceli. Pertek is the district where mudbrick structures are abundant. It is determined that mudbrick structures are mainly located in Derebaşı and Camiikebir Neighborhoods, the oldest quarters of Pertek district center. All structures were found out to be made of reinforced concrete structures. Thus, Derebaşı and Camiikebir Neighborhoods were chosen as the study area.

As they are natural, ecological, easily producible, sustainable and environmentally friendly mud (adobe) bricks should reclaim their place in modern architecture through various supports and projects. Mud brick structures are the most healthy structures for humans. They are hot in winter and cool in summer.

Structural damage was assessed by examining the mud brick structures commonly found in Derebaşı and Camiikebir in Pertek District of Tunceli Province. Approximately 50 buildings, made of mud bricks, were found in the Derebaşı and Camiikebir Neighborhoods. Ten buildings were inspected in each site and necessary evaluations were made. It was also found that the mud brick structure problems were similar in both localities. At the end of this study, the most common reasons for damage, especially in abandoned mud brick structures, were determined to be unconscious use, improper construction, lack of maintenance, water-humidity etc.

Key Words: Pertek, Mud brick structures, Structural damages, Mud brick material

1 INTRODUCTION

Post-graduate studies conducted in Turkey on the subject of adobe construction were examined. Due to undesired level of activities promoting the adobe, which is a commonly used material in traditional architecture structures, this material does not get the respect it well deserves. After examining studies conducted on this subject from the aspects of occupation and the years in which they were conducted, it was concluded that they have yet to reach the desired level. To achieve the desired level, adobe material needs to be introduced to all occupation groups. Adobe can become widespread especially in the rural region and may regain its former value in modern use. In this context, post-graduate studies conducted on this subject were examined. This study makes note of the strikingly few studies that covered this subject in depth.

2 MATERIALS AND METHODS

Post-graduate studies concerning adobe material that are available online on the national dissertation screening center were evaluated. A mere 21 post-graduate dissertation studies with the title keyword 'kerpiç' were accessed from the national dissertation screening center and examined and evaluated from different angles. While 20 of the studies examined were of the post-graduate dissertation level, only one was at the doctorate level. The number of studies conducted at the doctorate level is very low (Table 1).

3 DISCUSSION AND CONCLUSIONS

While the architecture occupation group submitted the highest percentage of post-graduate studies with 12 dissertations, this was followed by three dissertations, each in the job fields of civil engineering and archaeology. On the other hand, one dissertation study was carried out in each of the fields of mining engineering, archaeometry, fine arts and technical education.

The most research on adobe was conducted in 2011 with 3 dissertations. 2011 was followed by two dissertations each year of 1998-2002-2004-2007. One dissertation was prepared in each of the following years; 1988, 1997, 1999, 2000, 2001, 2003, 2005, 2010, 2014, 2015 and 2016. It has been concluded that academic interest in the subject has intensified over the past decade.

When the study scale is evaluated according to occupational groups, studies to improve the technological properties with various additives to be added in the production phase in the field of civil engineering have been determined, while the emphasis is on adobe structure investigation, evaluation, damage assessment, plaster improvement and the improvement of adobe quality in the dissertations carried out in the field of architecture.

Because the scope of the study is multi-disciplinary, the use of adobe and contemporary architecture can be brought to the desired level through collaboration among different disciplines. Adobe dwellings, adobe structures and adobe materials can be adapted to current building technology at the macro- and micro-levels.

When our universities increase their interest in the subject through the introduction of 'Adobe Information' courses at the undergraduate level in the fields of architecture and civil engineering, more academic studies can be conducted in this regard. Moreover, academic activities regarding adobe, such as symposiums, competitions, technical field excursions, etc., may be organized to draw more attention to the importance of the subject, and the use of adobe can become more widespread at the present. Thus, adobe architecture can be brought to even higher levels.

Table 1. Graduate theses on adobe in Turkey

Year	Thesis Title	Thesis Type	Topic
1988	A research on mud brick production with rice husk	Graduate	Civil Engineering
1997	Studies on the protection of mud brick structures of Aşıklı mound	Graduate	Archeology
1998	Total quality management in building production and application in adobe construction	Graduate	Architecture
1998	Characterization of Odunpazarı (Eskişehir) mud bricks	Graduate	Mining Engineering
1999	Exterior surface protection by plaster in adobe building	Graduate	Architecture
2001	Comparison of plastered mud brick and brick wall on Şanlıurfa mass housing project in order to improve human settlements in the GAP region	Graduate	Architecture
2002	Durability and failure analysis for building examination on gypsum stabilized adobe building	Graduate	Architecture
2002	An experimental mortar research by mixing gypsum based material with soil in order to repair damaged adobe structures	Graduate	Architecture
2003	Archaeometrical investigation of mud plasters on Hittite buildings in Şapinuwa-Çorum	Graduate	Archeometry
2004	Investigation of clay mixed outer plaster damages for adobe walls	Graduate	Architecture
2004	The using of sun-dried brick houses as image in painting	Graduate	Fine Arts
2005	Test and evaluation of the applicability of shotcrete technique in alker (adobe with gypsum additive) technology	Graduate	Architecture
2007	A Research on improvement of adobe material used in Safranbolu houses by using blast furnace slag	Graduate	Civil Engineering
2007	Investigation of physical and mechanical properties of silica fume blended adobes	Graduate	Technical Education
2010	An experimental study on natural pozzolan blended lime mortar with soil mixture in the adobe structures used as external plaster	Graduate	Architecture
2011	Investigation on production of reinforce adobe panel wall by fiber	Graduate	Architecture
2011	Güvercinkayası adobe characterization	Graduate	Archeology
2011	Improvement of adobe material by using glassfiber and air-entraining	Master	Civil Engineering

Year	**Thesis Title**	**Thesis Type**	**Topic**
2014	Evaluation of the use of acrylic resin, alkali silicate, ethyl silicate, and nano-lime in the conservation of archaeological adobe	Doctorate	Archeology Architecture
2015	Physical and thermal properties of pine-needle lightweight loam	Graduate	Architecture
2016	The buildings and the structures in Akşehir that are built with earthen material are examined for their structural systems and the earthen buildings and the structures are evaluated in terms of current conditions	Graduate	Architecture

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Review of the Appraisal of the Study of Crack Propagation of Alker


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ABSTRACT

The study reviews the appraisal of the study of crack propagation of Alker (earthen construction stabilized with gypsum and lime) that is further improved by the addition of polypropylene fiber. The methodology employed by most researchers include Finite Element Methods and other Image Analysis Techniques to study the spread of cracks and concluded that Reinforced and Unreinforced samples are observed to show similar initial response as a result of the linear behavior between the origin and first crack load. However, the influence of the fiber becomes more obvious in the post cracking behavior due to the improvement in the energy absorption and ductility. The post cracking properties is observed to be controlled by the fiber weight ratio and the fiber length. The increase in strength is observed by some researchers to be linked to the increase in friction between the fiber and the soil matrix. The fibers form bridges across cracks hence prevent the cracks from spreading and therefore contribute to the improved strength. Nevertheless, after a critical point, an increase in fiber content caused strength reduction when fibers begin to knot and overlap each other, thereby resulting in reduced cohesion with the soil and break-up of the soil matrix, causing the soil–fiber composite to weaken.

Key Words: Alker, Crack propagation, earthen, Filter paper

1 INTRODUCTION

Earthen construction has been in existence since time immemorial and has continually provided alternative construction methods compared to conventional methods in both developed and developing countries as a result of the cheap materials utilized and its environmental friendliness [1] although there have been growing concerns related to its strength, durability and water resistance, especially in regions with severe climates [2]. The problems inherent in earthen buildings begin with the cracks which occur almost immediately after construction and spreads over time, thereby leading to a compromise in the integrity of the structure. Lack of knowledge and technology sometimes allows these cracks to develop and propagate [3]. Clay makes up the largest proportion of the soil used in the production of traditional adobe, which is approximately 30% in order to meet the binding requirement, hence providing weaknesses that appear as a result of shrinkage during the drying phase in the form of internal or surface cracking [4]. The need to improve the properties of the earthen buildings precipitated the studies, which considered the addition of minerals and fiber such as gypsum, lime, natural and synthetic fiber, and marble dust to the mixture.

One of the numerous studies conducted on the improvement of earthen construction involves Alker, which is basically earth with about 8% clay stabilized with lime and calcined gypsum to improve the durability, physical and mechanical properties of the earthen construction [5-9]. Sustainable construction has been achieved from low energy consumption associated with the use of this technology. Its lower shrinkage value has also contributed to the development of fewer cracks compared to the traditional method that involves simply soil. The physical and mechanical properties of Alker are shown in Table 1.

Table 1. Physical and mechanical properties of Alker [6]

Unit weight	1.6-1.7 kg/lt (1600 -1700kg/m3)
Shrinkage	1.0-1.5 %
Compressive strength	2.0-4.0 N/mm2
Shear strength	0.9-1.3 N/mm2
Water absorption	very low
Long term water exposure (except direct rainfall)	no erosion
Heat transfer value	0.4 - 0.5 kcal/mhC
Specific calorific value	1.0 kJ/kgK

The low water absorption observed is based on the reduction of the clay content from 30% in the traditional building to 8% in Alker building, which influences the fewer cracks that occur after construction due to reduced shrinkage.

2 ALKER PRODUCTION

The production of Alker requires earth (contains 8% clay), gypsum (8 to 10%), lime (2 to 5%) and water (15 – 22%) in proportions [7][8]. Gypsum stabilized earth materials sets in 3-5 mins, which would be inadequate to properly work. To delay setting time, it is imperative to integrate lime into the water before adding gypsum, which will eventually provide extra 20 mins of working time during production [5]. Lime has been used for soil stabilization in earthen construction since ancient times based on the pozzolanic reactions that take place with clay minerals [10]. The water-lime-gypsum mixture is then added to the earth and mixed manually or with a machine for 3mins. Afterwards, the mixture is poured into molds and consolidated through vibration for 30s [7]. In recent studies, Alker has been further improved by the addition of marble dust and polypropylene fiber [7].

3 CRACK PROPAGATION OF EARTHEN BUILDING

Traditional earthen construction requires 30 -50% clay content to achieve the desired binding property, which is in contrast with Alker that requires 8-10% clay as a result of the gypsum, which contributes significantly to the binding properties [6]. The cracks that appear and how they propagate have been observed in various studies by using methods such as finite element method and other Image Analysis Techniques.

3.1 Finite Element Method on Earthen Construction

Finite element modelling produces isotropic nonlinear damage model, which is based on damage mechanics, and this makes it possible to identify the decrease in stiffness as a result of the appearance of micro crack damage in the materials described in tensile or compressive loadings [11]. In a study on the failure of rammed earth walls, two types of cracking was observed, i.e. vertical cracks appearing at the central part and inclined cracks at the corners. Figure 1 shows the experimental setting on a wallete (Rammed earth wall containing 8% clay, 34% silt, 8% sand and 50% gravel).

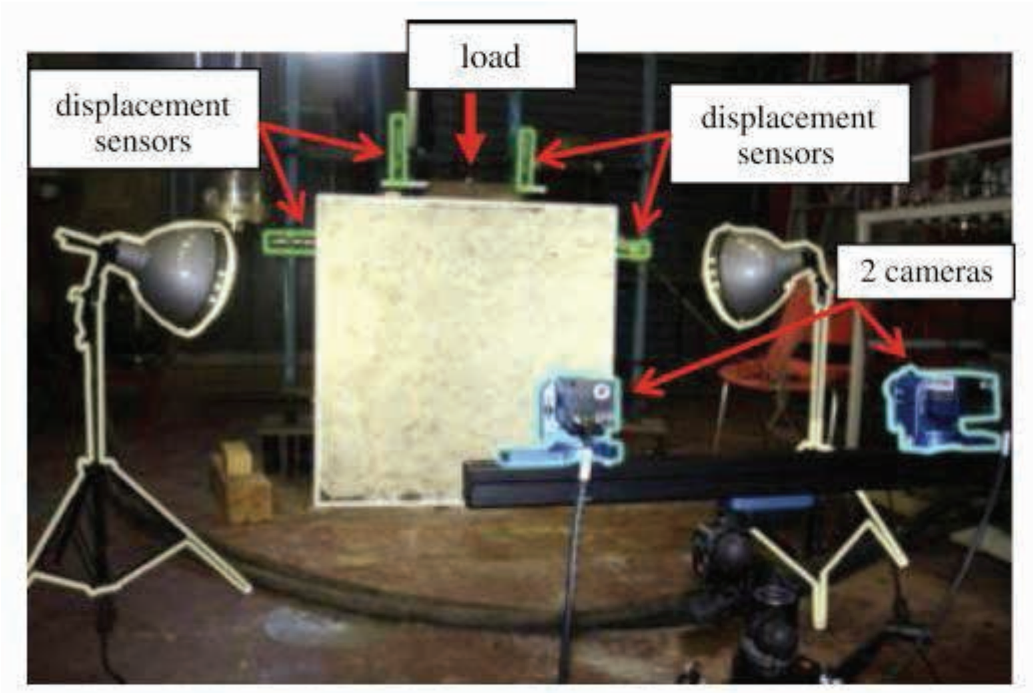

Figure 1. Experimentation on a wallet [11]

Displacement sensors were positioned on the wall to measure wall displacements while 3D image correlation technique with a stereo vision system was used to record the deformation on the surface in three directions. The image was obtained by using two 4-megapixel cameras. The side to be investigated first was coated by a white pure hydrated lime and then black speckles were painted on this white background. The movements of these speckles were recorded during observation and this helped to measure the 3D displacements. Then the strains were calculated automatically from these displacements by using Vic-3D software [11]. Figure 2 shows the failure modes of the wallets. It was observed that zones in direct contact with the load experienced failures and greater settlements than other zones.

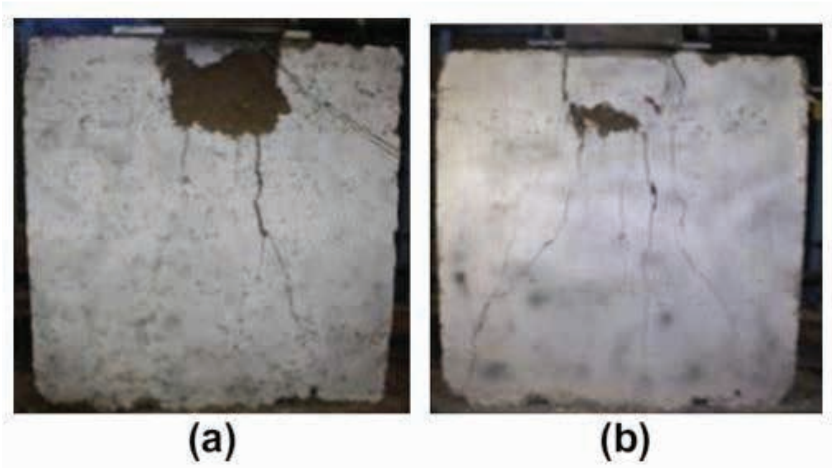

Figure 2. Failure modes of the wallets [11]

In another study, adobe building was modeled by using soil compositions of 78-91% silt and clay, 8-18% sand, 1-4% gravel, and finely chopped straw fibers with 3-25 mm length, and the laboratory testing and finite element simulation of the structural response under horizontal loading was performed (Fig. 3). The failure evolution and crack opening-closing were monitored through digital cameras [12].

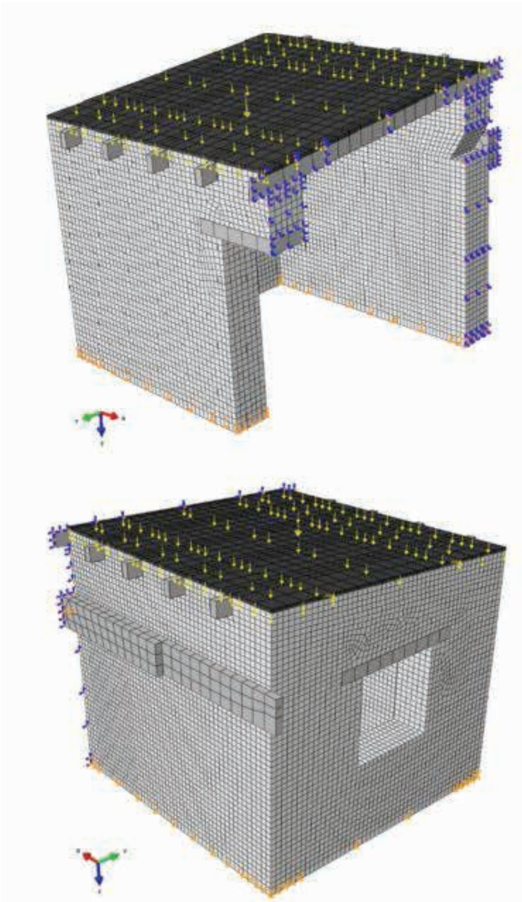

Figure 3. 3D Finite element model developed for simulating the structural response of the scaled adobe building subjected to lateral loading laboratory tests [12]

3.2 Behavior of Improved Earthen Construction

Traditional earthen construction required merely earth and water to produce it but Alker is formed with the stabilization of the mixture by using gypsum and lime. Studies showed further improvement with the addition of fibers, which could be natural or synthetic. Natural fibers which were used in researches include cotton, flax, jute, hemp, and bats fibers [13-17]. Synthetic fibers include polypropylene, acrylic, polyester and polyamide [18][16][15][19][20][7]. Cracks were observed before the peak load was achieved during three-point bending testing. These applied to both reinforced and unreinforced specimens. This increase of strength in the reinforced specimen results from the high stiffness of the fibers and the internal lateral confinement by the stiff fibers. After first cracking, load was transferred to the fibers at the crack site and one of several types of behavior might then ensue depending on the strength, volume fraction and length of fibers. Abrupt failure was observed to occur in all instances for unreinforced earthen blocks and the failure that occurred in reinforced earthen blocks was gradual, as shown in Fig 4. This resulted from the bridging of the cracks by the fibers before the failure occurred [21]. Other studies observed that the failure that occurred in the unreinforced blocks was abrupt and was generally initiated by one or two large cracks, whereas that of the block reinforced with fiber was more ductile and preceded by multiple cracks, as shown in Fig. 5 [20]. The fibers try to prevent crack formation as the stress on the earthen brick increases and when the cracks eventually begin to appear, they bridge the micro cracks to prevent further expansion.

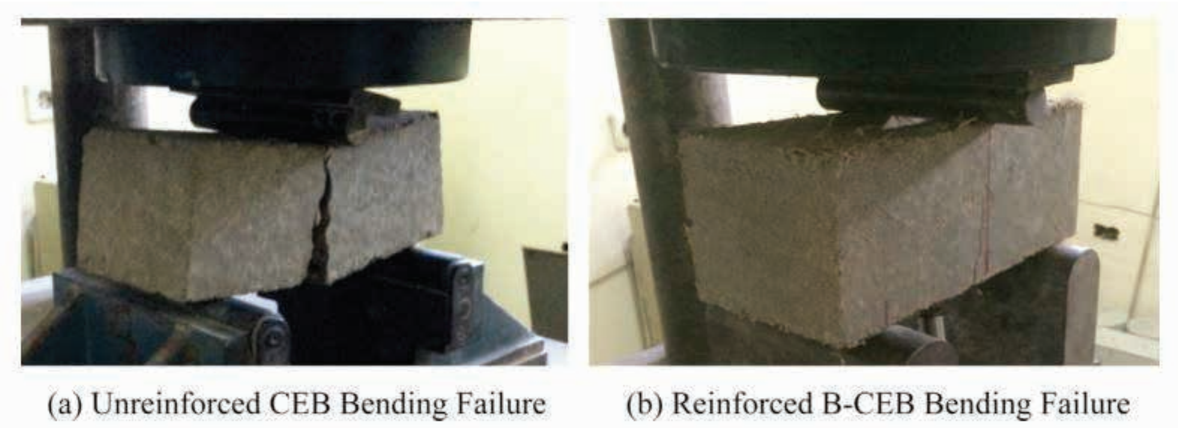

Figure 4. Block's failure modes of three-point bending test [21].

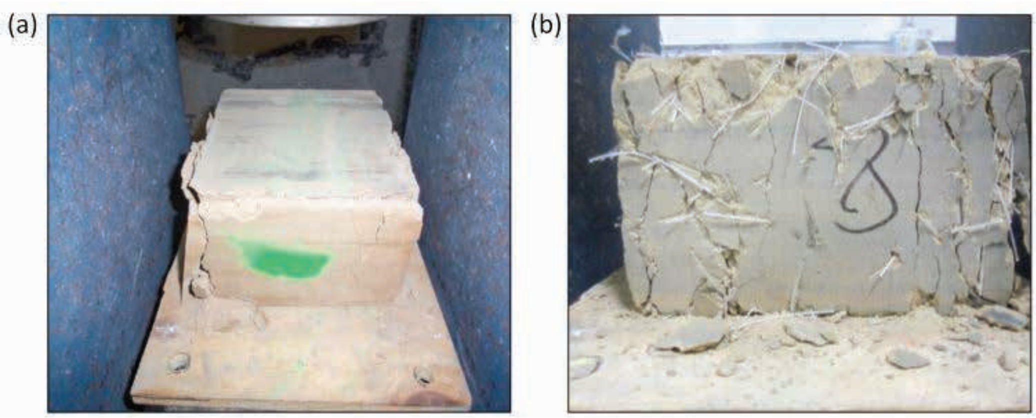

Figure 5. Typical failure mode of blocks (a) unreinforced blocks showing two cracks and (b) blocks reinforced with 0.8% fibers showing multiple cracks.

Some studies suggested that the use of 54mm polypropylene fibers yielded the best result in terms of crack behavior of earthen blocks based on the influences of modulus of rupture, compressive strength and deformability [1].

The unreinforced blocks, when compared to the reinforced blocks, experienced a catastrophic failure such that blocks were separated into two halves during the 3-point bending tests. Through the bridging of cracks, the fibers prevented catastrophic failure of the reinforced blocks (Fig. 6 and Fig. 7). The fibers prevented crack-face separation mainly through a stretching process, which provided an extra energy-absorbing capacity while also reducing the stress around the micro-cracked region surrounding the crack-tip. The observed enhancement in ductility and flexibility of the reinforced blocks improves the capacity of the blocks to store elastic energy [20][14].

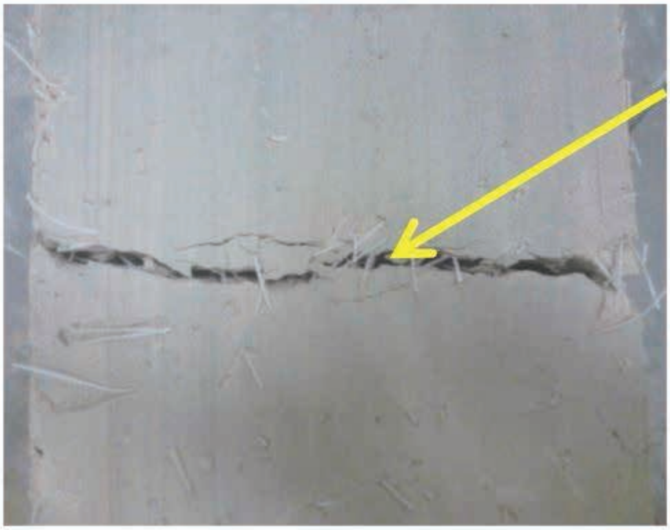

Figure 6. Fiber bridging a crack during 3-point bending test [20]

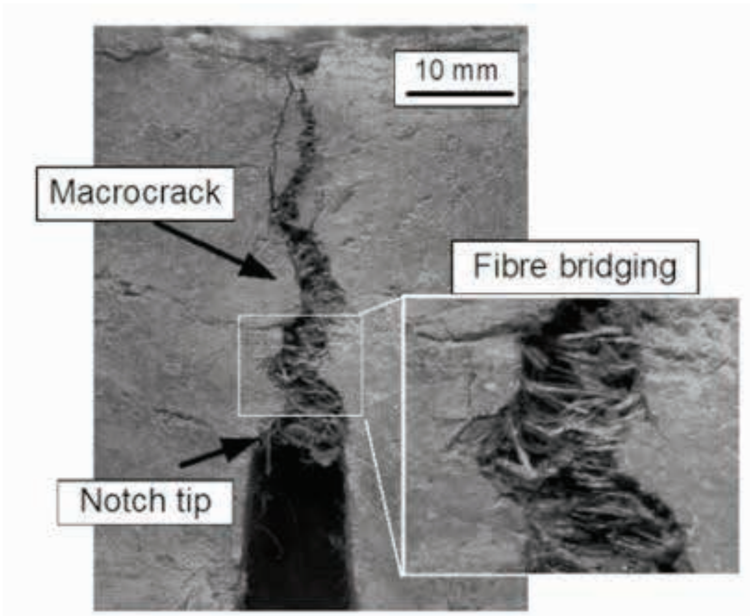

Figure 7. Fiber bridging across cracked surfaces in a sample reinforced with 2% of 10 mm fibers

4 CONCLUSION

Earthen construction has received considerable attention in modern times due to the need to reduce cost of construction, enable a sustainable environment and provide an alternative to the available construction techniques. It has achieved success in the area of improving the properties of traditional earthen construction, which have been plagued with numerous deficiencies. Gypsum, lime and fibers have been commonly used for stabilization since the clay content has been considerably reduced.

Crack propagation of earthen construction has received limited interest as few researches have studied the stabilization of earthen materials and the spread of cracks that occur. There is a need to understand the crack propagation, which will eventually lead to water absorption and loss of strength. Finite element modelling and other imaging techniques have been widely used and given an insight to the behavior of earthen construction under load when cracking begins to occur.

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6th International Conference
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The Significance of Cultural Villages for the Survival of the Southern Ndebele's Earthen Houses

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ABSTRACT

The Southern Ndebele architecture in South Africa is an example of earthen architecture in the African continent. It is a sustainable vernacular architectural style that has transformed and adapted over time to reflect the cultural, ethical and historical context in the South Ndebele society. The South Ndebele is a branch of Bantu speaking people, Nguni, who migrated into the South African Highveld during the fifteenth or the early sixteenth centuries and they were defeated by Boers and left their ancestral lands in 1883. According to their migrations over time, their main tangible culture, architecture, has different sequences. In this paper, the researcher used the written sources and descriptive - analytical methodology to explore the different sequences of the Southern Ndebele architecture over time. In fact, the last sequence of Ndebele earthen architecture has survived with economically marginalized and mostly rural Ndebele families. The results indicate the role of cultural villages as an effective way to enable the survival and conservation of the Southern Ndebele architecture. These new cultural villages have created opportunities in an authentic way to enable the survival of the Southern Ndebele people's heritage and allow visitors to experience the traditional South Ndebele lifestyle.

Key Words: Cultural village, The Southern Ndebele, Earthen houses, South Africa.

1 INTRODUCTION

Some researchers continue to misunderstand the relationship between the Ndebele people in South Africa and Zimbabwe. These two ethnic groups have the same origin in Bantu- speaking people but Ndebele (amaNdebele) group in South Africa is a branch of the Nguni tribe and Ndebele (Matabele Ndebele) group in Zimbabwe is a part of Zulu tribe that immigrated compulsorily by Shaka king of Zulu. 'The amaNguni, with the baSotho, baVenda and baTswana people constitute the main abaNtu (Bantu)-speaking peoples of South Africa, who together with the Khoikhoin and San, make up the bulk of the native South African population. The abaNtu people appeared on the South African scene relatively late and the exact time of their arrival from the north of the country is still an enigma' (Fourie 1999:18). The amaNguni main tribe consists of Zulu, Xhosa, Swati and Ndebele tribes whose languages are close enough to be considered (Kamwangamalu 2001).

3 NDEBELE SETTLEMENT

Ndebele settlement architecture evolved three major typological sequences: 'a pre-colonial grass (beehive) dome, followed by a cone-on-cylinder ('rondavel') type, and the current square and rectangular shapes. These developments should not be seen in terms of precise datable stages, but rather as succeeding stages which often overlapped as earlier types were gradually phased out' (Van Vuuren 1993: 51). The origin of the third stage could have been backed to the 1940s or 1950s (Frescura1985: 265). The architectural patterns changed after 1883, 'especially because of the introduction of large courtyard walls (iirhodlo) and square and rectangular house forms (called iirhaesi, derived from "house")' (Van Vuuren1983: 44–45).

3.1 Grass (beehive) dome

Up to 1883 (the Mapoch War), the Southern Ndebele people built their homes in the form of grass domes (Van Warmelo 1930). The construction of the grass domed house involved three stages: the wooden frame, applying thatch and rope, and finally the earthen work (Van Vuuren 2007: 183). 'The Ndebele dome featured two types of doorway, namely, the snout type and an extended doorway with verandah walls on either side of the doorway' (Van Vuuren 2007: 184). In this pattern, a cattle byre (kraal) was in the middle, which was surrounded by the homes of different wives and children of the chief, storage huts and similar facilities. The huts of the wives of the polygamous male were arranged in order of their rank (the houses of the first wife and mother of the male were settled in the main corner) (Van Vuuren 1983: 49-51).

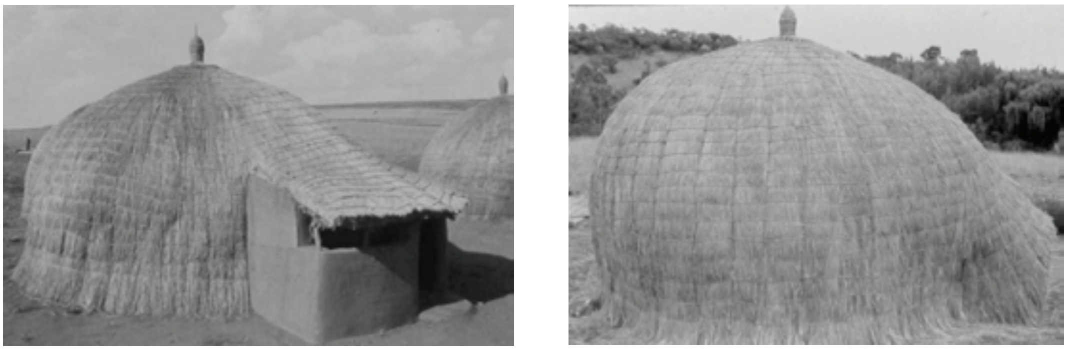


Figure 1. Gross domes (Photograph by Van Vurren).

3.2 Cone-on-cylinder (rondavel)

The second sequence of the Southern Ndebele architecture was cone-on-cylinder type, which was approximately sixty to seventy years old (pre-1883 and up to the 1950s) (Van Vuuren 1983: 85, 96). 'The walls of historic Ndebele cone-on-cylinder dwellings were constructed of columns made from tree trunks or branches, filled in with wattle and daub, and plastered with mud, which was decorated seasonally. The conical roofs were constructed of beams made from branches, had twig purlins tied to the beams with thongs or rope, and were thatched with long grass' (Bakker & Van Vuuren 2004: 130).

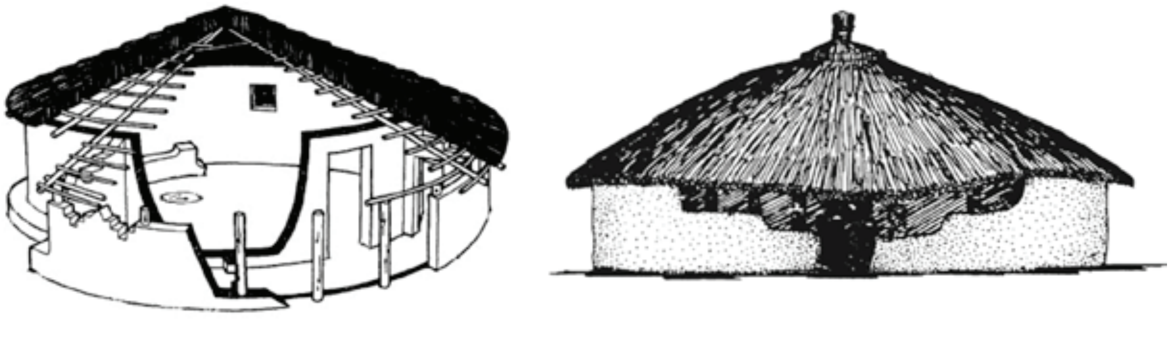


Figure 2. Section of South Ndebele rondavel, 1979 (Frescure/left – Van Vuuren/right).

3.3 Square and rectangular shapes

In the last stage of Southern Ndebele settlement, the cattle byre (isibaya) had a four-cornered shape and was placed in the central position but the layout of the settlement had a linear shape (Van Vuuren 2008: 141). 'Indigenous architecture of the 1950s developed in the context of experience with European architecture, and the murals became the sign of a slow but inescapable surrender to the Western world. The Ndebele were "suspended, temporarily, between two ways of life," the European and the indigenous' (Dainese 2015: 460). Women of South Africa's Ndebele tribe have become world known for their mural designs of their homesteads. The patterns of their designs are geometric expressions and combined with Ndebele beadworks designs, which passed down from generation to generation (Birabi and Nawangwe 2008).

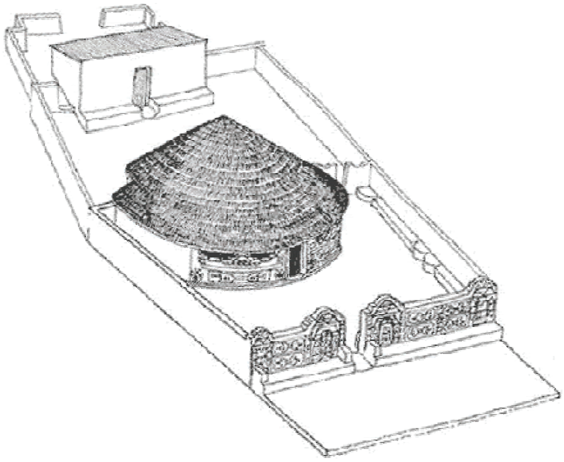


Figure 3. Hut and mural decoration.

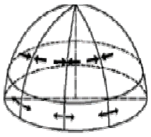
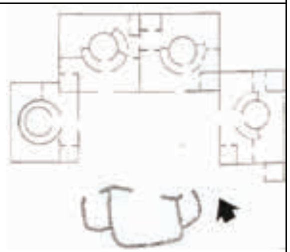
4 ANALYSIS OF THE SEQUENCES

The principal of the sequences in vernacular South Ndebele architecture emerged due to their displacements and social conditions of each period. In response to their needs for the available means in every location, they changed or improved different aspects of their architecture such as form and construction, settlement pattern and decoration. 'The first south Ndebele homes were very similar in both form and construction to those found in their old homeland in northern KwaZulu. Their dwellings were probably built in the form of a thatched dome' (Frescura 2011). In the middle of the 19^{th} century, the Boers forced the southern Ndebele people to leave their lands. Then Ndebele people were settled with Pedi tribe neighbors. Therefore, their architecture began to adapt to the Pedi's architecture, 'cone-on-cylinder, but with significant differences such as double earthen walls, frontal verandah about 150cm wide, which ran from about 4 o'clock to 8 o'clock on the floor plan and perpendicular shapes of the entrance' (Frescura 2011).

By the 1950s, the form of architecture was developed in square and rectangular shapes with the influence of European architecture. Although the construction was the same with the previous sequence, the concrete structures were also observed. It seems clear that Southern Ndebele architecture is a vernacular architectural style that has transformed over time in three stages and one of the main materials used in the different stages of this architecture was earth. This architecture has three main different patterns but tangible and intangible aspects of socio-cultural practices have survived.

The last sequence of this vernacular architecture has been preserved predominantly in Ndebele villages but it is currently in danger of being destroyed. The result indicates that this tribe in South Africa needs to use a practical way to preserve their valuable architecture and develop their dwellings. One of the most efficient contemporary actions to regenerate this historical architecture is the role of cultural villages to sustain and conserve the Southern Ndebele architecture. In continuance, the researchers were introduced with cultural villages as a recent movement in South Africa's tourism business.

Table 1. Analysis of the sequences (by authors)

Style	Date	Materials	Hut diagram	Form	Settlement pattern	Settlement pattern
gross dome	Pre-colonial (pre-1883)	Wood, Thatch, Rope, Earth, cow dung,				
rondavel	1883- 1950	Wood, Thatch, Rope, Earth, cow dung, pigment				
square and rectangular	1950-Present	Wood, Thatch, Rope, Earth, cow dung, pigment, synthetic	-			

5 CULTURAL VILLAGES

Over the past decades, cultural tourism has been one of the key opportunities in South Africa. Cultural villages are a part of cultural tourism, which offers tourists the opportunity to explore and learn about cultural diversity in South Africa. They can experience living in a traditional hut for a short time and gain insight into how tribes live. 'The cultural village is a development of a village in the form of integration between attractions, accommodation and supporting facilities presented in the community life structure' (Sukariyanto 2015). 'Cultural Village is a rural area that offers a whole atmosphere that reflects the authenticity of the countryside, both in terms of social culture, customs, daily life, traditional architecture, village spatial structure, and has the potential to be developed as various components of tourism, for example: attractions, food and beverage, souvenir, lodging, and other tourist needs' (Dewi et al 2018 : 4).

The different cultural villages show the different ethnics groups and their life across South Africa such as Xhosa culture, Zulu culture, Ndebele culture, and etc. More than two dozens of "cultural villages" are located across South Africa. These villages are planned not only for tourism purposes but also as homes for indigenous people of each tribe. In continuance, the researchers introduce two examples of Southern Ndebele cultural villages, which continued their traditional architectural style and serve as a touristic attraction.

5.1 Cultural Village of Mapoch

Mapoch village is one of the villages developed as a cultural village in South Africa. The Southern Ndebele village of Mapoch is situated on the west of Pretoria, which offers a very rural (and non-commercial) experience. Mapoch Ndebele people were forced by the apartheid's government to leave their lands in 1952 and they settled in their present location. The Mapoch people have maintained their traditional lifestyle and practiced their customs and traditions. The geometric mural art is applied in their traditional earthen houses. Daily tours and ceremonies where tourists take part are organized and the local Southern Ndebele people of the village can be supported when their art and craft items are bought.

Figure 4. Cultural Village of Mapoch (www.gauteng.net, www.portfoliocollection.com).

5.2 Cultural Village of Mpumalanga

Mpumalanga village is a cultural village, situated a few kilometers north of Middelburg town in South Africa. This village preserves the culture of the Southern Ndebele people and the community preserved their traditional earthen architecture as a part of their identity. The women and men still wear their traditional clothes and practice their geometrical mural art, which has passed down from generation to generation.

Figure 5. Cultural Village of Mpumalanga (www.flickr.com)

6 CONCLUSIONS

The results indicate a sustainable vernacular architecture progress created by indigenous Southern Ndebele people, which had three sequences and where earth was one of the main materials used in the constructions. As the last sequence, the earthen architecture survived only in rural areas where the community is economically marginalized. Cultural tourism and especially cultural villages are the most fundamental way to help this low income community to preserve their culture and traditional lifestyle as well as their architecture. Mapoch village and Mpumalanga village are two successful examples of Southern Ndebele cultural villages, which offer visitors the opportunity to explore the space of traditional earthen architecture of Southern Ndebele tribe and their traditional costumers. The local Southern Ndebele communities benefit from the tourism business and they have preserved their earthen houses.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Determination of Shear Strength of Bamboo Panel

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ABSTRACT

This paper aims in determining the lateral resistance capacity of the bamboo panel. The main purpose of this study is to determine the shear strength of bamboo wall panel so that this property can be used in the design of earthquake resistant, cost-efficient housing in Nepal. The test was carried out on two types of panels: one with cement mortar plaster on outer face of panel and the other as non-plastered. Each type of panel consists of wooden frames with bamboo strips on the outer face. A total of eight samples were prepared for the test with a panel size of 600mm x 600mm, wall thickness of 150mm x 75mm. The number and thickness of wooden frames used in the sample also vary.

The diagonal compression test method was used to determine the correlation between the lateral resistance and the deflection of bamboo shear wall. The monotonic load was applied until the load stopped to increase from the peak load. The test results showed that ultimate load for various samples varied from 8 kN to 29 kN and also the shear strength for various samples varied from 0.35 MPa to 1.47 MPa, where higher values corresponds to the plastered wall. Similarly, the modulus of rigidity for various samples varied from 7.49 MPa to 87.92 MPa. It can be concluded from the results that the wall with cement mortar plaster on the outer face helps in resisting against higher loads, but as we know that the plasters are non-structural components, it is advisable to consider the strength values obtained for non-plastered wall for the design works.

Key Words: Bamboo Panel, Shear Strength, Nepal

1 INTRODUCTION

The 2015 Gorkha earthquake in Nepal caused loss of many lives and property. As a consequence, the people are more interested in reducing the damages incurred due to earthquake. In recent years, many types of house construction techniques with different types of material have been introduced. Bamboo wall construction, one of such techniques, has also been introduced. In rural areas of Nepal, the availability of building materials such as cement, aggregate, reinforcement, bricks etc. is rather limited, thus, the readily available materials such as timbers, bamboo etc. can be efficiently used for the construction of houses. Bamboo wall panels can be made locally in the village. Untreated bamboo may be attacked by termites and decay after a few years. Treated bamboo will last for more than 30 years and is good for permanent houses. The difficulty in making connections and joints suitable for round (and variable) sections is also evident for mainstream construction; however, an increasing number of researches demonstrates a growing industry and demand for sustainable building products [1]. Light-frame residential and commercial wood structures have performed quite well during earthquakes. However, assessments performed after several natural disasters demonstrated that the prevention of damages to residential wood structures, including residences designed in accordance with current building codes, is crucial [2].

Several studies were conducted on the composite structure of plastered-bamboo structure and shear walls. Hutubessy et al., [3] conducted a study on the material behavior of plastered-bamboo wall towards lateral loads. They determined that the plastered-bamboo wall using wire mesh bracing had the peak load capacity, energy dissipation, and higher ductility than the plastered-bamboo wall that uses bamboo bracing. Also, the elastic stiffness of the plastered-bamboo wall using bamboo bracing was 1.27 greater than plastered-bamboo wall using wire mesh bracing. Miller et al., [2] conducted a study on monotonic and cyclic load testing of partially and fully anchored wood-frame shear walls. Their results show that the ductility of partially anchored walls is below the acceptable criteria for shear walls with structural panel sheathing.

For a seismically active country like Nepal, the design of structures should focus on the earthquake resistance. Therefore, extensive research should be carried out in the respective field to determine the strength of materials. As the bamboo-walled panel type construction is new, research on this field has not been carried out at the desired level. The aim of this study is to determine the strength of the bamboo-walled panel for the lateral forces. To determine the shear strength parameters, diagonal compression test is carried out. This study will also be the guide for the future studies in the field of bamboo-walled construction.

2 TEST PROCEDURE

2.1 Theoretical Background

The shear stress and shear elastic modulus (modulus of rigidity) for specimens are calculated from the experimental test by using the ASTM [4] loading protocol standards. In this case, the Mohr's circle is centered in the origin of the Cartesian system of axis and the value of the shear stress τ is equal to the principal tensile stress f_t. The shear stress τ is obtained as follows:

$$\tau = \frac{0.707P}{A_n} \tag{1}$$

Where, P is the load applied by the jack and A_n is the net area of the specimen, calculated as follows:

$$A_n = \left(\frac{w+h}{2}\right) \times t \times n \tag{2}$$

Where, w is the specimen width, h is the specimen height, t is the thickness of the specimen and n is the percentage of the unit's gross area that is solid, expressed as a decimal. Consequently, the initial shear strength τ_o and the tensile strength are defined as:

$$\tau_o = f_t = \frac{0.707P_{max}}{A_n} \tag{3}$$

Where, P_{max} is the maximum load applied by the hydraulic jack. Furthermore, shear elastic modulus G is obtained by:

$$G = \frac{\tau_{1/3}}{\gamma_{1/3}} \tag{4}$$

Where, $\tau_{1/3}$ is the shear stress for a load of 1/3 of the maximum load P_{max} and $\gamma_{1/3}$ is the corresponding shear strain.

2.2 Sample Description

Wall panels of size 600 mm x 600 mm were used in this study. Two types of samples were used for this purpose based on the wooden frame used and thickness of panel. The descriptions of samples can be seen in Figures 1 and 2 below.

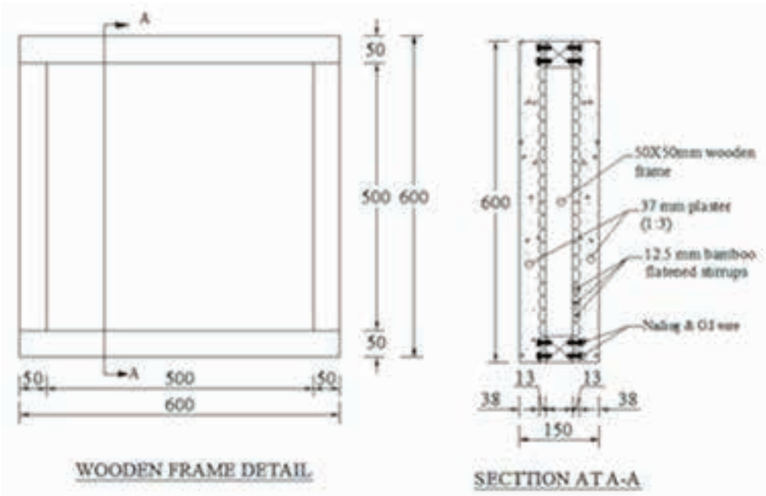


Figure 1. Sample type 1 with 600mm x 600mm panel size and thickness of 150 mm. The cross-section of wooden frame is 50mm x 50mm. Bamboo strips of 12.5mm and 37mm, plaster with cement/sand ratio of 1:3 is used. The joint connections are made with nails.

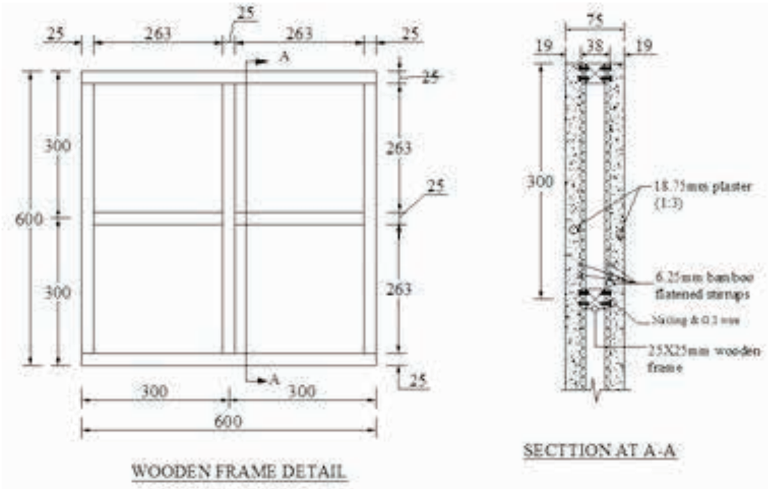


Figure 2. Sample type 2 with 600mm x 600mm panel size and thickness of 75 mm. The cross-section of wooden frame is 25mm x 25mm. Bamboo strips of 6.25mm and 18.75mm, plaster with cement/sand ratio of 1:3 is used. The joint connections are made with nails.

A total of eight samples were made for the study, four for each type. For each type, a single sample is made without plaster on its outer face. The sample identifications for various types are shown in Table 1 below.

Table 1. Sample identifications from S1to S8 for various types.

Type	*ID*	*Description*
Type-1	S1	With plaster around all sides (Outliered)
	S2	With plaster on two opposite faces
	S3	With plaster on two opposite faces
	S4	Without plaster
Type-2	S5	Without plaster
	S6	With plaster on two opposite faces
	S7	With plaster on two opposite faces
	S8	With plaster on two opposite faces

Here, the sample S1 became an outlier since all of its sides were plastered (which is not practical) and it shows completely different behavior than other samples. So, the results of samples S2 to S8 alone are considered.

2.3 Laboratory Testing

The experimental setup is shown in Fig. 3. The sample is placed diagonally and provided with the loading shoe at each end of diagonal for proper load distribution and to prevent the edges from crushing. Dial gauges are fixed properly at the suitable locations so that the horizontal and vertical deflections can be measured easily. The load is applied by the hydraulic jack manually at an interval of 2 kN. Due to application of load, the displacements were recorded by reading the dial gauges. The load is applied and measurement is taken till the maximum load is applied where the sample fails and it can no longer bear any load.

Figure 3. Test instrumentation setup; 1- hydraulic jack, 2- loading shoe, 3- test sample, 4- vertical displacement dial gauge, 5- horizontal displacement dial gauge

3 RESULT AND DISCUSSIONS

3.1 Failure Modes

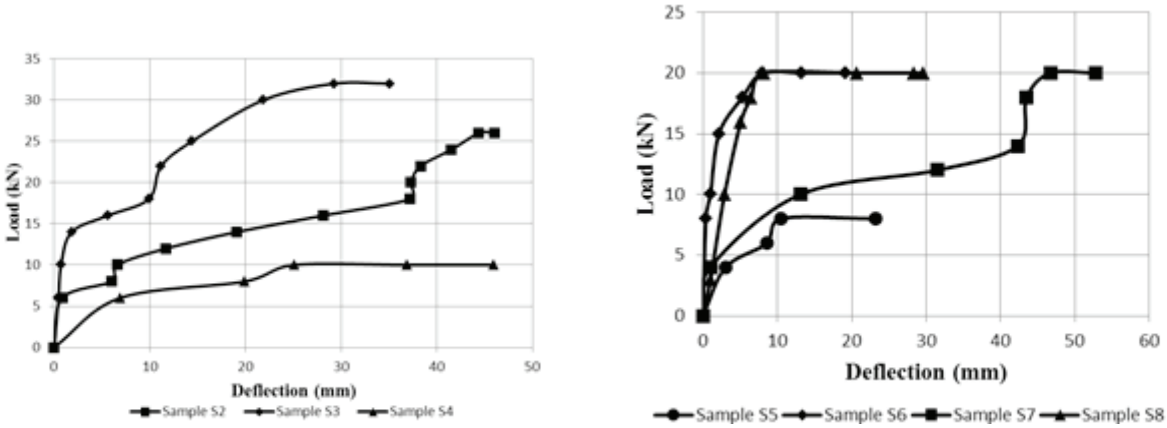
Initially the cracking of the plaster from the either side of the frame can be seen throughout the sample during loading. After load is gradually increased, separation of plaster from the face of panel and failure in the joint of the wooden frame are observed. On further loading, tendency of bamboo strip to be separated from the nailed joint is observed. As the ductility of the wooden frame as well as bamboo panel is higher than plaster, the separation of plaster occurred before the ultimate loading. Various failure modes of the samples are shown in Fig. 4.

(a) (b) (c)

Figure 4. Various failure modes of the samples. (a) Separation of plaster form the panel and cracking of the wooden frame in nailed joint, (b) separation of plaster, and (c) cracking of plaster.

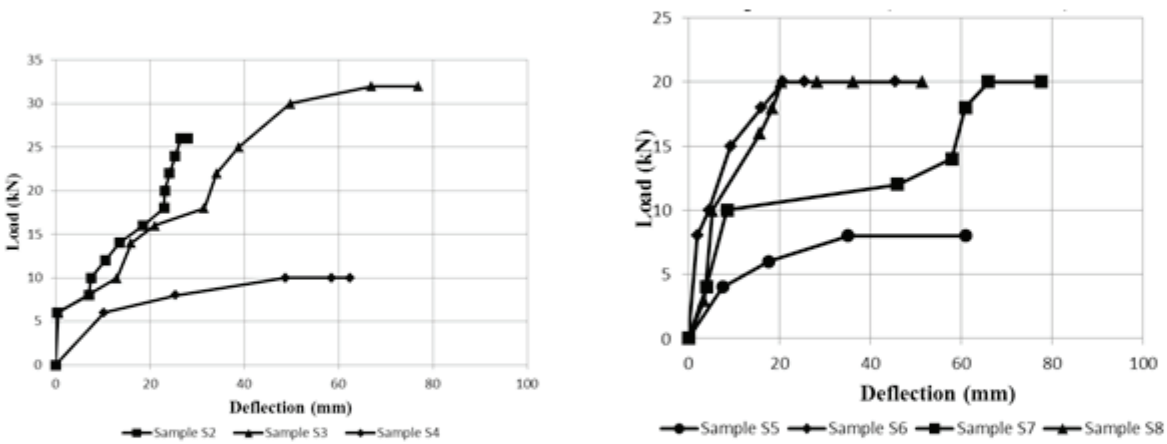
3.2 Load Deflection Curves

The data obtained from the experiment are the loads and the corresponding deflections in horizontal and vertical directions. The maximum load at which the sample fails and can no longer bear any load is defined as the ultimate load. The load-deflection curves for both horizontal and vertical directions for various samples S2 to S8, shown in Figs 5 and 6 clearly specify the characteristic of the wall panel.



(a) (b)

Figure 5. Horizontal load-deflection curve. (a) Sample type 1, where samples S2 and S3 are plastered and sample S4 is without plaster and (b) sample type 2, where sample S5 is without plaster and samples S6, S7 and S8 are plastered.



(a) (b)

Figure 6. Vertical load-deflection curve. (a) Sample type 1, where samples S2 and S3 are plastered and sample S4 is without plaster and (b) sample type 2, where sample S5 is without plaster and samples S6, S7 and S8 are plastered.

3.3 Shear Strength and Modulus of Rigidity

The shear strength of the wall can be determined with the help of Eqn. (3) and the modulus of rigidity is determined with the help of Eqn. (4). The stress-strain diagram for various samples is shown in Figs 7 and 8.

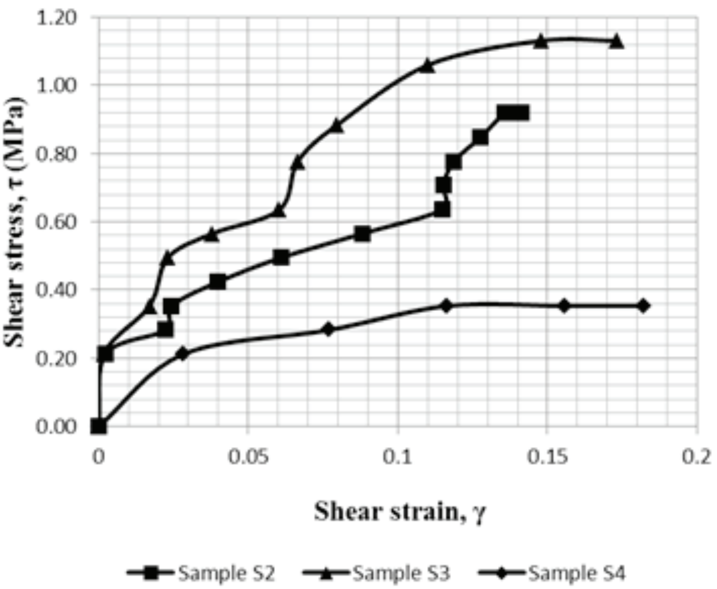


Figure 7. Shear stress-strain diagram for sample type 1, where samples S2 and S3 are plastered and sample S4 is without plaster

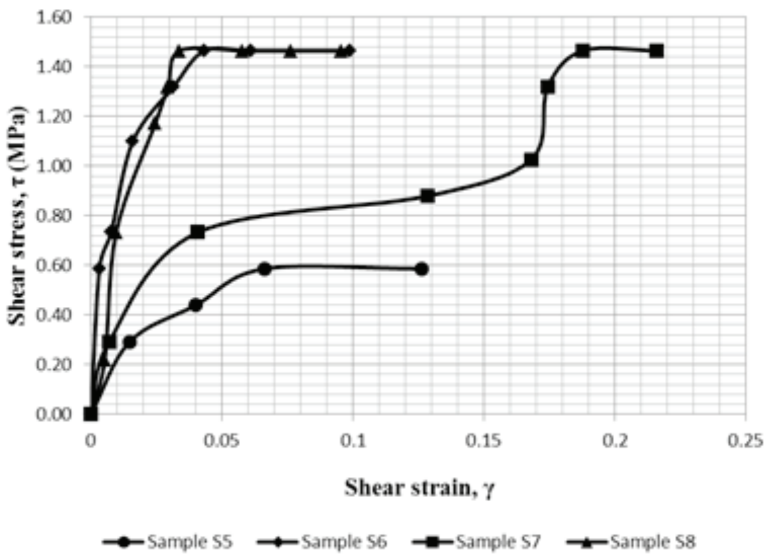


Figure 8. Shear stress-strain diagram for sample type 2, where samples S5 is without plaster and samples S6, S7 and S8 are plastered

3.4 Summary of Results

The final target of the experiment is to determine the load carrying capacity and strength of the bamboo panel for applied loading, which is determined by using the parameters as the ultimate load, shear strength and modulus of rigidity. All these parameters are summarized in the Table 2 below.

Table 2. Outline of ultimate load, shear strength and shear modulus of samples

Sample type	*ID*	*Ultimate load (kN)*	*Initial Shear Strength, τ_o (MPa)*	*Shear modulus, G (MPa)*	*Remarks*
Type-1	S1	36	1.27	17.14	Outliered
	S2	26	0.92	13.28	
	S3	32	1.13	20.89	
	Average	29	1.03	17.09	
	S4	10	0.35	7.49	
Type-2	S5	8	0.59	19.63	
	S6	20	1.47	177.52	
	S7	20	1.47	22.08	
	S8	20	1.47	64.16	
	Average	20	1.47	87.92	

As already mentioned in the previous section, the sample S1 is outliered due to its impractical construction and has the highest ultimate load capacity, which is 36 kN. But for our purpose, we consider only the results of samples S2 to S8.

4 CONCLUSION

The test results showed that the ultimate load for Type 1 samples are 29 kN for plastered wall and 10 kN for non-plastered wall and the corresponding shear strength is 1.03 MPa and 0.35 MPa, respectively. For Type 2 sample, the ultimate loads were 20 kN and 8 kN for plastered and non-plastered wall panel, respectively and the corresponding shear strengths were 1.47 MPa and 0.59 MPa, respectively.

For Type 1 sample, the modulus of rigidity was obtained as 17.09 MPa and 7.49 MPa for plastered and non-plastered wall, respectively and for Type-2 sample, the modulus of rigidity obtained were 87.92 MPa and 19.63 MPa for plastered and non-plastered wall, respectively.

From the obtained values, it can be seen that the walls with plaster have higher shear strength than non-plastered walls. As plaster is a non-structural component, it deforms during earthquake, so the shear strength value obtained for non-plastered wall is the representative one. This study is carried out for the particular type of sample, i.e. sample with specific wooden frame, bamboo properties etc., but the result may vary according to the materials used and the method of construction.

4 ACKNOWLEDGEMENTS

This project was jointly supported by Abari Bamboo and Earth Initiative Pvt. Ltd. & Himalayan Bamboo Pvt. Ltd., Kathmandu, Nepal. We thank Kathmandu University, faculty & staffs of Department of Civil & Geomatics Engineering, Students of Masters in Structural Engineering Batch of 2015 and 2016 for their assistance to conduct the shear strength test of bamboo panel in Kathmandu University horizontal load testing lab.

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6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Godal Baghcheh (Traditional Courtyard) the Climatic Approach in Desert Region of Iran in order to achieve an Earthen Architecture and a Sustainable Environment

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ABSTRACT

Godal Baghcheh (Traditional Courtyard) the climatic approach in desert region of Iran in order to achieve a sustainable environment.

Modern societies face various crises such as environmental, economical, social and identity. The study of evidences from local or ancient architecture of any region demonstrates that humanity's attempts to meet their needs were in harmony with the nature. Yazd is a city, rich of practical solutions in order to solve the environmental problems. Small garden is one of the crucial elements in traditional houses of the region situated in the desert of Iran. This element, usually located below the level surface of the whole or a part of the front yard, has a major role in architectural and urban system of Yazd traditional houses.

Making the abovementioned gardens by digging to the depths of the earth causes to decrease air interchangeable wall surfaces and minimize the heat exchange with outer space. Probing the elements around the small gardens and studying other types of the cases shows that various factors such as changing in Ghanats' systems, the flow of underground water, the process of urban development in different historical eras and many other climatic conditions were effective in the formation of these small gardens.

This article is going to investigate the specified proportion of the small gardens from the climatic aspect by introducing different patterns of small gardens from the viewpoint of their depth from the earth and other important elements in traditional houses.

Key Words: Godal Baghcheh (Traditional Courtyard), Proportions, Climatic efficiency

1 INTRODUCTION

Iranian architecture is rich in variety and internal spaces. Iranian architecture has special features and internal spaces in the desert areas, which could have been the best response to the limitations of climatic conditions in those areas. Godal baghche has been one of the spatial factors in the desert architecture and Yazd city. The name is somehow representative of the qualitative aspects of this environment and also indicates that the courtyards are located below the ground.

Godal baghche (baghchal) was built in the center of the courtyards and inserted a floor inside the ground. The sample of these spaces can be seen in desert cities of Kashan, Naein and Yazd. Godal baghche could provide soil for the materials of buildings and also helped reaching the water of the qanat. This was of high importance specifically for those cities like Naein, which had a complicated network of qanats underground. Around this courtyard, there were often some open rooms or porches, and the growing of pistachio, pomegranate and fig trees was popular in these godal baghche (zandieh, parvardi nezhad, 1389).

Figure 1. The view of Yazd city, the location of Yazd in Iran

Trees in the middle of the yard or another part of the building, in which there is a hole as a result of digging for building the monument and which was cultivated. In fact, godal baghche is considered a part of the building that had close contact with the globalization and the various cultures of the Iranian dynasties" (Gooyay et al, 60:90).

Most of the godal baghches have been destroyed by the natural disasters such as earthquakes or other social factors, and thus, their origin is not clear enough to be reported. For example, there were a high number of godal baghches in Kashan city during the saljoughi'e period, which were destroyed by the 1192 earthquake (Gooyay et al, 60:94).

Most of the studies report that godal baghche did not relate to any specific period, and little by little, as the climate of the deserted areas became drier, many houses were sunk in the holes and then godal baghche was created. These godal baghches had not had any decorations before, but in time, the decorations were added. (Gooyay et al, 60:94).

Figure 2. The houses with godal baghche in various cities of Iran, Isfahan, Yazd, Kashan, Naein

Table 1. The various nominations of godal baghche in different sources

The various nominations of godal baghche in different sources		
source	**definition**	**The names**
Pirnia, 1378:198	padiave, meant to clean	Godal baghche
Pirnia, 1378:286	Another type of green space and used where there was no water	
Hajighasemi,1375	The courtyard in the hole located in the middle of the house, sometimes the difference in height is about one floor	
Rafiei sereshki,1382	Baghchal, or a place in middle with a garden	
Fallahfar,1379,195	A hole with trees in the middle of the yard, a yard which is located one floor below the rooms and is usually surrounded by porches	
Rafiei sereshki,1382,91	padiave, a place for cleaning in the mosques	A deep garden
Mahmodi,Shadpi,1389,1263	a deep garden, a garden with a geometry under other borders	Sunken garden
Heris,1390:1105	a garden with a geometrical design below other borders	Chal bagh
Dehkhoda,1335:5	cavity, a low ground	Godal
Dehkhoda,1335:46	a small garden	Baghcheh
Moein,1386,34	a low ground	Godal
Moein,1386,461	a small garden for growing flowers	Baghche
Khoddari,1388,34	a huge section of the courtyard in the houses decorated with trees	Godal baghche
		(gooyay et al, 60:92).

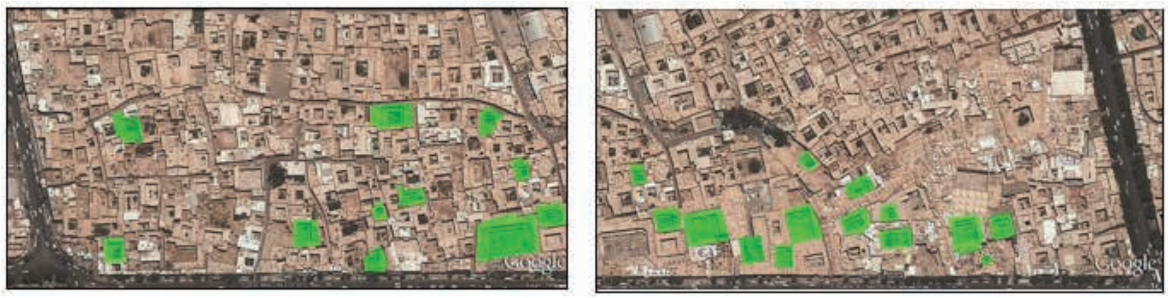


Figure 3. The dispersing of the locations with godal baghche in the twoborhoods of Gazorgah and Mosalla in Yazd

2 INTRODUCING THE HOUSES WITH GODAL BAGHCHE IN YAZD

Among the houses of Yazd with centering yards, most of them were equipped with godal baghches. They had a variety of spaces surrounded by these godal baghches, which are of utmost importance to be studied in greater detail. Thus, to understand the qualities of these spaces, we should study their surroundings. According to the needs of the landlords or on the basis of the depth of the godal baghche, the surrounding spaces were different, and most of them were surrounded by porches and open rooms. The geometry, depth and the surroundings of these godal baghches play an important role in understanding their spaces.

Table 2. Introducing the houses with godal baghche in Yazd

	Naghib alley, Imam street	Safavid era	Malek Sabet house
	Naghib alley, Imam street	Safavid era	Ilchi Khan house
	Iranshahr alley	Safavid era	Imamzadei house

	Amirchakh magh	Qajar period	Oloomi house
	Sahebneali alley, Imam street	Qajar period	Ghazinasab house
	Sahebneali alley, Imam street	Qajar period	Lariha house

2 ALEK SABET HOUSE

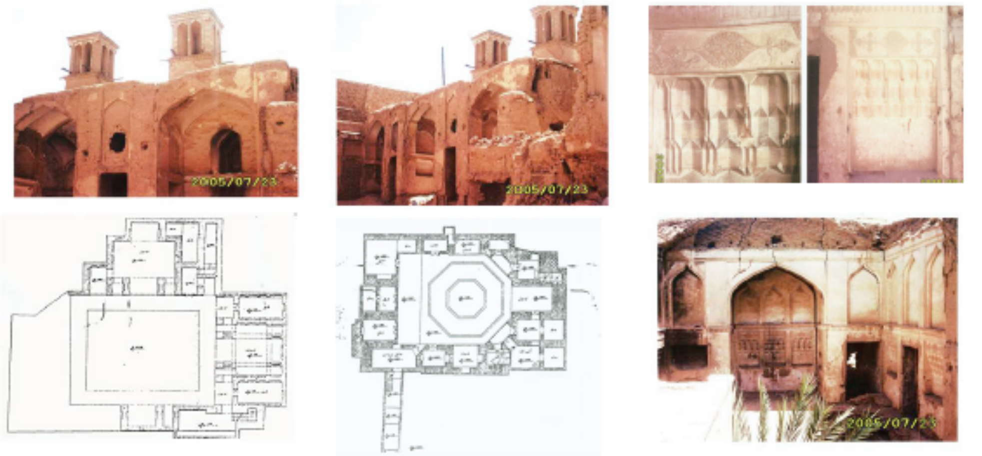
Maleksabet house is one of the inscribed houses in Yazd belonging to the Safavid era. It is one of the rare houses from the Safavids that is equipped with godal baghche and could survive. The godal baghche is octagonal and the two wind catchers on both sides of the yard are its outstanding characteristics.

Table 3. Alek Sabet House

Description	Location	the period	House name
This building is in the form of godal baghche that its interior courtyard is octagonal.	Naghibolashraf alley, imam street, yazd	Safavid's period	Malek sabet house
     			Maps and pictures

3 ILCHIKHAN HOUSE

Table 4. Ilchikhan House

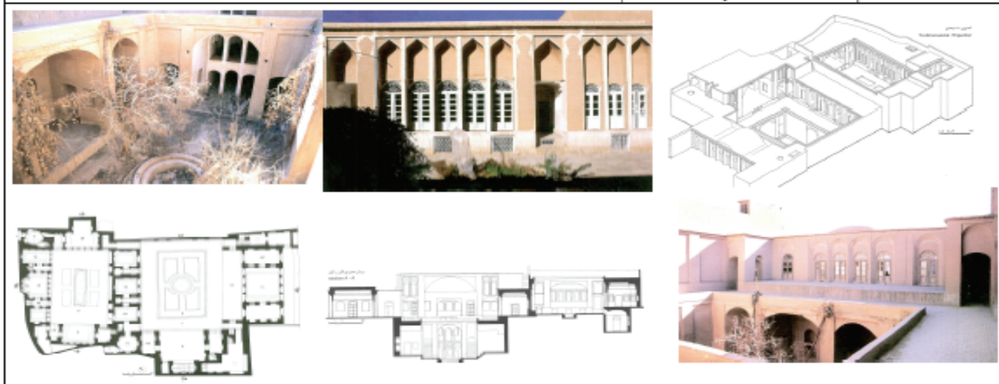
Description	Location	the period	House name
In the past, this house contained two sections of interior and exterior that both had godal baghche.	Naghibolashraf alley, imam street, yazd	safavid	Ilchikhan house
			Maps and pictures

It is one of the inscribed houses in Yazd belonging to the Safavid era. It is equipped with two yards, interior and exterior, both following the model of godal baghche. It has two homolographic windcatchers. Its unique features are beautiful interior design and decorations and plaster work. It should be noted that a majority part of this monument has been destroyed.

4 OLOOMI HOUSE

It is one of the inscribed houses in Yazd belonging to the Qajar period. It has two independent sections: interior and exterior courtyards. Its interior courtyard is bigger and has godal baghche. Its unique feature, among others, is its highly deep godal baghche. Its godal baghche is composed of two deep floors, and the surroundings with two floors are located around this godal baghche.

Table 5. Oloomi House

Description	Location	the period	House name
In the past, this house had 2 sections of interior and exterior that only one courtyard had godal baghche.	Ghassabbha alley, amirchakhmagh, yazd	qajar	Oloomi house
			Maps and pictures

5 THE REASONS FOR FORMING GODAL BAGHCHE

There are various hypotheses about forming godal baghche, several of which are explained below.

1. The lowering of the surface water and the availability of water

One of the existing hypotheses about forming godal baghche is the lowering surface of water and the decreasing level of water in qanats during the times. As the level of the water of godal baghche was the same with the level of the water of qanat, godal baghche could provide the availability of the water of qanat (Memarian, 1373:276). Among the deserted cities of Iran, Yazd, Kashan, and Kerman are a few examples that used godal baghche to reach the water of qanats underground.

There are various reasons why the level of underground water decreased during different eras such as the sinking of water to the deeper layers of the earth or the various diggings of qanats in the villages and cities. We can prove this by locating the traditional houses in the ancient texture of Yazd. To this end, we figure out that all these houses are built above the path of qanats.

2. The city development and building houses above the holes of the city.

Another hypothesis in this regard is that some of the neighborhoods of Yazd like Godal Mosalla and Godal Abbassi were located out of the downtown area, and usually, the soil out of the city was used to build the town houses. In later eras, while the city expanded to these areas, the architectures decided that instead of filling these holes, they would keep them as godal baghche with the yards in lower levels and create the yards with two floors.

3. The climatic procedure in arid areas

One of the customary ways to escape from the extreme hot weather in deserted areas is to go inside the depth of the ground. Going inside the depth of the earth can help to reduce the degree of the hot weather exchange. Godal baghche is a comfortable place during the hot and scorching summers as it is deep in the underground and surrounded by green trees. Because of these trees, the sun light cannor enter the space directly, and this location can prevent the harsh desert winds.

Since the surrounding of these godal baghches was pure soil, a large number of people chose the nearby rooms to live during the hot summers. In fact, it can be said that godal baghche tried to moderate the temperature by going deep inside the ground. Also, building the houses deep inside the ground helped to protect the buildings against earthquakes.

6 RESULT AND CONCLUSION

Each reason mentioned above can be considered one of the reasons for forming the houses with the model of godal baghche in the deserted areas. Being located in different areas, the houses are subject to various conditions and thus, the necessity of forming this element has arisen. These various factors resulted in different models of godal baghches in Yazd and there are three different models of godal baghches in the courtyards. In some houses, this garden was located at the surface of the yard, and in others, it was located deep in the ground. But by studying them more elaborately, we can get more comprehensive models and detailed information in this regard. Therefore, from the various types of gardens and godal baghches, we can outline some points below. Thus, shading and going to the underground to escape from the hot weather was one of the reasons for making godal baghche.

Table 6. The various models of godal baghche in Yazd

The various models of godal baghche in Yazd	**The first model**		This model exists in most of the houses in Yazd	The gardens at the same level from the courtyard
	The second model		We can see this model in some of the houses in Yazd, such as Ilchi khan, Lariha, and Ghazinasab	The godal with the depth of 2.5 to 3 meters
	The third model		It is rarely seen in houses of Yazd like Oloomi house	The two-floor godal baghche with the depth of more than 6 meters

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Reuse of Traditional Earthen Wind Catchers in Contemporary Architecture (Case Study: Yazd-Iran)

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ABSTRACT

The city of Yazd is renowned as the city of "Wind catchers". However, after the introduction of modern cooling systems, these earthen elements, which used to ventilate and cool the buildings in the past decades, started to become a thing of the past and constructed less and less.

Wind catchers can provide thermal comfort in summer with little or no use of electricity. Therefore, they can be incorporated into new building designs in the hot-arid regions.

In this paper, after explaining the design, construction, climatic and structural characteristics of this earthen element, some of the new constructed wind catchers, which were modified to increase their efficiency according to intended use, will be introduced.

The results indicate that if wind catchers are equipped with the water vaporization system, the temperature can be decreased considerably and sustainable environmental comfort is achieved.

Key Words: Wind catcher, Earthen structure, Sustainable Cooling System

1 INTRODUCTION

Wind catchers or Badgirs are towers installed on top of buildings, which are used to ventilate and cool the buildings in hot and arid or humid areas around the world. By chanelling the outside air into the building, wind towers serve as a natural ventilation system for architectural spaces. On the other hand, nowadays, with the introduction of fast-changing advanced technology, the wind catchers has great potential to align with modern energy efficiency. This article intends to share present knowledge about wind catchers and develop their performance in combination with modern technology.

As an initial step, traditional wind catcher and its function will be introduced and then, the paper will focus on the history of traditional ones. Improved wind catchers available in the city of Yazd and new methods to increase their energy efficiency based on the author's experiment will be covered in the last section of the paper.

This paper is presented based on an experimental study conducted during a field study on wind catchers. Theoretical and basic studies were conducted through library studies. Structural and material researches were prepared by investigating the wind catchers in Yazd and interviewing with experienced skilled workmen.

2 THE WIND CATCHERS IN YAZD

The province and the city of Yazd are located on the central part of the Iranian plateau. Being located near the central mountains and far from the Caspian Sea and the Persian Gulf, Yazd has a climate that resembles to dry and semi-dry desert climate. Hosting a large number of earthen monuments and sites, Yazd possesses a rich heritage of ancient culture and civilization acquired throughout various historical periods of Iran[1].

A large number of historic areas of Yazd contain various traditional earthen structures such as wind catchers, water cisterns and Qanats, many of which are still used. Among the key architectural and urban features of Yazd, wind catchers have been among the most significant elements of its built environments for centuries [2] (Fig.1).

Figure 1. Skyline of the city made of earthen materials has been dominated by the domes and wind catchers (www.iranreview.org).

3 THE WIND CATCHER AND ITS FUNCTION

A wind catcher is a structure built above the roof of the buildings that catch the passing fresh air and channel it down to the ground floors and basements. Weathering shaft, ventilation shaft and wind tower are some other names used for the wind catcher. In the wind catcher, the hot air is catched at the top of the structure and passed through a simple channel, delivering the air at the bottom of the channel, which is the ground floor or basement[3].

Wind catchers have two main functions:
The first function is based on the principle of suction of opening facing the wind and the suction of openings back against the wind.

"The way a wind catcher operates is mainly based on taking the fresh air into the building and sending the hot and polluted air out', i.e. 'the suction function". It may be not necessary to explain when the wind hits against the walls of internal partitions of the wind catcher, it necessarily falls down, but it is necessary to refer that the other holes of the wind catcher turning back to the wind direction give the hot and polluted air into the wind and thus, works like a ventilation and a suction machine (Pyrnia, M.K, 1981).
"This type of wind catcher actually functions based on the principle that when the wind hits an obstacle, since the density of the air is thick on the side of the wind direction, a positive pressure is set against the negative pressure in this direction on the other side. Therefore, when the ventilation

1 Abouei,R,2006 , page 1
2 ibid,Abouei,R,2006 , page 1
3 ibid,Abouei,R,2006 , page 2

is opened on one side of the wind, there will be a positive and a negative pressure. According to this principle, in the wind catcher, the opening facing the wind takes the air into the space underneath (Tallar)[1] and the air in the tallar with its negative pressure on the opening back of the wind is drawn out" (Azami, 2005) (Fig. 2).

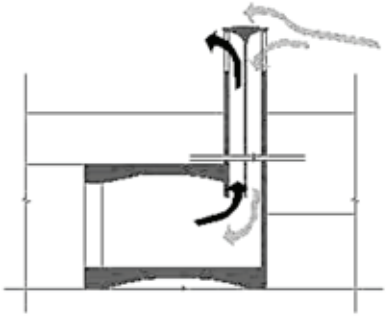


Figure 2. Traction and suction in Badgir (Azami, 2005).

The second function is based on the temperature difference. "It seems that technicians show little interest in the function of a wind catcher regarding the temperature difference. In fact, when there is not a sensible wind blast, the wind catcher acts according to this phenomena. "During the day, since the sun hits on the southern face of the wind catcher, the air heats in the southern face of the wind catcher, and goes up" (Bahadori, pp. 144-54). This air rising above through the inner air of the tallar is replaced and in fact, it creates a sort of proportional vacuum inside the tallar, and takes the cool air of the inner court into itself, so the existing air in the northern opening is pulled down (Fig. 3). During the night, it becomes cold outside, and the cold air moves down. This air is saved by the heat and becomes warm on parapets and then, goes up. This circle continues till the temperature of the walls and outside temperature become equal. But usually before it arrives at this point, the night ends and once again the wind catcher functions as described above. In general, most of the time, wind catcher performs as we described due to traction, suction, and temperature difference" (Azami, 2005).

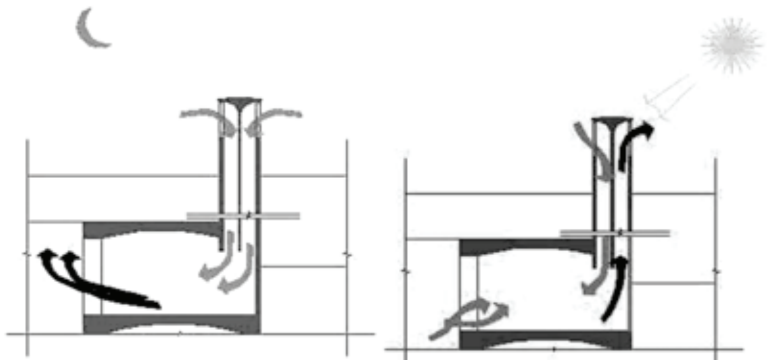
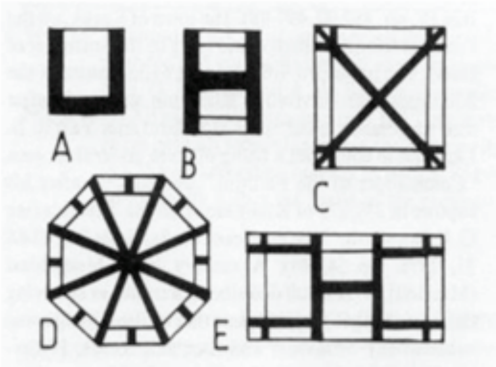


Figure 3. Badgir function during the day and night (Azami, 2005).

4 DIFFERENT TYPES OF TRADITIONAL WIND CATCHERS IN YAZD

"Wind catchers have various forms and plans such as square, rectangular and octagonal. The square form is the type used in the four-way wind catchers. The rectangular forms consist of one, two or four directions. The octagonal form is the type used in eight –way wind catchers in Yazd. (Fig. 4)

The four –way towers are the most popular wind catchers in the city of Yazd. They have four main vertical shafts divided by partitions" (Roaf, s,1982) .



A: Unidirectional

B: Bidirectional

C: Four -way

D: Eight -way with two vents on each side

E: Four -way with two "false" vents on two opposite sides.

Figure 4. Diversity of forms and plans of Yazd wind catchers (Roaf, p. 1982).

5 STRUCTURE AND CONSTRUCTION OF WIND CATCHER

Wind catcher is constructed of different elements and the cooperation among these elements will be effective in the final formation and structure. Every component has unique structural and functional properties and their order in a wind catcher is: stalk, partitions, shelf and crown from the bottom to the top.

Stalk or column is the lower part of wind catcher, which is placed between the roof and the shelf. The stalk is the connection between the shelf and the space beneath the wind catcher and bears most of the weight of wind catcher. The mass center is located there. The stalk's shape is like an incomplete pyramid and helps its stability.

Partitions are made of Khesht (mud brick) and brick which divides wind catcher's channels into smaller channels and moves the air down the wind catcher from different directions. These partitions are placed throughout the entire wind catcher from the bottom to the ceiling. The partitions have different shapes and vary by materials used. They absorb a great amount of heat. In addition to increasing the wind speed by decreasing the canal's width, the partitions increase the structure's stability. As woods are placed between partitions, partitions and other parts of wind catcher are more connected, which further increases the stability and strength.


Figure 5. (top left): Stalk of a destroyed wind catcher in sahlebneali quarter of Yazd (Authors)
Figure 6. (top middle): The major partitions of a wind catcher (Rudiger Lorenz, der Windturnbauer).
Figure 7. (top right) : The major partitions of a 3D model of wind catcher (Authors).

Source, mouth or shelf is the upper part of wind catcher's stalk, which sends the air into the wind catcher. The normal form of the shelf is horizontal, vertical or square-like. The source surface is divided by some blades, which increase the beauty of the wind catcher. These blades are connected to the walls and strengthened against destruction and fall by woods within their formation.

A crown is the ceiling cover and the highest part of wind catcher, decorated by a special type of brick. The materials used for crown are essentially brick and mud that are put together like floors and they create some projection that plays a key role in directing the wind to the source.



Figure 8. (top left): The shelf facade of a wind catcher in yazd (Authors).
Figure 9. (top middle): The 3D model of a wind catcher's shelf (Mahmoudi, M, 2007, p103).
Figure 10. (top right): The crown of a wind catcher in yazd (Authors).

To build a wind catcher, the stalk is built up to a certain height and then the interior partitions. The partitions' weight will be transferred by the wood placed between them. After finishing the stalk and placing the partitions, the process of building the shelf begins. After finishing the shelf and its internal and external blades and fixing the wood between them, the ceiling is built and the crown is placed on top. At the end of building process, wind catcher will be covered by mud and decoration will be added to some parts.

To increase the stability while building the wind catcher, the parts are connected with a type of wood named Shouruneh[2]. The essential point is to use a great deal of woods in different parts and levels of wind catcher. These woods are generally Shouruneh, which offers high resistance and high mass and is resistant against penetration of insects and ants. The wood plays a major role in the stability of structure of wind catcher and acts as a joint. The connection between these woods is Sazou [3] or nail in modern structures and this connection is linked and fixed to other parts by plaster of stucco with mud.

Figure 11. A 3D model of a badgir's construction procedure from the left to the right (Authors).

6 THE NEW IMPROVED WIND CATCHERS IN YAZD

In recent years, new types of wind catchers have already been reconstructed in different forms. This paper will introduce some of these new restored and reconstructed wind catchers in Yazd, which belong to different buildings such as houses, mosques, and official buildings. Some of them have been constructed by new materials instead of earthen materials. In all of these examples, cooling water evaporative is required, and as water flows in some internal parts of wind catcher, it is not possible to use earthen materials. Therefore, brick, cement, and steel were used. The forms of these new wind catchers are the same as the traditional ones.

6.1. Wind Catcher of Rasoulian House (art and architecture faculty of Yazd University)

After the house had been vacant for several years, the heirs of the deceased Rasoulian donated the house to serve as the School of Architecture in 1999 and after a period of rehabilitation and restoration, it was officially opened as an academic building in January 2000[4].

As the pictures show, wind catcher of Rasoulian house is not so tall and connected with the closed space under it and is situated in the upper level of sardab[5]. Considering the hot and polluted air, the suction ability was utilized instead of blowing function. In fact, the cool and wet air comes from the basement and sardab through this function (Fig. 2).

The results of climatic analysis of the current use of the wind catcher showed that the current use of the wind catcher would not bring the space cooling requirements to the desired comfort level. The strategy to use the wind catcher for suction and force the cool air from the sardab to circulate through the space is considered as a suitable and logical proposal to bring the wind catchers back to life again [6] (Fig. 3).

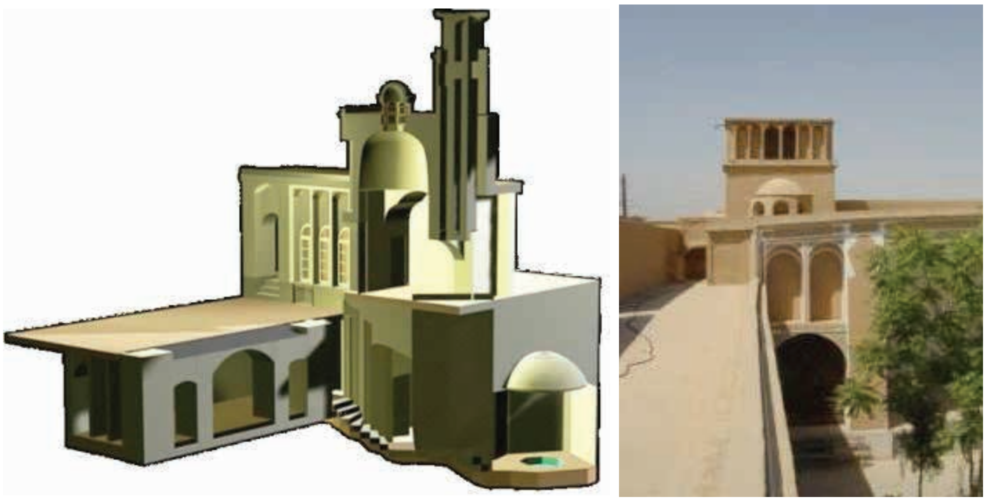


Figure12. Picture and section perspective of the summer side of the Rasoulian House (Ayatollahi, 2007).

4 Ayatollahi,2007 , page 4

5 Cellar, digging space in the basement space to access the Qanat (subterranean).

6 ibid ,Ayatollahi,2007 , page 5

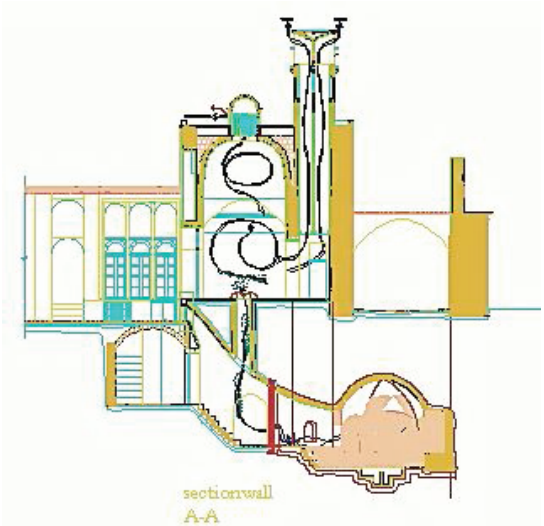


Figure13. Section showing the air and suction effect of the wind catcher (Ayatollahi, 2007).

6.2 Wind Catcher of Yazd University Mosque

Due to lower temperatures through evaporative cooling, water is collected and used as the symbol and minaret of mosque. By using cotton curtains and straw (such as the straw used in water cooler) in two openings and wetting them, the air temperature is reduced. In the third opening, just like the traditional wind catchers, air flow entered the space without evaporative cooling. Experiments show the superiority of these two new models which use evaporative cooling.

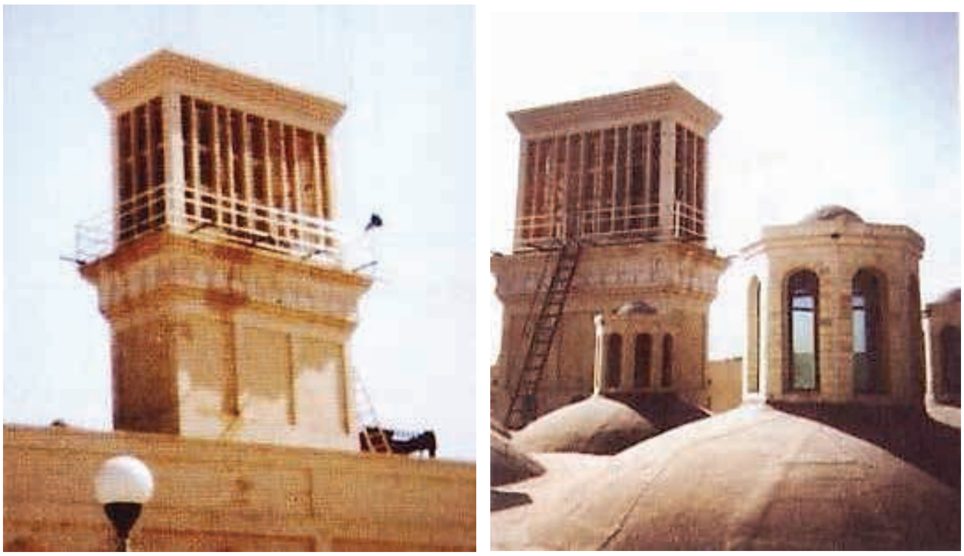


Figure 14, 15. Wind Catcher of Yazd University Mosque (Bahadorinejad, 2008).

6.3 Wind Catcher of Asr-e-Enghelab Research Center

One of the three openings in this wind catcher, just like Yazd University's mosque, used the traditional method without evaporative cooling and in the two other openings, wetting was applied and thus, the effectiveness of new methods was approved.

Figure 16, 17. Wind catcher of asr-e-enghelab research center building procedure (Bahadorinejad, 2008).

6.4 Wind Catcher of Farahza House

This house was modeled similarly with the historic house, where evaporative cooling was used for Houzkhaneh [7]and wind catcher. Natural air flow hits the wet perforated bricks and lower the temperature and from the lower level, it is transferred to the house. This transfer to the Houzkhaneh and the lowest level of house makes the basement cool.

Figure 18, 19, 20. Wind catcher and Houzkhneh of Farahza house (Farahza, personal archive).

7 TRADITIONAL WIND CATCHER'S PERFORMANCE IN TODAY'S CONDITIONS AND THE STRATEGY TO IMPROVE THEM

7.1 The Weaknesses of Using Traditional Type Wind Catchers in Modern Architecture

- Due to global warming in recent years and the increased number of cars and increasing environmental pollution, the air temperature, which enters the building from the wind catchers, is almost equal to the environment temperature and does not have the ability to provide thermal comfort to the residents.

7 It implies a basement with pond and in some cases water pond is passing in the middle of it.

- In traditional types of wind catcher, the heat radiation of the exterior walls of the wind catcher to the outdoors decreases the temperature. But today, due to the low mass of building materials, this radiation does not occur.

- Traditional ones are highly dependent on weather conditions and winds. When the wind speed is low (less than 2 m/s), they cannot provide the amount of air required to provide airflow in the building.

- The valves of the inlet of the traditional wind catchers are where dust, insects and sometimes small birds enter the building.

- In traditional wind catchers, their efficiency decreases when they encounter unforeseen unpleasant winds at times of the year.

- The height of the wind catcher has a big role in the efficiency of cooling and air conditioning and as the height increases, its efficiency also increases. But there are architectural and engineering constraints to maintain this height. In today's conditions, there are also restrictions imposed by urban laws that do not allow the construction of a wind catcher with the desired height.

Wind catchers, at certain times of the year, provide comfort conditions inside the building through natural ventilation and minimize the use of mechanical ventilation. In the following, the necessary solutions to overcome the defects of the traditional types and to improve their performance for current use are presented. These solutions are designed to reduce energy consumption and increase the cooling efficiency of these wind catchers. Suggestions are also made for designing new (modern) wind catchers.

7.2 Strategies for improving the Performance of Traditional Wind Catchers

- To control unpleasant and unexpected winds, the valves can be fitted higher than the wind catcher with easy access and remote control capabilities, so that they could be blocked during the cold weather of the year. One-way dampers can also be used at times of efficient wind, they open and allow the air to enter. At times of undesired wind flow from other fronts, they close due to negative pressure and will not allow dust to enter the space.

- To counteract the low wind speed and increase the wind catcher's efficiency in such regions, a number of small pools (ponds) placed on top of each other can be used as the wind passes through this pond. Its temperature decreases with evaporation cooling and its humidity increases. The location of this secondary pond should be within the main column of the wind catcher.

- In regions where wind speed is appropriate, the combination of a mechanical system with a wind catcher can have its benefits. Using a rust (such as a water cooling system) or other wet surfaces, called a moisturized pad, and combining them with a mechanical system in the badgir's opening valve that is connected to a continuous water flow, perform an evaporative cooling function with higher efficiency and is effective in reducing the appearance of insects.

7.3 Suggestions for Designing New Wind Catchers

Taking into consideration the height of the wind catcher for cooling efficiency and restriction of city ordinance, it is suggested to design the main wind catcher based on the requirement and condition of cooling efficiency with the possibility to alter the height of wind catcher when it is necessary. So, the height of wind catcher varies by climate.

For the increasing the efficiency of the wind catcher, which has a direct effect on decreasing the energy consumption inside the building, wind catcher bonnet should be able to put wind catcher crater in the direction of the wind automatically without using any energy. By perching the wind catcher crater on the direction of the wind, the efficiency of the wind catcher increased as result of the consumption of the energy inside the building.

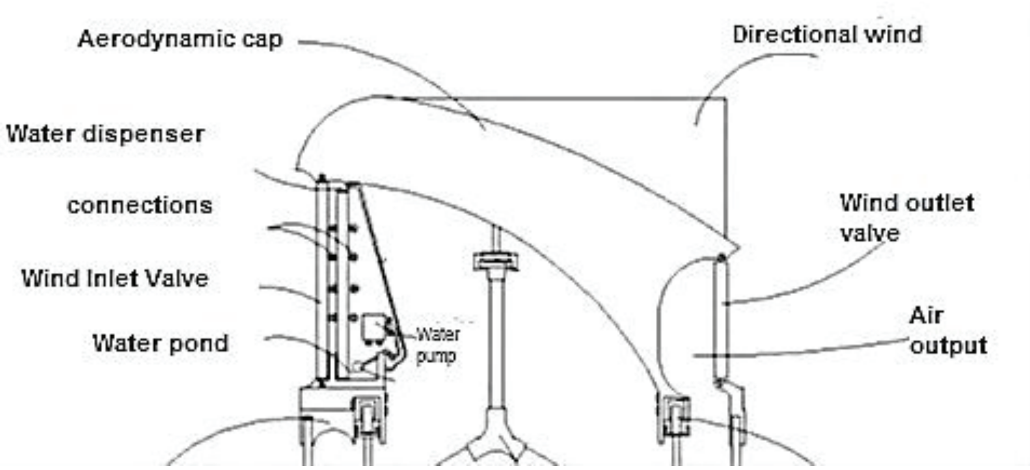


Figure 21. Design and details of a wind catcher's bonnet (Authors).

A moving wind catcher bonnet is putting its crater in the direction of the wind, which increases the wind flow inside the wind tower. For the increasing the difference between walls speed, wind catcher celling window should bend and be designed aerodynamically. So wind can flow through the end where the wind catcher span ends, and thus, increases the speed and decreases the pressure difference on wind catcher back window. This pressure difference is creating the suction inside the wind catcher air exit column. Therefore, by creating a closed system and exiting on the back of the wind catcher crater, this decreases the pressure created inside the wind catcher's air exit and can be used for ventilation and increasing the wind flow on input column of wind catcher.

One of the main problems of traditional wind catchers is their dependence on atmospheric conditions and wind flow. In other words, in case of lack of wind flow, wind catcher cannot ventilate and cool the building. And this creates a big problem for using any wind catcher on structures where cooling operation is important. Solar chimneys can be used to overcome this problem. The working principle of solar chimneys is as follows:

With solar radiation (3) on wind catcher (1) the air inside the chimney gets warm and then it travels inside the chimney solar duct (4), (5) pressure decreases, which results in air suction inside the building. While solar radiation hits the solar chimney, the air inside the chimney gets warmer and a as result, its density decreases and hot air starts to move upwards and the pressure inside the chimney column decreases, and this pressure decrease causes the suction inside the chimney.

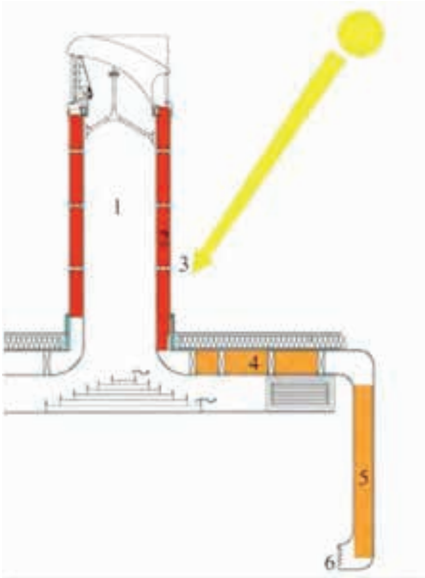


Figure 22. Using solar chimney system in wind catcher (Vosoughifar, personal archive).

The use of a solar chimney has a big effect on wind catcher's function and it increases its efficiency inside the building. American researchers report that they could increase the efficiency and ventilation inside the building by using a closed system in the wind catcher, as shown in Figure 22.

8 CONCLUSION

Wind catchers are still considered and used in different shapes because of their unique performance. Advanced technologies, materials and new methods improve the quality and effectiveness. This paper shows that the traditional and modern types of wind catchers of earthen materials can still be used if the function is improved with modern technologies.
Wind catchers play an important natural role for building ventilation and for reaching sustainable architecture. For achieving complete design, a combination of different professions such as architectures, structural engineers, mechanical engineers, energy specialists and other related expertise are needed.

By providing new solutions for building a novel wind catcher, we are able to use this ventilation method on modern buildings. In order to promote wind catcher applications further, method of joining solar chimney inside wind catcher, increasing the efficiency by embedding water pond, modifying the input wind catcher bonnet, and other functional ways are aimed. The modification of input bonnet on wind catcher will prevent the entry of insects, small birds, and dust,. The efficiency will be increased by modifying the altitute and moving bonnet systems on wind catcher.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Plano-Convex Bricks in Ancient Mesopotamian Architecture

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ABSTRACT

Mudbrick is the main building material used in ancient Near Eastern architecture since the Neolithic Age. With a wide range of uses, mudbrick was employed in walls, floors, roofs and drain systems in Mesopotamian architecture. The material was also used in columns. Mudbrick columns were used for decorative purposes, especially in the facades of ziggurats and temples. Mud was easy to be found and labor costs were low. In early periods, walls were built up in lumps, with almost no shaping, which was a method named tauf in Arabic and pisé in English, from the French word 'pisé de terre'. The mud was then molded or hand-shaped into brick formations.

Various shapes and sizes of mudbricks appeared through the centuries. Their earliest examples being long and thin, bricks generally took on a rectangular shape in the fourth and third millennia, and were characterized by being twice as long as they were wide. By the Early Dynastic period (3100-2300 BCE), the use of mudbricks had evolved into the frequent use of rectangular materials with convex tops, now known as plano-convex bricks. The name "plano-convex" refers to the special shapes of these bricks, characterized by a cake-shaped, domed upper surface. One of the sides of the brick forms is a convex protuberance, very much like the impression of a finger or hand. This particular kind of brick is peculiar only to Mesopotamian architecture. The brick is molded into a rectangular form while the surplus earth on the top is hand-shaped and raised into a mound. The base and sides are flat but the brick is convex on top. The sizes of these bricks are on the average about 10x19x34 cm. The advantages plano-convex bricks held for construction were the speed with which they could be produced and the irregularity of their surfaces, making it easier to apply a finishing plaster coating compared to other types of smoother bricks. These bricks were laid flat but were commonly bonded on walls in a herringbone pattern.

Plano-convex bricks were used in both baked and unbaked form. Clay, bitumen and lime were employed as plaster material. The bricks were used in structurally strategic parts of the building such as corners and doorframes. Another area in which these types of bricks were used was in the construction of vaulting and arches. This was particularly seen in the Early Dynastic Period.

Keywords: Mudbrick, plano-convex bricks, Ancient Mesopotamian architecture.

1 INTRODUCTION

Mud-brick is the main building material used in ancient Near Eastern architecture since the Neolithic Age. With a wide range of uses, mud-brick was employed in walls, floors, roofs and drain systems in Mesopotamian architecture. The material was also used in columns. Mud-brick columns were used for decorative purposes, especially in the facades of ziggurats and temples. Mud was easy to be found and labor costs were low. The mud was molded or hand-shaped into brick formations. These forms were dried in the sun before being used in building. Mudbricks were also baked in a kiln. In early periods, walls were built up in lumps, with almost no shaping, which was a method named *tauf* in Arabic and *pisé* in English, from the French word 'pisé de terre'. The mud was then molded or hand-shaped into brick formations.

Various shapes and sizes of mudbricks appeared through the centuries. Their earliest examples being long and thin, bricks generally took on a rectangular shape in the fourth and third millennia, and were characterized by a length that was twice their width. Four types of mudbrick were used in Mesopotamian architecture:
1). Flat, square bricks
2). Flat, rectangular bricks
3). Long, narrow bricks of square cross-sections (*Riemchen*)
4). Plano-convex bricks [1].

Rectangular bricks with convex tops, known as plano-convex bricks, were commonly employed in the Early Dynastic period (3100-2300 BCE) [2]. The nomenclature was derived from the characteristic shape of the brick. The "plano-convex brick" resembles a cake and has a domed upper surface [3]. These bricks are oblong and the proportions between their lengths and widths vary. In general, however, the bricks have an average size of 10x19x34 cm [4]. They may be in different shapes (Fig. 1). In any case, the surplus clay is not removed but pressed down with hands. This particular kind of brick is peculiar only to Mesopotamian architecture. The brick is molded into a rectangular form while the surplus earth on top is hand-shaped and raised into a mound. Bases and sides are flat but the bricks are convex on top [5]. They are shaped by hand. The convex side of the brick typically reveals the impression of a finger or hand [Figure 1]. The advantages plano-convex bricks held for construction compared to other types of smoother bricks were the speed with which they could be produced and the irregularity of their surfaces, making it easier to apply a finishing plaster coating. [6].

The plano-convex brick was essentially rectangular with a mound on top that typically had a depression on it. This irregular shape was the result of rounding the brick off its wooden frame by hand in place of striking off the surplus mud to create a flattened surface [7]. This type of brick was commonly set out in a characteristic herringbone pattern although other types of bondings were also conventionally used [8]. The brick was flat on the base and sides but took a convex shape on top [9]. The herringbone patterned bricks were laid on their sides and were covered by the wall plastering.

This characteristic building material is identified with the early Sumerian period, a very early stage of Mesopotamian history. The bricks were first seen in the Early Dynastic I period (c. 3000). At first, plano-convex bricks were thought to be only a part of early Sumerian culture but later, after they were discovered in settlements such as Ur, Ubaid, Fara, Bismayah, Warka, Kish and Khafaje, it was understood that they were a type of building material that was indigenous to the entire region [10]. The spread of these materials, first thought to be peculiar to Sumerian culture, to the north of the region may have been a result of the craft contacts carried out along the Euphrates and its tributaries [11].

Figure 1. Plano-convex bricks with the impression of finger (URL 1).

Differing opinions exist about the origin of these bricks in the architecture of Lower Mesopotamia. The most widespread speculation is that these bricks were first produced by strangers to the region who had come down from the eastern mountains [12]. This belief, however, has been replaced in recent years by the conviction that the appearance of these bricks was the result of the process of development of the brickworking tradition [13]. Particularly by the 3rd millennium BC, the rapid urbanization of the area, the production of these bricks is thought to have accelerated.

2 THE EMPLOYMENT OF PLANO-CONVEX BRICKS

These bricks can be differentiated by their *outward-projecting* forms. Because of the irregularity in their shapes and proportions, the outward projections are also irregular. The reason for this is described as the result of the omission of a stage in their manufacture [Figure 2]. The first appearance of the plano-convex brick has been associated with the start of a particular method of bonding that produced herringbone patterns [14]. The bricks were used in both baked and unbaked, or sun-dried, form. There are size differences between the baked and unbaked bricks.

Besides being used for walls, roofs and floors, these bricks were used in corners, door-frames and other important structural points, and the herringbone style made it possible to work faster and did not require complicated skills. Because of this, the researcher Nissen has written that the technique could easily be implemented by unexperienced artisans and this was an example of how labor divisions developed in the culture [15]. The advantages plano-convex bricks held for construction were the speed with which they could be produced and the irregularity of their surfaces, which adapted more easily to the finishing plaster.

Buildings belonging to royalty that were made of baked or sun-dried mudbricks sometimes bore the stamp of the royal builder and the name of the structure. These inscriptions have been useful in dating or identifying buildings but it has been shown that bricks that were intended to be used on one building were in fact employed in others. No other structural materials were used when mudbrick or baked brick arches and vaults were built but lintels and roofs were usually constructed from timber or reed [16].

Figure 2. Unbaked plano-convex bricks at Khafaje (Delougaz 1993*:* Fig 3).

As in the contemporary Near East, structures in ancient Mesopotamia were commonly built of molded mudbricks that were rectangular or square, which were laid out with mud mortar and mud-plaster. Roofs were supported by wooden beams and they were topped with brushwood or matting, mixed with earth and mud-plaster. Bitumen was employed instead of mortar in both baked and crude bricks to achieve watertightness [17]. Another material used in place of mortar was lime. This was employed on the surface of the bricks as a plaster. More costly materials such as baked brick with bitumen mortar were used in prestige buildings built with plano-convex bricks.

3 STRUCTURES BUILT WITH PLANO-CONVEX BRICKS

The plano-convex bricks were used in structures not only on walls, floors, roofs and in areas such as drain systems, but also in building corners, door-frames, columns and other strategic locations. Corners were bonded by means of alternate headers and stretchers. Buttresses drained the bonded brickwork. Each settlement boasted of a different type of bonded brickwork. The most common type of bonding, especially on walls, is flat bonding.

Typically, bricks of the plano-convex period were laid by setting them on their edges rather than placing them flat. Thus, the bricks did not stand vertically but remained sloped on an angle. Some rows sloped to the right, some to the left, forming a herringbone pattern [18]. The bricks lay on their longer edge so that the shorter edge formed the face of the wall. In some cases, the rows of bricks lying on edge alternated with rows that had been laid flat [Figure 3]. This, however, was not a decorative endeavor since it is seen that most such examples were covered with clay plaster. The herringbone formation closed up openings in the wall and in doorways and the herringbone structure was not resistant to the pressure of superimposed walls [19]. Bonded bricks on the flat can be seen in walls where the herringbone formation appears in significant amounts.

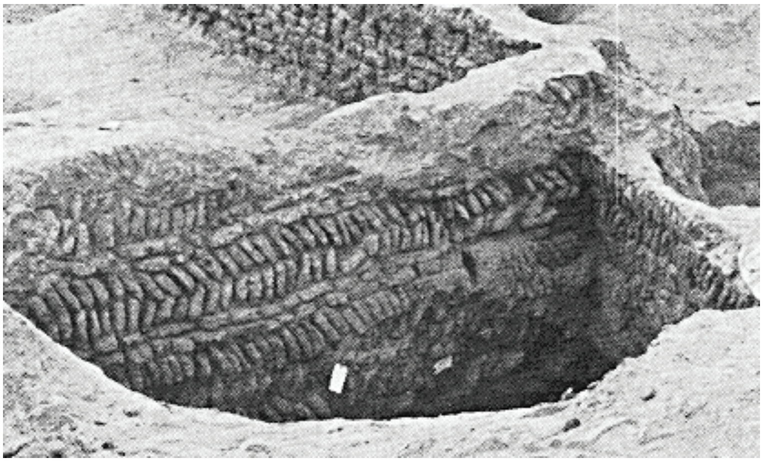

Figure 3. Herringbone patterns (URL 2).

Plano-convex bricks were used for a versatile array of purposes such as in ziggurats, platforms, fortification walls, houses, drains, doors, vaulting and arches. There were innovative decorative and structural techniques used in working with plano-convex bricks. A few houses in Fara, domiciles in Khafaje, the Sumerian palace of Mound A in Kish, the temple platform in al-Ubais and the oval enclosure walls in Khafaje are examples of the numerous structures, in which plano-convex bricks were used. There are two ziggurats in Kish made from plano-convex bricks. In Nippur, a massive structure was erected from plano-convex bricks that dates back to the Early Dynastic period [20]. Two wells and a water-course were built from plano-convex in Babylonia in the era of Eannatum; they carry impressions of two fingers. This type of brick was even used in staircases. The columns of structures also display the use of plano-convex bricks.

Some circular structures in Khafaje whose function is not fully known were made with plano-convex bricks. There are also some round structures of a diameter of 2-6 m. made of plano-convex bricks in Telloh, Fara and Kish. These are thought to be wells but they are not horizontally bonded bricks and largely exhibit a herringbone pattern.

The plano-convex bricks were also used in the construction of vaults and arches. Most sites that display the use of plano-convex bricks also include vaulted drains made from the same material. Some of these were so large that it is estimated that they could have spanned doorways or rooms [21]. There are also some plano-convex sewers at Khafaje [Figure 4, right]. This was detected by the discovery of vaulting beneath the streets. The vaulted drains served the toilets in the rooms. There were also similarly vaulted drains running east beneath the outside walls of the palace and joining the sewer at Khafaje [22]. The drains in the street were built of plano-convex bricks.

Also, vaulted tombs of plano-convex bricks have been unearthed in Khafaje [Figure 4, left]. These vaulted tombs of plano-convex bricks in Khafaje stand beside simple pit burials close to houses and temples. Graves, too, had plastered floors that were surrounded by plano-convex brick walls with rounded corners.

Figure 4. Right: A vaulted sewer of plano-convex bricks Left: A vaulted tomb of baked plano-convex bricks (Lloyd 1967: Plate 40; Delougaz, Hill, Lloyd 1967: Plate 76, 60: B).

The Royal Cemetery in Ur is known to have been a product of the "plano-convex brick period" [23]. All of the bricks there are shaped in the plano-convex style. The walls of the royal tombs at Ur are made from plano-convex bricks. Most of the tombs are plano-convex and laid flat, displaying a single finger impression on top. The pavements around the graves have been covered with plano-convex bricks. The plano-convex period of mud-brick building is characterized by the method in which the bricks were laid slanting on an edge; when they were laid out in alternating directions, a herringbone effect was created. The dimensions of the plano-convex bricks are 0.28 m. x 0.18 m. x 0.05 m. [24]. The Ur graves also reveal vaulted tombs built from plano-convex bricks. The Ur graves also reveal vaulted tombs built from plano-convex bricks (Repeat). The semi-corbel or corbel vaulting here are of baked plano-convex bricks. The tomb-chambers' vaulted roofs at Ur also reveal arches made of plano-convex bricks.

Plano-convex bricks were also used in arched doorways. In Kahafaje, House II is called the "Arched House." The doors of all of the rooms of this house are arched. The herringbone pattern is a typical type of bonding used in plano-convex bricks and it was this that was uncovered in the walls of this building [Figure 5]. The bricks appear in alternating patterns of herringbone and flatly laid bonding. The houses in Khafaje also reveal plano-convex pavements.

It has not been determined exactly when plano-convex bricks stopped being used and it is seen that with time, the bricks eventually appeared flatter and the flatly-laid bricks increased in number (Delougaz 1993: 34). The plano-convex bricks began to be seen as materials used only in important buildings and on walls and then disappeared altogether from the architecture of Mesopotamia.

Figure 5. The Arched doorway in the Arched House inTell Asmar (Delougaz, Hill, Lloyd 1967: Plate 69: B).

4 CONCLUSION

A new type of brick that was added to various other types used in buildings in ancient Mesopotamian architecture around the beginning of the third millennium B.C., plano-convex bricks were successfully employed in all types of structures, including houses, palaces, temples, walls and sewage systems, over the course of a thousand years. These bricks pointed to the use of a new brick-laying technique in ancient Mesopotamian architecture and were the preferred material in this period because of the way they could be rapidly manufactured and did not need an advanced level of artisanship. It was the technique used that defined the form of the plano-convex bricks, with the bricks being laid edgewise rather than flat and sometimes producing a herringbone pattern. The technique is still widely used today by the local inhabitants of the area in the construction of their buildings.

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URL

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URL 2: https://oi.uchicago.edu/research/projects/nippur-regional-project

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
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Studying the Critical Factors related to Social Acceptance of Residing in Earthen Houses (Case Study: Yazdi Young Educated Couples)

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ABSTRACT

Contrary to the common belief that buildings made of earth are not efficient, earthen building is a useful type of building nowadays, in which almost one third of the world's population live. Yazd, known as a historic earthen city and now a world heritage, however, no longer use these materials in newly-built buildings.

An assessment for implementing earthen architecture should be done to know how much Yazdi young couples, as a part of the society, who need a habitation, are inclined to live in these buildings. In fact, the fundamental question of this research is "How will Yazdi young couples agree to live in earthen houses?"

Aiming to arouse Yazdi young couple's interest to live in modern earthen houses, this research tries to discover the critical factors related to social acceptance of residing in earthen houses. To achieve this aim, ten open interviews have been carried out to find out the factors having an effect on choosing an appropriate house and after that, they have been categorized into four topics: namely, functional, physical, economic and environmental factors. Eventually, according to the expressed theories about the social acceptance of technologies, a model is presented to show the factors which are related to Yazdi young couple's social acceptance of newly-built earthen houses.

Key Words: Earthen architecture, Human behavior, Residing, Social acceptance

1 INTRODUCTION

This research is a part of a research project that aims at arousing Yazdi young couple's interest in living in modern earthen buildings.

Today, construction is done without consideration of traditional architecture; that is, modern buildings constructed by steel, concrete and glass do not have any relationship with human's needs. Whereas there is a harmony between the nature of human and traditional architecture, contemporary buildings are too detrimental for human health and the future of mankind. Instead of using these harmful materials, we can return to earth as a compatible material with humanity and environment. In our ancient architecture, whether it was created or used by our ancestors, materials were applied homogeneously with the environment. The natural energy was used at most and it had the least environmental degradation. Our ancient architecture decreased not only environmental pollution, but also the construction budget.

Concerning earthen architecture, people remember images of poor houses but the reality is different. Throughout the world, earthen buildings are diverse in technical skills and artistic genius.

As Yazd has developed, a decrease in earthen buildings has been seen and these materials are no longer used in these buildings, some of which are demolished or ruined. Buildings that are inhabitable have become a shelter for Afghan, Arab and Baluch refugees or for people who inevitably cannot afford to buy house or land in the new texture of the city.

One of the obstacles in the field of earthen architecture in societies is that people are not interested in such buildings, they are reluctant to construct these houses. However, they sometimes destroy valuable remnants of the past, and instead build houses with modern materials. There are also well-off and educated people, who are not into living in these buildings and textures, which can be one of the reasons why the historical texture of Yazd, built from earth, is scarcely inhabited. It seems even if the technical issues of earthen architecture are resolved, public acceptance will still be low. Thus, solving the social acceptance problem is a priority.

The fundamental question of the present research regarding positive effects of earthen architecture is "What are the critical parameters that can influence the social status of the newly built earthen buildings in Yazd so that specifically young educated couples have a tendency to settle in these houses?"

1.1 Definition of Earthen Architecture

Soil is one of the natural material sources available in most parts of the world. About 74 percent of the earth's crust is made up of clay and materials suitable for architecture [1]. In fact, there are no other materials of this kind on the planet. It is readily available in most construction workshops and is very cheap and workable and most low-income people can use this material.

Earthen architecture is considered to be a sustainable architecture, technologically, historically or in terms of cultural environments. Soil is one of the natural materials tested over hundreds of years and can be used in modern ecological buildings combined with new technology [2].

Low energy consumption during construction, reduced transportation costs due to on-site construction and the use of local materials rather than imported materials, building quality houses for a larger population, simple technology in the manufacturing process, no requirement for specialized labor and offering resistance, better thermal properties and reduced carbon emissions are some of its advantages. Also, creating less waste during the manufacturing process, absorbing air humidity and providing a healthier environment for residents are some other benefits [3], [4].

1.2 Theoretical Framework

In qualitative researches, theories can be used as a guide for further interpretation and explanation of various aspects of study [5]. To clarify the meaning of social acceptance and its perception by people, interpretive methodology is used. From the interpretive point of view, human action (social) is inherently meaningful. Hence, to understand a particular social action like social acceptability, the researcher must understand the perceptions that lead to such action. This type of understanding requires that the researcher interpret the particular methods of action, which, in many cases, are interpreted differently.

Sapp and Harrod [6] defined social acceptance as a reference point reflecting the views of a broad social system. Sapp (Sapp S. G., 1991) calls it a new dimension of normative attitude. The initial roots of this type of social acceptance should be attributed to Shibutani's ideas [7] as "public reference groups" [8]. This index can be effective in understanding the behavior by the general public [6]. According to Sapp and Harrod, this concept is completed by two categories of reference groups. The first is the type of comparison used by individuals to evaluate a particular behavior, and the latter is the normative type that is used to shape and sustain behavior.

In the field of social acceptance of earthen architecture, no research has been done, but studies have been carried out that are closely related to this research topic. Below are some of them:
Davis (1989) stated that to accept a technology, there should be two factors, i.e. Perceived Ease of Use (PEU), Perceived Usefulness (PU) of that technology. These two have influence on the Intention to Use (IU) which precedes the actual use in the model. Also, in this model, perceived ease of use might affect perceived usefulness of that technology [9], [10]. In other words, when people perceive the use of a system easily and conveniently, their perception of the usefulness of that system increases. In fact, technology acceptance model (TAM), the initial model in this field, introduces the core of technology acceptance. Venkatesh and Bala (2008) introduced TAM3 as another version of Davis's theory that not only covers the PEU and PU, but also explains moderating factors such as experience and voluntariness. Schwarz and Chin (2008) added the Perceived Usage Compatibility of technology for analyzing interactions between man and technology.

2 RESEARCH METHODOLOGY

Because the research focuses on a social process, qualitative method, based on grounded theory, is used. Qualitative researches are usually referred to as researches, findings of which are not found by statistical process or which do not aim to quantify [11]. Ten open interviews, gathered with semi- structured technic, were carried out to discover the factors having an effect on choosing an ideal house**.** These interviews were conducted among a sample of our statistical society. First, for achieving our goals, some arguments were put forward, and then when the main concepts were structured, open questions were designed. In this research method, although questions are predetermined, the interviewees have the opportunity to explain further should the need arise. Actually, these questions were just a list of topics addressed by interviewer like keywords or a guide. The survey consisted of several parts. The survey structure was:

- General questions. Some open questions concerning interviewees' personal information
- Questions on the materials and features of their ideal house
- Questions on cons and pros of residing in historical earthen buildings in Yazd
- Questions on their lifestyle features such as the importance of privacy, territory, judgment against others and hospitality
- Questions on earthen architecture and their awareness to its cons and pros and whether they are eager to live in these houses

Table 1. Profile of interviewees

Type of ownership		Type of housing		Level of education		The number of children	
Tenant	5	Apartment	4	Bachelor	3	None	4
Owner	5	Villa	6	Master	4	One	4
				PhD	3	Two	2

In brief, the research process includes the following steps:

1. Research planning
    a. Defining research questions
    b. Defining research design
2. Conducting the interviews
    a. Conducting oral interviews
    b. Transcription of interviews
3. Preparing the analysis

   a. Extraction of relevant statements
   b. Definition of categories and encoding to core statements
   c. Mapping the analysis to the categories
4. Analysis
   a. Deducing the analysis for earthen architecture

Table 2. Examples of the coding process

Statement	Core- statement	Category
"The old houses were good for their time. They needed a lot of work. Currently we do not have much time to spend on cleaning, washing, etc. They are time-consuming. Materials that are used for plastering should be easy to clean and resistant to scratches and damages for avoiding the requirement to replace them."	Convenient cleaning	Perceived Ease of Use
"Adobe houses were always needed to be controlled against termites and they cause a lot of damage to them; moreover, they were susceptible to water."	Ease of restoration	
"We have a land in Isfahan, but because construction is time- consuming and difficult, I prefer to sell it and spend more on buying a larger and completed home."	Building construction speed	
________________	Accessibility to materials*	
________________	Learning construction skills*	
"In apartments with current materials, we always need to turn on air conditioner in summers and because of poor insulation, heating costs are so high in winter."	Environmental factors	Perceived Usefulness
"I like spacious houses with a large closet and storage space."	Functional factors	
"In my opinion, adobe houses are not resistant to earthquake and the walls are always cracked, they are full of dust, they have thick walls evoking a dungeon."	Physical factors	
"Nowadays cost of land is so high, so waste of land is not logical and it should be utilized to the full extent."	Economic factors	
"Earthen houses smell of moisture and remind me of the underground, which is not good at all."	Previous memories and experiences	Previous experience of habitation

*It should be noted that these two factors are derived based on literature review and the features of earthen buildings; otherwise, people did not mention them in the interviews, but in our opinion, they can be one of the factors affecting this social behavior.

3 RESULTS

With analysis and word by word open coding of the interviews, premier concepts were found, then based on their identical themes, were categorized into the following concepts:

- **The perceived usage compatibility of earthen buildings**
- **The perceived ease of use of earthen buildings**
    1. Learning construction skills
    2. Accessibility to materials
    3. Building Construction speed
    4. Ease of restoration
    5. Convenient cleaning
- **Previous experience of habitation in earthen buildings**
- **The perceived usefulness of earthen buildings**
    - **Environmental factors:**
        1. How to use natural resources
        2. How to deal with natural resources
    - **Economic factors:**
        1. Budget and individual income
        2. Execution costs
        3. Utilization costs
        4. Maintenance costs
        5. Building energy saving
    - **Functional factors:**
        1. Supplying the desired function
        2. Providing comfort and relaxation
        3. Observing division of functions
    - **Physical factors:**
        1. Exterior architecture
        2. Interior architecture
        3. Possibility of restoration
        4. Technological factors
            a. features of materials
            b. construction methods
            c. construction process

To achieve our goals, we reviewed the literature of already investigated factors related to social acceptance of technologies and turned them into a model. We expanded this model with factors from our own experience and opinions about what factors affect social acceptance of earthen houses too.

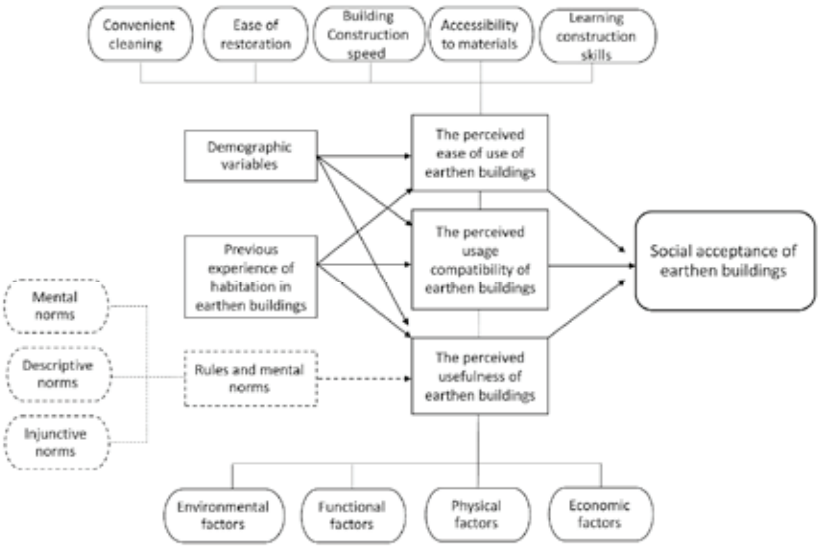

Figure 1. A Model for social acceptance of earthen buildings

4 CONCLUSION

The main goal of this research is to define critical factors related to residing in earthen houses. In this paper, the results of a study among ten Yazdi young educated couples are presented. It seemed that if the abovementioned parameters are considered in earthen houses, Yazdi young educated couples' tendency in living in these houses will increase. The result of this qualitative research determines the critical parameters that can help ascertain the suitability of building with earthen architecture and the level of willingness of Yazdi young couples to live in them by further studies. According to these parameters, a questionnaire will be distributed among these people to find out how much statistically they are eager to live in this type of buildings.

5 ACKNOWLEDGMENTS

I would like above all to thank my mother whose unfailing guidance and encouragement has always supported me in hardships and difficulties.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Ecological Sustainability Strategy of Historical Adobe Structures Considering the Energy Stability by Traditional Methods and Nano - Technology

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ABSTRACT

Nowadays ecological pressures require a new approach to upgrading buildings to ecological standards. Building standards for energy effectiveness are increasing constantly and they are updated by constructing new buildings in accordance with standards and refurbishment of the existing buildings.

Adobe structures, as part of the existing heritage, like other buildings, require ecological refurbishment to achieve ecological sustainability and their sustainable refurbishment is creating a demand for suitable materials, retrofitting techniques, technologies and research.

This paper first describes the research of literature and then analyzes it systematically and covers the theme of refurbishment measures by considering ecologic sustainability in historical adobe structures and specific measures like insulations.

Then it reviews an abstract of innovative methods or technologies, especially nano technology for energy saving in clay structures and their potential. All these factors reflect local and national preferences, generate local identities, and often determine future building decisions.

Key Words: Ecological Sustainability, Adobe Structures, Saving Energy, Nano-technology, Identify.

1 INTRODUCTION

Earth has been used for thousands of years as a construction material for human shelter and approximately 30% of the world's current population still lives in earthen structures. [1, 2]
For example, the Bam Arc is the largest adobe complex in the world (Fig 1).

In a residence in which humans lead an immigration life, there are often temporary shelters of brush and wooden frames covered with mud. [3] More than half of the world's people live in earthen structures. [4]

Adobe is a historic building material that is used extensively in dry and semi-arid soils as an indigenous material, along with small amounts of other building materials [5]

Figure 1. The Bam Arc is the largest adobe complex in the world.

Sustainable architecture or sustainable construction calls for the creation of structures in accordance with social-economic, cultural and environmental conditions. In order to achieve its environmental goals, energy consumption in buildings should be reduced and minimized, and then various techniques can be applied. [6]

Nanotechnology is one of the world's top technologies, a measure of the progress and civilization of nations and an indication of its renaissance. By examining materials on a nanometer scale, a nanometer of a billionth of a meter, one of the advanced materials can be produced with dimensions of 1nm or 100nm for its internal grain. The Nano-Scale materials change behaviors of traditional materials with large dimensions that are over 100 nm. All of this leads to an overwhelming feature that does not exist in traditional materials. [8]

Apart from all these definitions, the issue of identity and originality arises that any action taken in the monument should respect its originality, and this does not allow the use of all techniques and technologies in the cultural heritage.

The aim of this paper is to investigate the thermal properties of the adobe structures and its methods of upgrading so as to preserve the authenticity of the buildings.

2 THERMAL BEHAVIOR AND ITS TRADITIONAL TECHNIQUES

Traditionally, terrestrial construction has been around for centuries throughout the world and some buildings are 500 years old. These buildings are designed to communicate with the nature and weather conditions as well as social traditions for cooling and heating, and to reduce expensive needs. Compared to contemporary architecture and modern buildings, traditional buildings are affordable and efficient. [9]

The specific heat capacity of adobe wall is 1260J/kg K and its density is 1540kg/m and it is capable of absorbing heat during the day and releasing this stored heat at night. This behavior results from high thermal capacity, which reduces the heating gradient of the adobe buildings. [10] Adobe is warmer in winter and colder in summer.

Water (Fig. 2) is a determining factor in thermal behavior because it has the effects of latent heat that changes the thermal conductivity and heat capacity of the material. Additionally, the water has the same effect on the thermal behavior of the adobe and the energy storage through heat. Crystallization from salts occurs inside the clay structure of brick materials. As a result, the effects of rain moisture and the absorption and evaporation of water vapor due to the relative humidity change improve the thermal performance of the adobe structures. [10]

Given the ability to save energy due to the presence of moisture in adobe, it can be concluded that a strong relationship exists between the amount of water and its thermal conductivity. [11]

Figure 2. Water is a determining factor in thermal behavior of adobe structures.

Demir (2008) showed that sawdust (Figs 3, tobacco 'Fig 4, and grass 'Fig 5) can be used to improve thermal properties and store thermal energy in adobe. Increasing the porosity of the soil clay causes an increase in the insulating capacity of the clay. Organic allergenic additives are proven to enable purity in the body of clay and clay is acceptable in maintaining mechanical properties. [12]

Figure 3. Sawdust

Figure 4. Sawdust

Figure 5. Tobacco

Figure 6. Grass

3 NANOTECHNOLOGY AND THERMAL INSULATION

3.1 Aerogels

Aerogel (Fig 7,8) is a type of thermal insulation that uses black carbon to prevent heat loss and maintain energy in the materials. Thermal conductivities as low as 4mW/(mK) may be reached at a pressure of 50 mbar. However, commercially available state-of-the-art aerogels have been reported to have thermal conductivities between 13 and 14mW/(mK) at ambient pressure.

Due to its tensile strength, which is very fragile, Aerogel has relatively high compression strength, but tensile strength may be increased by combining carbon fiber matrix. A very interesting feature of aerogel that distinguishes it from other insulators is that they can be produced as porous, transparent or translucent materials, so they can be widely used in the construction industry, especially historic buildings. [13, 14]

Figure 7. Aerogel

Figure 8. Aerogel

According to the study, the results of the researches show that the above-mentioned ones have the power to improve the properties of thermal conductivity of adobe, and the use of old and indigenous techniques and advanced techniques in the field of nano-technology in the form of an Aerogel can be used in the field. Due to its high transparency and since it maintains the authenticity and identity of the historic buildings and especially the adobe structures, Aerogel can save energy in such structures.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
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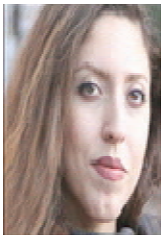
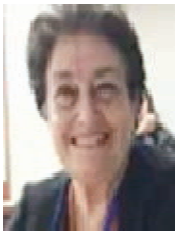
Sustainability Indicators: Natural Light in Iranian Bazaar

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ABSTRACT

Iranian traditional architecture has some specific features. It aims for subjects such as aesthetics and environmental matters. These criteria are observed in traditional Iranian buildings such as residential houses and in urban spaces such as bazaars, mosques and schools. Sustainable architecture makes an effort to create comfort for users in economic, social and environmental areas. Many of the traditional Iranian buildings have sustainability principles on design, which are reflected in the old textures of the city. Although these principles are less considered in the contemporary Iranian architecture, it is crucial to preserve this historic city structure.

With the review of sustainability principles used in architectural and urban elements in Iran, it is possible to upgrade its quality. This paper focuses on studying the bazaar in traditional Iranian architecture as a sustainable urban element. For this purpose, we first discuss the meanings attributed to sustainable architecture and its principles and then the principles of sustainable architecture, especially the use of natural light in bazaar design.

Key Words: Traditional architecture of Iran, Principles of sustainability, Ancient buildings and texture, Bazaar.

1. INTRODUCTION

The allegory of light has a profound history in Iranian belief system. In pre-Islamic period in Iran, religions such as Zoroastrian, Manichean and Matraite used light allegory to clarify their teachings [1]. Light is the manifestation of God's existence, and therefore, considered holy and is respected. The use of light in the building is the main pillar of Iranian aesthetic architecture and reflects the main purpose of the transition from the dark to the brightness. Light and architecture are intertwined. Over the past years, architects have recognized the importance of light in architecture and come up with smart ways to use light in buildings. In Iranian architecture, light is not used in a single form, but in many ways [2]. The efforts and innovations made to use light are evident in the traditional architecture of Iran that spans over multiple eras. Traditional Iranian architects have learned at first hand that if they use environmental lighting well in architecture, they can convert the simplest forms and invaluable materials to elements and decorations. Persian architecture is rich in light. So, it can be said that the warp of traditional monuments is mixed with the woof of light [3].

2. BAZAAR HISTORY

The word "Bazaar" originates from Persian language spoken in Iran and dates back two thousand five hundred years ago and entered the languages of other nations of the world and refers to the place of commodity exchanges as a kind of marketplace with architectural considerations. In Iran, bazaar is set up due to the long history of trade and it has become a valuable heritage of Iranian civilization and played various roles in the Islamic ideological and transcendental architecture beliefs of Iran as a model of the design of commercial spaces with components and elements and as a place of economic, social and cultural exchanges between Iranian and many other cities. It has the responsibility of economic centrality with sustainability considerations in structure and serves as the symbol of the values of the community, and it is the manifestation of a transcendental and mystical sustainable architecture [4].

Figure 1. Historical Bazaar of Tehran

Bazaars are one of the most important national heritages of Iran and they are regarded as significant architectural treasures in Iran as the hub of the economy of Iranian cities. They consist of main and sub parts and are in various forms such as open and closed, indoors and outdoors, along a fixed axis or branches, with arches and beautiful decorations. [4]

Daylight has a unique quality in Iranian architecture and for shaping interior spaces. In Islam and Islamic world view, daylight has a special and valuable position. Therefore, Islamic artists have always tried to use light as a symbol of the divine unity.

3. HISTORY OF USING NATURAL LIGHT IN ARCHITECTURE

Understanding the process of using sunlight is as necessary as the formation of materials or different forms of building infrastructure design. The earliest history that we know for gaining light and shadow is the third century of the fourth millennium BC, when they used the light to make a difference in the outer walls. It can be deduced from the works of houses of the period, walls of which remained under the ceiling, that each room is connected to the outside by a door without any window. From the Elamite period around 6822 and 6822 BC, an example of glass windows was discovered, which consists of tubes of glass paste placed side by side and inside a frame and used for lighting the interior of the building.

The most ancient documents and samples of doors and windows in Iran architecture can be found in the pattern of castles in the works of the Sharking era. From Assyrian's prominent pattern, it is possible to identify the apertures made on the towers. In the Achaemenid period in Persepolis, the doors remained light and in these palaces, there were huts over the doors and even roofs. Otherwise, how could several doors light up the large indoor space? [5]

4. NATURAL LIGHT IN ARCHITECTURE

Light is the key to understanding space, which directly affects the quality of space perception [6]. Light is the source of everything. "Light shapes the things when it is in contact with the surface of things and deepens them by stacking the shadow on their back. Light is the creator of the proportions that regulate the world. Although it is the source of everything, it is never static. Light, in contrast to its constant transformations, vibrates and continuously makes the world open"[6].

About the role of light in the architecture of Isfahan, Mirmiran states: "Light is not a problem in this architecture. But it is related to the truth and the essence of it. Light in this architecture has not just a functional task, and its effect is not limited to the creation of beauty, but light makes truth of the architecture of Isfahan "[8].

Until the eighteenth and nineteenth centuries (contemporary era), lighting in Iranian architectural spaces determined the location and orientation of the city's texture, and its buildings followed a model called orientation. Orientation is a hexagonal rectangle where longitudinal direction is the best direction for buildings to be energy-efficient. In general, there were three commonly used orientations: Raste, Kermani and Esfahani, each of which was suitable for particular cities. It should be noted that direction of orientation was determined by issues such as atmospheric conditions, wind, and the intensity and direction of light in a region, which illustrates the effect of light on macro-scale urban planning and architecture [9].

The light element has been used to diversify the urban space in the form of a porch and sunshade and to play with light and shadow. Sunshade has shadow and provides a cool place for passersby. The presence of shadow of adobe domes and arched roofs in desert cities and the visual play of light and shadow compensate the lack of openings in the external walls. City has various manifestations in different hours of the day, and the color of sky is reflected from the sunrise to the sunset in its general context and displays a special characteristic.

The first effect of light as lighting is its expansion in space. Creation of space takes place not only through walls, but also through light, order and perspective. It is obtained not only with cones and balconies, but also by lighting. Views not only owe their faces to the arrangement of windows and plaster, but also to the light. Architects have always known that space can be built with light and have tried to work with it throughout history [10].

In the bazaar, the rhythm and bright angle of the light rays upon penetrating the interior, which guide the passerby like night-stars, compensate for the impossibility of detecting the hour and orientation due to the lack of connection to the outside space. In addition, the central courtyards that are alternately in the path reduce space uniformity and prevent the sense of fear from closed space [11]. These lights, apart from providing optimal lighting, have a dramatic effect on stretching, attracting attention and pausing.

Figure 2. Example of Light in Iranian Architecture

How lighting in different places gives comfort and natural light contributes to mental health is manifested from different concepts such as navigating from a space to another space and orientation, determining the path, focusing and emphasizing light, dividing the space into separate arenas, the tradition of lighting for any kind of use, determining the degree of importance of each space with the intensity of light and dark used in it, the transition from dark to light and the creation of diversity and the preservation of the hierarchy of the presence of light. Light-related elements in traditional architecture in Iranian architecture have not used light uniformly and the application of this natural element has varied. The mosaics and wooden windows with colored glass with a geometric composition are different ways of shaping the light, and this continuous change that leads to a variety of colors and shades conveys the proper and sufficient visual messages to the human eye [5].

5. LIGHTING ELEMENTS IN IRANIAN TRADITIONAL ARCHITECTURE

Light is not used uniformly in Iranian traditional architecture, but light has always been moderated and incorporated into the space. For this purpose, architects have been trying to use the daylight in the best viable way by using innovative techniques and quite simple elements. Building elements that utilized natural light in Iranian traditional architecture are studied in two groups. The first group includes lightings which often transmit the light to the interior, and the second group includes light controllers that act as regulators of light penetrating into the building such as the types of canopies [12].

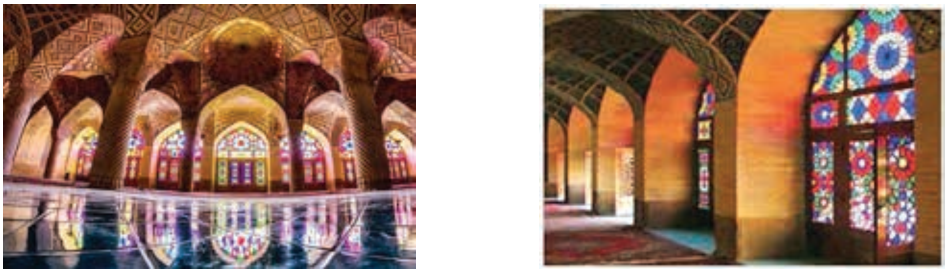

Figure 3. Example of Light in Iranian Architecture

5.1. Types of Lightings

5.1.1. Lattice

The lattice surface composed of two empty and full spaces so that the other side is also visible [13]. Variable weather conditions, bright sunshine, wind and rain, hurricanes and specific religious beliefs in Iran made it necessary to equip the buildings with a curtain or lattice for protection in the building in addition to windows. These lattices absorb light intensity and produce a weaker light among them. Deviation of the light rays from hitting the designed edges of lattice resulted in light emission and contributes to the uniformity of light. Meanwhile, even though the entire outside space was easily visible, there was no light penetration from the outside during the day [14].

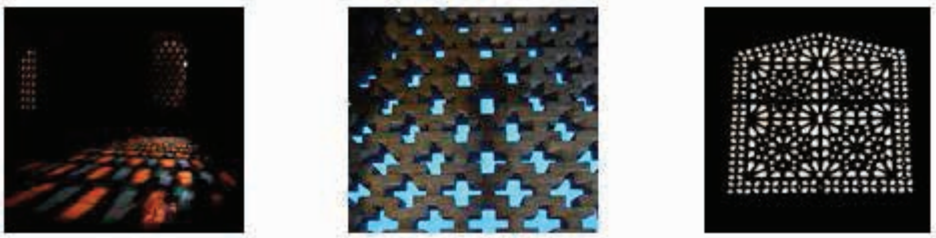

Figure 4: Example of Lattice in Iranian Architecture

5.1.2. Lattice doors and windows

They are the most basic lighting methods and made in different sizes based on the amount of light entering the building. The window is usually built to scatter light, to see the outside landscapes without disturbing the interior space and the flow of air. In areas where sunlight is intense, the lattice door and window create equilibrium between the exterior and interior light, which prevents sunlight and eye fatigue against bright light. Thus, designs for making these elements often adjust the light inside the room [14] .

Figure 5. Example of Lattice Door and Window in Iranian Architecture

5.1.3. Fenestration

It is a small shield for ventilation as well as lighting. It should be noted that the fenestration is not open and is designed in a small framework in a fixed form. Fenestration and window cannot be separated. In fact, fenestration can be considered a small window that is usually used on top of the door and sometimes on both door sides to capture light and provide fresh air for closed spaces [4].

During the Qajar period, many of the fenestrations over the doors, which were rectangular or had arches, become semicircle or oval [15]. It should be noted that the holes over arches were also referred to as fenestration. The fenestrations used on the body of the domes were used for ventilation and lighting under the dome.

Figure 6. Example of Fenestration in Iranian Architecture

5.1.4. Horno

Horno is a common noun for roof lightings. This term was originally derived from Hur + Light, which turned in time into Horno. As it is located near the dome, it is not possible to run the dome as the rest of its parts. The gap near the dome is not filled and the hole thus created above arch illuminates the space. In the coverage of bazaar, most of the Horno holes were used for lighting and ventilation purposes [16].

Figure 7. Example of Horno in Iranian Architecture

5.1.5. Light (Roshandan)

In buildings where any window cannot be placed on the walls such as bazaar and other public buildings, architects in the "Solar" part of formalization (center circle) created a hole called "skylight" (Roshandan) [4]. Roshandan is usually in the form of a pergola that is perpendicular to the solar part to allow the optimum light and ventilation.

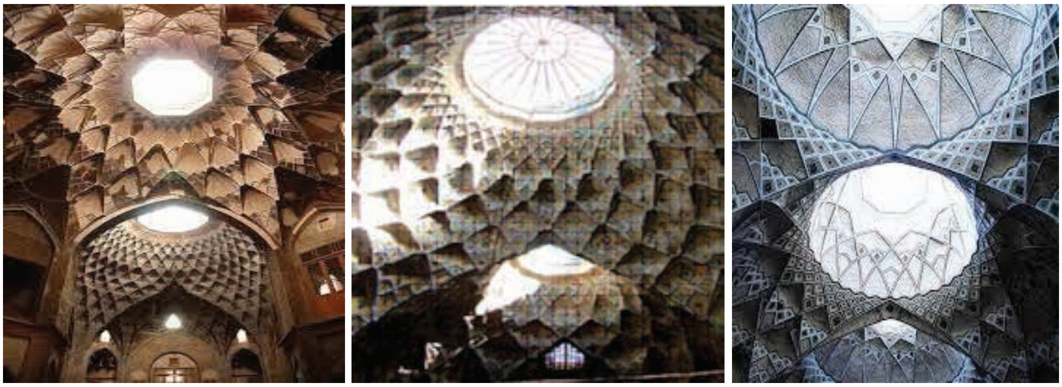

Figure 8. Example of Light (Roshandan) in Iranian Architecture

5.2. The Role of Formalization and Mogharnas in Lighting

In spaces where lightning and space lighting are achieved through the ceiling, the light directly enters the space and illuminates simply a part of it. Formalization and mogharnas are used as an extra element of beauty to utilize sunlight to the full extent. This causes the light to diverge in different directions from its path and to be released into space. In this case, in the interior of the building, we will have a uniform and decentralized lighting that includes a greater volume [12]. This quality of formalization and mogharnas is used in mosques and lighting in different directions enables any stone and plaster to have a distinctive manifestation.

Figure 9-1. Example of Mogharnas In Iranian Architecture

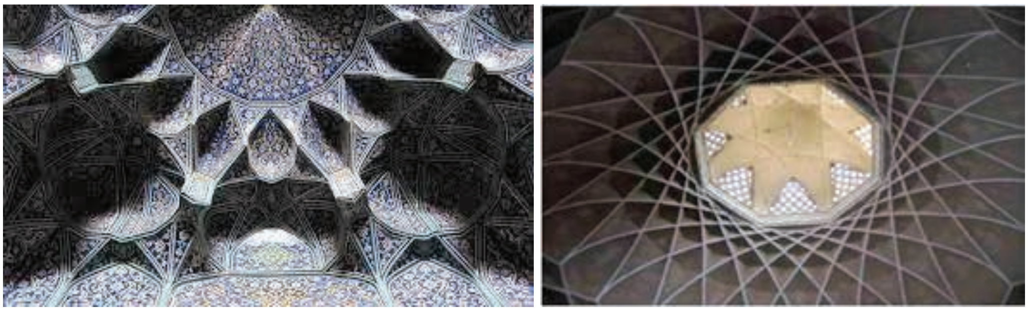

Figure 9-2. Example of Mogharnas In Iranian Architecture

6. THE EVOLUTION OF LIGHT IN ARCHITECTURE

6.1. Light in the Egyptian architecture

According to the Egyptian people, the essence of God is inaccessible and invisible for humans, so it inevitably should be in darkness. The path to this God must be from going from the lightness to the darkness. Jean Louis describes the illumination of the statues of the Khofran Temple such that light shins from the small windows located between the wall and the ceiling and lights up the inside and the sculptures and it is reflected by white marble polished stones that illuminate the space, and the pillars and walls of red granite remain in the darkness [16]

6.2. Light in Greek Architecture

As for Greek temples, it can be said that most of these temples were sculptural and they corrected the statue lighting. The light that shined inside was reflected by the water surface and illuminated the statue. In spaces that needed more light, the Greeks used the ceiling light, building a part of the roof with higher altitude, and used the space that was created to light up the interior [17].

6.3. Light in Byzantine Architecture

In the architecture of the mysticism as well as in the Byzantine architecture, the attempt was always to add a spiritual aspect to the interior and create a dream space, and it is clear that lighting played a major role in this regard [17].

6.4. Light in Gothic Architecture

The main idea of the Gothic style was to create a part of the sky or paradise on earth in order to induce ambiguity in the creation of immaterial space. Natural light played a role in creating ambiguity in building as a vital factor, and the exciting games of light and shadow contributed to this role [17].

6.5. Light in Baroque Architecture

Baroque space is full of contrasts. Lighting is very important for this style. The alternating arrangement of clear and vivid parts and shadowy parts strengthens the depth perception. A viewer gets the impression of an infinite space. In these buildings, the viewer barely sees the windows, and the interior lighting is obtained from the reflection of light on the walls. The use of various optical tricks to increase the imagination from the Baroque period until today has been common [18].

6.6. Light in Islamic Architecture

Muslim architects have always sought the order in elements, components, spaces, and buildings and used important elements and components to achieve it. One of these elements is light. Of course, they have used the light to add meaning to and sanctify the space so that man can ascend to metaphysics in those sacred places [6].

6.7. Light in Iranian Architecture

6.8. In Iranian architectural spaces

The hierarchy of light in the darkness has been carefully used to divert the light from space to space. In this hierarchy, the intensity of light and darkness is created in spaces [3].

7. CASE STUDY (ISFAHAN BAZAAR)

By validity of light source	Sunlight enters directly into space such as a courtyard of caravansary or inn Indirect light: Light comes from interfaces into these spaces such as cellars around the houses and the bazaar order
By validity of how lighting	Right open space. The closed space is quite bright, and the light is saturated (Mosque, school and caravanserai). Semi-bright and semi-dark spaces with localized light. In these spaces, the source and path of light are clear. The dark spaces (such a difference in brightness is beneficial for the architect; e.g. the mosque's light with the semi-dark space of the bazaar provides a meaningful difference between the two, i.e. in spite of the proximity of mosque with the bazaar, upon entering the mosque, passersby are disconnected from bazaar space and find themselves in another world.
By validity of how achieving light	Fenestrations on the walls enable light penetration from the side and walls of the space (doorways, doors and windows). Fenestrations on the ceiling enable light penetration from above.

Figure 9. Isfahan Bazaar

8. CONCLUSION

Light not only plays an important role in valuing architectural elements, but also is one of the most important determinants of space. Architectural space is directly linked to visual perception, and visual perception is affected by light signals that optic nerves receive. Light and architecture are inseparable. Light is not the sole consideration for architecture, but architecture always seeks a way to use the natural and artificial light in the optimum way. It is simply enough to observe the tradition of organizing indoor spaces around the central courtyard or creating semi-light interface such as the porch to create the effect of light on the formation of types of building. Iranian architects from the past discovered the importance of light in architecture and came up with smart ways to use light in buildings. Light is not used uniformly in Iranian architecture, and the application of this natural element is very diverse and varied. The continuous change of light results in a variety of colors and lighting that gives the proper and sufficient visual messages to the human eye. Iranian architects instinctively or consciously followed these simple and natural principles.

Dynamic lighting, variable light in terms of quantity and direction of radiation and color have been among the study subjects of Iranian architects. Types of formalizations (geometric ornaments of domes) are structures with the primary task of absorbing light, reflecting it into hundreds of shapes and creating a wide range of lighting applications. In bazaars, the relation with time was provided through light columns, which reflected the light from the dome to the interior and altered regularly in every direction. Grids, mosaics and wooden windows decorated with colored glasses with a geometric composition have been diverse ways of shaping light, which is associated with architectural space and creates a certain hierarchy from darkness.

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Figures
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Figure 3: www. memarian.org
Figure 4: www. taghdesign.com
Figure 5: www. http://home.peymansaz.org
Figure 6: Pirnia, M.K.; 2001," Dome in Iranian architecture", No20.
Figure 7: www.cloob.com
Figure 8: www.honartech.ir
Figure 9: www.eligasht.com

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Features of Soil-Based Plasters Applied on Mud Wall Surfaces: The Case of Diyarbakır Region

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ABSTRACT

As is known, being a mixture of substances abundant and easily available everywhere, soil has always been used as one of the construction materials to build dwellings since the ancient times. Nowadays, dwellings built of soil-based materials are still used especially in rural areas. The mud, one of these materials, is an environment-friendly material that can yield high user comfort. As a result of such advantages it provides, mud is a material that has been investigated by many researchers to enhance its features so as to promote its wider usage. At present, many studies are being performed to investigate ways to enhance the features of walls built by soil-based materials and to protect them against external factors.

In the present study, laboratory experiments were performed to examine the physical and mechanical features of soil-based plasters applied to mud walls. It is of great importance, for the overall protection of a building, that the surfaces of mud walls are protected against external factors and strengthened against negative effects. In this sense, plaster coatings that cover wall surfaces and protect them from the effects of the external environment have an important function to ensure the protection of these walls. We can minimize the damages that can occur at external plaster coatings based on clay only if we specify the features of the plaster to be used. In this study performed to this end, samples from external plaster coatings with clay bond coat were collected from the village of Yuvacık in the district of Bismil in the province of Diyarbakır and subjected to experiments. The experimental examinations aimed to provide insights to the performance of plaster coatings with clay bond coat in respect of ensuring a protection against the factors of the external environment.

Key Words: Mud, Mud-wall, Soil-based Plaster, Clay Soil

1 INTRODUCTION

Soil has always been the major construction material known as the most ancient material through the human history. Soil is highly preferred as a building material due to its easy availability and economic advantages. Mud has been used in buildings for a long time. In our country, usage of mud is common in rural areas where it can also be seen in the cities.

Mud, which is a traditional material, requires minimum energy consumption from the production phase to the application phase and it is a eco-friendly and contemporary building material. Its bonding agent is clay soil that can be easily found in nature and mud is an economic material which can be used in load-bearing materials and also as plaster material. [1].

Mud is an elastic and soft construction material. It is fire resistant. Although there is a flammable material such as fodder in its content, fire-resistant property is protected. Mud has excellent noise and thermal insulation characteristics. According to health considerations, there should not be a great temperature difference between the living space and the construction materials that are used for the living space. As the second material that stores the energy most after water, soil embodies the heating energy. After heating is stopped, it balances the temperature by discharging the embodied energy to the living space for a long time. Since the generated vapor can penetrate into the walls easily, no condensation occurs on external walls and ceilings [1].

Two significant disadvantages of soil material are its low pressure resistance and high sensitivity against humidity. Some additives such as cement, lime, plaster and other materials can be added in the mixture in order to provide a mud, which is more resistant to pressure with lowered sensitivities against humidity, is not soluble in water, has smooth surfaces and non-dusting characteristics [2].

At present, many research studies are conducted on soil based materials. Utilizing the soil for mud (adobe) can only be possible by knowing the physical, mechanical, chemical and mineralogical aspects of its inherent structure. The characteristics of and grain size of clay, which provide a bonding property to mud, are also important. Any characteristics such as pressure resistance of mud that will be used in the building, its resistance against atmospheric impacts, solubility in water and dangerous effects on human health should be known in advance. The sand and gravel included in the soil, which is the primary material of mud, have a skeleton role and clay serves as a bonding material. The type and availability of clay cause major changes in the characteristics of the mud [1].

Since mud has low resistance against water and it gets softer and disperses when it is in contact with water, it causes damages in the regions that have high catchment areas. When it is used as a filling material within framed structures, it can be protected by plastering and large eaves. In hot regions, it has more advantages since contact with water is less.

Outdoor conditions may cause some damage on the surface by affecting the building external shell. Increasing performance of the building wall against outdoor conditions will contribute to the increase of interior comfort of the building, decrease repair needs by minimizing damages on the wall surface and reduce energy loss. Therefore, wall surfaces of the building should be protected against outdoor conditions and resist the adverse effects.

Plasters applied to outer surfaces of buildings play a major role in protecting the wall from environmental factors by ensuring that the wall is not directly exposed to the outdoor conditions. Plaster types obtained as a result of addition of some materials with different binding properties to the adobe mixture have different properties against environmental factors acting on the wall surface. Due to deformations in the plaster structure arising from environmental factors, some damages such as blistering, cracking and shedding may occur. These damages, which can be seen on the surface plaster, decrease the protective function of plaster and thus, the wall surfaces are worn out and exposed to some environmental factors and the strength is adversely affected. Therefore, it is important to well determine their plaster characteristics in order to increase their resistance. Clay bonding plastering on the surface of mud, which is generally used as a wall element in rural areas of Diyarbakır, is a wide spread application. Determining the material characteristics of clay bonding plasters used in this region will contribute to improvement studies. In the1st stage of the study, a representative sample structure was selected after examining the buildings in which clay bonding plaster was used in Yuvacık village of Bismil District in Diyarbakır province (Fig.1). In the 2nd stage, external clay bonding plaster samples were taken. In the 3rd stage, the physical and mechanical characteristics of the material were examined through test methods. In the 4th stage, the protection performance of clay bonding plasters against the external environmental factors was evaluated as a result of the tests conducted.

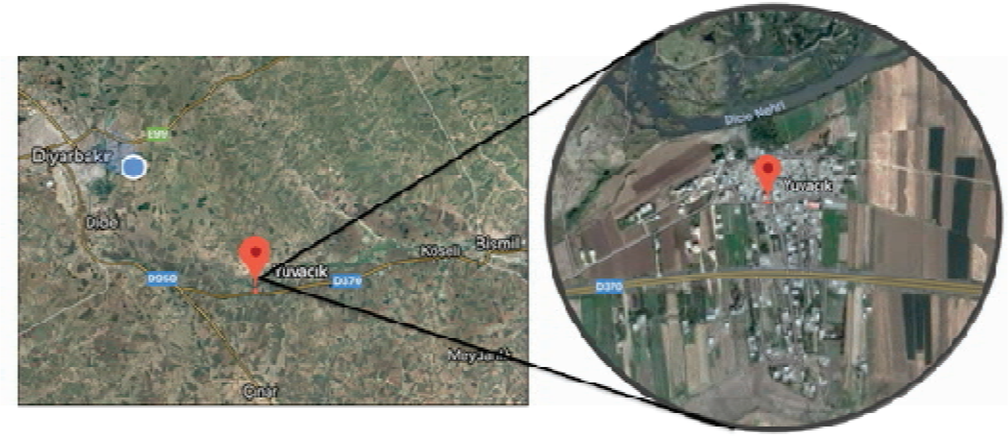

Figure 1. Yuvacik village of Diyarbakır

2 MUD-WALLS AND CLAY BINDED PLASTERS

Adobe is a building material obtained by mixing clayed and suitable soil with straw or other additives and kneading with water, then pouring the mixture into molds and shaping the mixture and finally, air seasoning. In different parts of Anatolia, wool, bristle, gypsum, lime, wood ash, salt, stalks, fibrous plant wastes, straw, etc. are included in the plaster [1].

The adobe masonry is similar to the brick masonry. However, lime is used instead of mortar and mud is used instead of cement. A wall is continued by laying adobe lines on each other by means of mud mortar. Adobe intersections along the wall - referred to as horizontal joints- are confused with vertical order cut joints that are called vertical joints. Since the mud mortar is a late drying binder, when joints are excessively thickened, it prevents maintaining the wall steepness and causes deformation due to the overload from the top [3]. The mud mortar used in mud-wall masonry is identical with the mortar used for adobe production. However, attention is paid that straw added in the mud mixture is fine-sized and soil is sieved.

Adobe may disintegrate after a while due to humidity and water. Therefore, foundations and foundation and basement walls of masonry adobe buildings are made of a material resistant to water up to the sub-basement level. In traditional construction, it is rubble stone [4].

Adobe balances the moisture content of the indoor climate much more than other building materials. It quickly absorbs the moisture in the air and can release the moisture in its body to the air quickly again. So, the indoor climate becomes neither too dry nor too humid. Temperature of the building is balanced in the use of adobe building [3]. Physical properties of some building materials are given in Table.1.

Table 1. Physical Properties of Some Building Materials [5]

	Material	Unit weight (kg/m^3) (r)	Thermal conductivity (W/mk) (l)	Specific Heat (kJ/kgK) (C)	Vapor diffusion resistance (m)
[SIA]	Brick	1100	0.37	0.9	4.0-6.0
381/1	Lime, Sandstone	1600	0.80	0.9	10,0-25
	Aerated Concrete	400	0.18	1,1	3.0-5.0
	Wood (pine)	450-500	0.14	2.0-2.4	20-40
	Wood Fiberboard	350-500	0.09	1,6	2.0-5.0
CRA	Massive Adobe	2000	0.46-0.81	1	10.0-11.0
Terre	Cement Adobe (%8)			0.65-0.85	
	Light Adobe	1200	0.47	1	8.0-10.0
Al-ker	Gypsum Adobe	1600	0.40		13

In water-related materials, water absorption occurs whereas in materials with superficial contact with water, water permeability occurs. Material gap is an important factor in water absorption. Pressured or capillary water permeability occurs in materials with superficial contact with water. Pressure permeability varies depending on water amount passing through the material, water pressure effective on a material with a particular section and thickness and pressure water permeability coefficient of the material. Pressure water permeability of the material varies by the porosity of the material, grain structure and diameter of granular materials. Additionally, another effect of water penetrating into the internal structure in materials is creating changes similar to thermal deformations and causing internal stresses. Capillary water permeability is that water rises in material openings and capillary channels due to the superficial tension of water when the material surface comes into contact with water. In this case, the amount of absorbed water varies depending on the material surface that is in contact with water, duration for water to pass to the other side and the material's capillarity coefficient [6].

Durability and load carrying properties of building materials are determined by mechanical strength. The level of mechanical strengths of a material depends on its elasticity modulus. This value is preferred to be high whenever the carrying quality is high, and to be low if it will serve as a shock absorber against flexible and sudden loads. In order to determine the material's mechanical behavior, conditions of the material such as pressure, tensile, shear, torsion, bending, buckling, fatigue, impact, hardness, etc. should be examined [6].

Adobe material is a compound composed of elements with different properties. Sand plays the internal skeleton role and also a binding role due to the cohesion it creates. Excessive or less than the required amount of clay causes serious damage to adobe [2]. Soil has various proportions of clay depending on its type. Adobe clays consist of various metal oxides and alkaline-earth such as calcite, gypsum, etc. and aluminum silicate systems. Another property of clays is that they take the desired shape when kneading with water and after water is discharged, shrinkage is formed in clay. Clay particles stop when they cannot move and plasticity of the clay is also lost [7].

Volumes of clay particles in the soil increase depending on water absorbed into the body. Clay, which has a binding property in soil, should not crack due to swelling or shrinkage resulting from changes in volume. The analysis of mechanical properties of adobe, made of clay bound earth material, should be performed so that they can be synthesized in a sufficient amount of clay, additive and water mixture by providing granulometry in the structural structure of the material. Sludge, prepared from clay-rich soil, shows more cracking during drying. In order to prevent this, additives can be added into soil [8].

Since the plaster material is clay- and earth-based, weak structure of the material, which is very susceptible to cracking, should be reinforced by mixing with water and then, applied. The most common method used for this purpose is to increase strength and binding property by adding fibers to the mixture. By adding straw, lax fiber, cotton stalk and similar plant wastes as organic fiber while the mixture is prepared, binding performance of the plaster will be increased by reducing cracks if the applied liquid is dried. During applications in some regions, only straw and cotton waste or plasterer's hair are added to the mixture as binder in order to prevent plaster cracks and to obtain a single layer on the whole surface [9].

Some effects such as expansion, shrinkage, vapor pressure, etc. may occur in clay bound plasters depending on the structure of the plaster. In the expansion effect; conditions such as frost, varying wetness or dryness, etc. may lead to disintegration of the clay and thus, to expansion on the inner surface of the plaster. If the plaster is very rigid, first cracks are formed and then disintegration into small pieces is seen. Similarly, in heterogeneous walls (stone-soil mixed), the difference in the thermal expansion of the soil and the stone may cause some deformations. In the shrinkage effect; the plaster shrinks when it dries first and makes the materials it contains stretched. If the structure of the wall is very rigid and smooth, relaxation occurs in the plaster. If the wall is rough, the plaster cracks. Depending on the binding property of the plaster, cracks may occur more or less. Cracks on the outer surface of the plaster due to the exposure to sun light and wind start from the interior of dry walls with less water and expand to the outer surface. The most sensitive points are niche corners and corners on the ledge. In the vapor pressure effect, water vapor can increase the expansion on the internal structure of the wall. Swellings may occur. It is more visible when internal vapor pressure is higher than the external pressure. This pressure difference directs the vapor movement in wall and plaster. Therefore, it is waterproof and thick plasters should be avoided [10].

Clay bound plasters are affected by water. Disintegration may occur in parts exposed to water. It can be eliminated by renewing the plaster. Straw added into this type of plaster prevents plaster cracking. Life of these plasters may be increased upon whitewashing. In outdoor plasters, lime plaster can also be applied to the surface [2].

Plasters may vary depending on clay binding properties and other binder types entering the mixture. These binder types are: clay-cement, clay-gypsum, clay-lime, hybrid and straw fiber bound. [11].

3 EXPERIMENTAL STUDY

3.1. Selection of Structure

Buildings constructed with mud and their external facade plasters in the rural area of Diyarbakır region were visually observed. Generally it is seen that external soil-based plaster coat with 3-4 cm thickness is widely used on the surfaces of the walls built with mud blocks. Lime is applied to some of the external plaster surfaces. It was observed that the plaster coat of some structures that were examined was damaged (Fig.2.).

Figure 2. Examples of disruption on the outer surface plaster

A single storey house, which was built in 1967, was selected in the Yuvacık village of Bismil District in Diyarbakır province in order to conduct experimental examinations (Fig.3.). Selected house is a structure where the wall and plaster materials are soil-based. Blocks made of mud, which was provided by adding fodder in soil, were used in construction of the house. Internal and external plaster of the structure was made with soil based material and the front facade was coated with lime.

This house consists of 4 rooms and 1 barn. Later, an addition was made to this structure with bricks in order to meet the space requirement for kitchen, bath and toilet. Damages in the plasters on the facades of the house are observed since no maintenance has been performed since its construction.

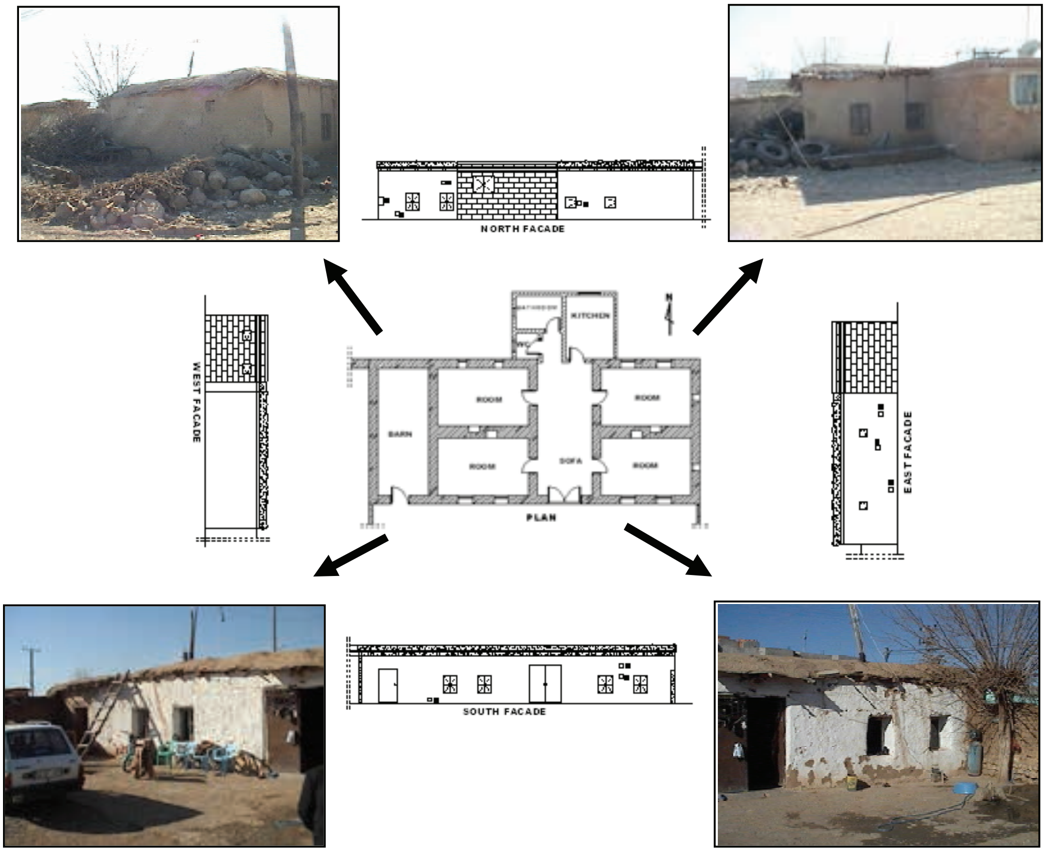

Figure 3. Layout and Facades of the Sample Taken Building

3.2. Sampling

North, south and east facades of the building are open and the west facade is adjacent to the building next to it. Therefore, the sample could not be taken from the west facade. Samples are taken from outer plasters of north, south and east facades (Fig.4). The sample taken from the north facade is coded as sample K1, from the south facade as sample G1 and from the east facade as sample D1.

a)  **b)**  **c)** 

Figure 4. Sampling a) North Facade b) South Facade c) South Facade

3.3. Experiments

In order to identify physical and mechanical properties of the plaster samples taken, experimental studies such as sieve analysis, mass per volume, composite-porosity, specific weight, water absorption by capillarity, time-dependent water absorption, vapor permeability were performed (Fig.5.). In the test study, test methods from Turkish Standards were used.

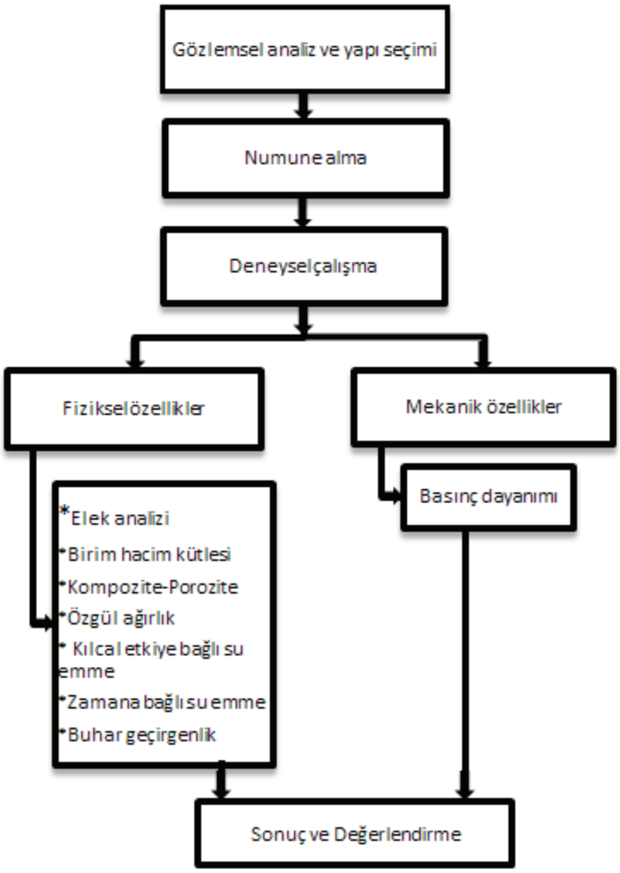

Figure 5. Experimental work flowchart

3.3.1. Sieve analysis

In order to determine the particle size of the material and physical properties of the used aggregate, sieve analysis was performed according to TS 130 standard [12]. The sample was passed through sieves with 0.63 mm, 0.125 mm, 0.25 mm, 0,5 mm, 1 mm, 2 mm mesh. Sample size in terms of particle size was identified. Weights of samples on the sieve and their percentage by weight to the total aggregate ratio were founded. The findings obtained according to the sieve analysis are indicated in Table 2.[13] (Fig.6.) (Fig.7.).

Table 2. Sieve Analysis Test Result

Sieve Opening (mm)	Weight on Sieve (gr)	Sample Percentage (%)
2	6,55	2,183
1	23,2	7,733
0,5	24,75	8,25
0,25	47,38	15,793
0,125	94,54	31,513
0,63	62,56	20,853
Collecting Vessel	41,02	13,673

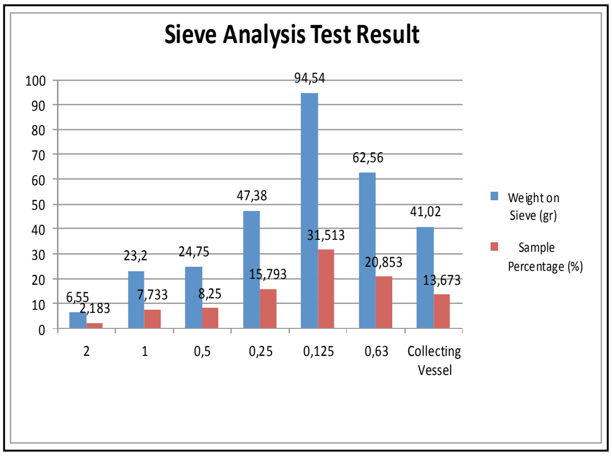

Figure 6. Sieve Analysis Test Result

Figure 7. Sieving the Sample

3.3.2. Mass per volume, composite - porosity, specific weight

The experiment was performed to find the material's mass per volume, composite-porosity, specific weight according to TS EN 1936 standard [14]. Weights per volume of the samples cut in appropriate sizes were calculated. Composite and porosity values of the samples were calculated by carrying out the specific weight experiment with samples. The findings obtained according to the experiments performed are shown in Table .3.[13]. As shown in the Table, porosity values of three samples are found to be higher than composite values.

Table 3. Mass per Volume, Composite - Porosity, Specific Weight experiment results

Sample	Dimensions (cm)	Weight (gr)	Weight per Volume gr/cm^3	Composite %	Porosity %	Specific Weight gr/ cm^3
D1	1,53×2,23×2,91	9,98	1,01	41.06	58.94	2,46
G1	1,63×2,50×3,68	16,48	1,1	42.95	57.05	2,56
K1	1,28×1,28×3,32	6,24	1,15	44.75	55.25	2,57

As unit weight and composite (fill ratio) increase in building materials, properties such as strength and thermal conductivity increase. As porosity (void ratio) increases, strength and thermal conductivity properties decrease. According to the results obtained from the experiment, the percentage of porosity of all three samples is higher than the percentage of the composite. This shows that the material is porous. As a result of the tests, it is determined that the resistance and thermal conductivity properties of the plaster are good.

3.3.3. Capillary affects water absorption

Water absorption by capillarity of the samples, weights and dimensions of which are calculated by cutting in uniform sizes, was measured according to TS EN 1925 Standard [15] [13]. The experiment was carried out with G1, K1, D1 samples. G1 sample was completely wet at 25th minute and completely disintegrated at 169th minute. It was seen that K1 sample was completely wet at 81st minute and mostly disintegrated at 121st minute. Complete disintegration was not observed in the sample, which was substantially disintegrated. Although it was seen that D2 sample was completely wet at 154th minute, it was not disintegrated (Fig.8.). Because D1 sample was not disintegrated, the experiment could be carried out to the end. The result of the experiment is shown in Figure 9 with the graphic method as indicated by the standard [15].

When the water absorption of the materials by capillarity is measured, the sample should not be disintegrated before 45 minutes according to TS 2514. In the experiment carried out, G1 sample was disintegrated at 169th minute, K1 sample was disintegrated at 121st minute and D1 sample was not disintegrated within the Experiment period of 2 hours and 49 minutes. The samples were not disintegrated before 45 minutes, which shows that disintegration depending on water absorption is less. Experimental study revealed that the water absorption performance of the used soil-based plaster is good.

a-) G1 **b-)K1** **c-) D1**

Figure 8. G1, K1, D1 Water Absorption of Samples by Capillarity

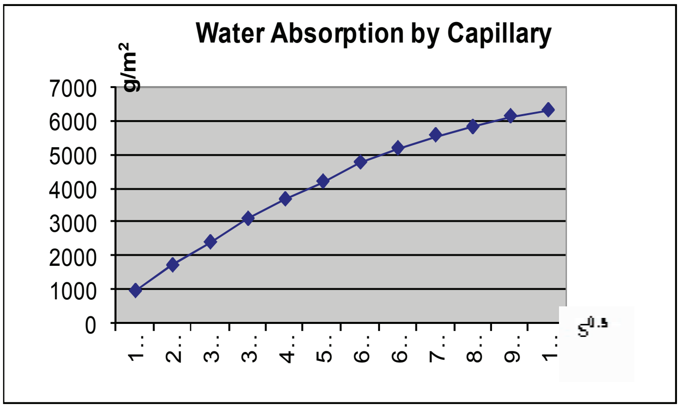

Figure 9. Water Absorption by Capillary Test Result Chart of the D1 Sample

3.3.4. Time-dependent water absorption

In the time-dependent water absorption experiment separately carried out for G1, K1, D1 samples, the experiment was carried out according to TS EN 1936 Standard [14][13] (Fig.10). In the time-dependent water absorption experiment, at the end of 90 minutes, the experiment period, the water amounts absorbed from the glass tube with a diameter of 1.4 mm are measured as follows: 3.6 cm for D1 sample, 2.1 cm for G3 sample and 4.4cm for K3 sample. The findings are indicated as graphs in Figure.11. It is seen that the sample taken from the south facade of the building absorbs less water compared to other samples taken from other facades.

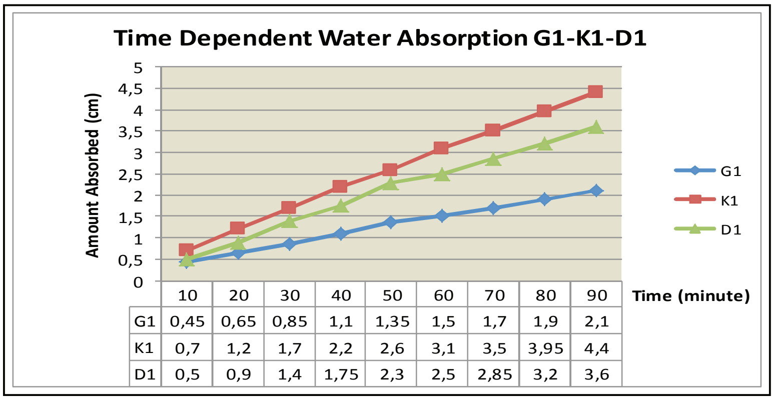

Figure 10. Time Dependent Samples

Figure 11. Time Dependent Water Absorption G1-K1-D1 Water Absorption Test

3.3.5. Vapor permeability

The vapor permeability experiment was carried out for G1, K1, D1 samples according to TS 7847 Standard (Fig.12) [16][13]. According to the results of the experiment, vapor permeability values of the samples were found to be D1- 5,13 m-1, G1- 4,89 m-1 and K1- 5,33 m-1. Data obtained from the experiment separately carried out for G1, K1 and D1 samples are shown in Table.4.

According to TS 7847, the water vapor permeability value (1/µ.d) must be at least 0,5m-1. According to the results of the experiment, because vapor permeability values of the samples are D1- 5,13 m-1, G1- 4,89 m-1 and K1- 5,33 m-1, it can be seen that it complies with the TS standard. It is important that the vapor permeability is at the proper value for fulfilling the performance related to heat and moisture expected from the material.

Figure 12. Vapor Permeability Experiment

3.3.6. Pressure resistance

This experiment for measuring the pressure resistance of the sample was carried out according to TS 2514 Standard [17][13] (Fig.13.). Pressure resistances of two samples of the D1 sample cut as quadrangular prism were calculated and their average was taken. According to the experiment result, pressure resistance of D1-1 sample is 60.32 kgf/cm^2, 32.22 kgf/cm^2 for D1-2 sample and 46.27 kgf/cm^2 for D1-1 and D1-2 samples [Table.5.].

When a sample is subjected to the pressure strength experiment according to TS 2514, the minimum pressure strength must be at least 8 kgf/cm^2 and the average of measurements must be at least 10 kgf/cm^2. According to the experiment result, pressure resistances were measured as follows: 60.32 kgf/cm^2 for D1-1 sample, 32.22 kgf/cm^2 for D1-2 sample and 46.27 kgf/cm^2 in average. The sample has the appropriate pressure strength according to TS 2514. It is seen that the plaster material used on the building's wall can withstand the effects of incoming forces.

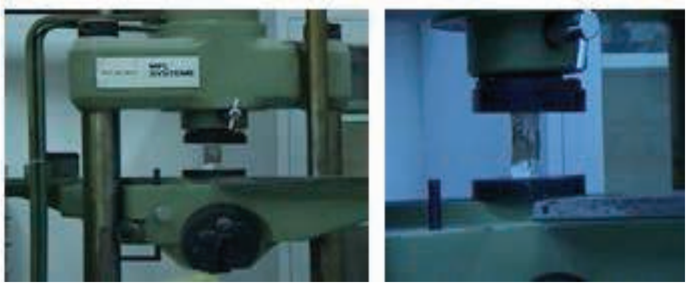

Figure 13. Pressure Test

Table 4. Vapor Permeability Test Flow and Results

	Thickness d (m)	Diameter m	Area m^2	Time Difference between Two Measurements (h)	Sample Weight (kg)	Weight Difference Δm	Water Vapor through-put (G) (kg/h)	Vapor Diffusion Resistance Factor (μ)	$\frac{1}{\mu * d}$
G1	d= 0.01137	0.06960	$3,80.10^{-3}$	0	0,10611535	0	0	18	4,89
				24	0,10669053	$5,75.10^{-4}$	$23,96.10^{-6}$		
				24	0,10711226	$4,22.10^{-4}$	$17,58.10^{-6}$		
				24	0,10741133	$2,99.10^{-4}$	$12,46.10^{-6}$		
				48	0,10808952	$6,78.10^{-4}$	$14,13.10^{-6}$		
				24	0,10847322	$3,84.10^{-4}$	$16,00.10^{-6}$		
				24	0,10886101	$3,88.10^{-4}$	$16,17.10^{-6}$		
				24	0,10920959	$3,49.10^{-4}$	$14,54.10^{-6}$		
				24	0,10962318	$4,14.10^{-4}$	$17,25.10^{-6}$		
				24	0,10999859	$3,75.10^{-4}$	$15,63.10^{-6}$		
				72	0,10999921	$10,00.10^{-4}$	$13,89.10^{-6}$		
D1	d= 0.01218	0.07060	$3,91.10^{-3}$	0	0,10641432	0	0	16	5,13
				24	0,10692752	$5,13.10^{-4}$	$21,38.10^{-6}$		
				24	0,10738312	$4,56.10^{-4}$	$19,00.10^{-6}$		
				24	0,10771101	$3,28.10^{-4}$	$13,67.10^{-6}$		
				48	0,10846637	$7,55.10^{-4}$	$15,73.10^{-6}$		
				24	0,10889201	$4,26.10^{-4}$	$17,75.10^{-6}$		
				24	0,10931364	$4,22.10^{-4}$	$17,58.10^{-6}$		
				24	0,10969011	$3,76.10^{-4}$	$15,67.10^{-6}$		
				24	0,11013146	$4,41.10^{-4}$	$18,38.10^{-6}$		
				24	0,11053827	$4,07.10^{-4}$	$16,96.10^{-6}$		
				72	0,11162201	$10,84.10^{-4}$	$15,06.10^{-6}$		
K1	d= 0.01043	0.07171	$4,04.10^{-3}$	0	0,10287144	0	0	18	5,33
				24	0,10340338	$5,32.10^{-4}$	$22,17.10^{-6}$		
				24	0,10388227	$4,79.10^{-4}$	$19,96.10^{-6}$		
				24	0,10422566	$3,43.10^{-4}$	$14,29.10^{-6}$		
				48	0,10502938	$8,04.10^{-4}$	$16,75.10^{-6}$		
				24	0,10547517	$4,46.10^{-4}$	$18,58.10^{-6}$		
				24	0,10592834	$4,53.10^{-4}$	$18,88.10^{-6}$		
				24	0,10633344	$4,05.10^{-4}$	$16,88.10^{-6}$		
				24	0,10680141	$4,68.10^{-4}$	$19,50.10^{-6}$		
				24	0,10723465	$4,33.10^{-4}$	$18,04.10^{-6}$		
				72	0,10838351	$11,49.10^{-4}$	$15,96.10^{-6}$		

Table.5. Pressure Resistance Test Results

Sample	Dimensions (cm)	P_{max} Breaking load (kgf)	A Pressure applied area of the sample (cm^2)	σ_k Pressure resistance of the sample (kgf/cm^2)
D1-1	2.58*2.89*5.15	450	7.46	60,32
D1-2	2.23*3.62*5.76	260	8.07	32,22
D1-average				46,27

4 CONCLUSION AND RECOMMENDATIONS

It is important to make the use of environment friendly, economic, less energy consuming materials which can provide structural comfort such as mud universal in order to make future generations live in a healthy environment. We know that the number of structures made of mud, which brings great advantages, is decreasing day by day and is faced with the risk of disappearance. Therefore, knowing and determining the characteristic of mud material and improving them and continuation of such traditional structure building and making such materials used in new settlements can be possible. The number of mud buildings that could survive until today particularly in rural areas of Diyarbakır region is decreasing day by day. Getting the qualities of such structures in the region acknowledged and improving them will contribute to making them usable by future generations. According to the results of the experimental studies conducted to determine the characteristics of the soil based plasters used in mud buildings, it is seen that the porosity of the samples are higher than their composite values and accordingly, heat conductivity property is poor. This reveals that this material has a good heat insulation characteristic. Water absorption tests revealed that their disintegration due to water absorption is less. Furthermore, it was observed that the sample taken from the south facade of the building showed less water absorption than the samples taken from other facades. The results of the tests reveal that this material has a good performance against water impact. Yet, protecting the soil-based material from the impacts of water will be efficient to minimize the deformations that may occur. In order to prevent any cracking in the facades, it is recommended to develop structural details that will protect the plaster coat from the impacts of water. Since the vapor permeability value of the material conforms to the TS standard, it reveals that the thermal and humidity performance of the material is as good as required. It is observed that this material has good performance for providing required internal comfort. Pressure resistance tests were conducted to measure its resistance against any force effects on the surface of plaster coat. The corners of the building and areas near the foundation were subject to force factors and thus, these areas deformed the most. Taking precautions in order to protect the structure from the effects of any impact will minimize the possible damages in the plasters.

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The Features of the Climate-Centred Design in Traditional Dwellings: The Case of Suriçi in Diyarbakır

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ABSTRACT

Climatic factors have played a significant role in designing the architectural characteristics of many structures in places with predominantly traditional dwellings. The principles that should be taken into account in planning in aspects such as the form, shape, direction, façade features and spatial usage of structures are important criteria with respect to a harmonious design matching to local climatic conditions. Architectural plans designed in line with climatic conditions ensure that users of structures get protected from negative effects of cold and hot periods of the year while, on the other hand, benefiting from positive effects. A structure design in harmony with local climate is an effective tool in ensuring the conditions of climatic comfort conditions in internal spaces and reducing the need of energy in structures.

Climatic factors did also play the most determinant role in designing the traditional architectural fabric of the dwellings in the district of Suriçi (Walled Town) in Diyarbakır and in the development of the architectural character of the area where these dwellings are located. Having a decisive role in the design of traditional dwellings in the area of Suriçi, the principles of design specified to match to the negative effects arising from hot-dry climate in the province of Diyarbakır have distributed to the formation of a local architectural identity.

This study is of importance with respect to ensuring the usage of the traditional houses in the area of Suriçi in Diyarbakır in a manner whereby special attention is paid to the protection and preservation of their original architectural features. The study aims, in this sense, to define the architectural development of the traditional houses located in Suriçi in line with climatic conditions. The study examines, to this end, the architectural solutions provided in the dwellings with a focus on the local climatic conditions. The investigations conducted in the study show that the traditional dwellings in Suriçi have design characteristics in harmony with the local climate as regards providing climatic comfort conditions.

Key Words: Traditional Houses of Diyarbakır, Architectural Formation, Design in Line with Climate

1 INTRODUCTION

Named as "Suriçi" (Walled Town) in Diyarbakır city and reflecting the traditional settlement order by being surrounded by high castle walls, the region is established on the east side of the wide basaltic plateau with a height of 650 m. extending from Karacadağ to Tigris River and is located on a wide basaltic plane with a height up to 100 m. from the Tigris Valley [1].

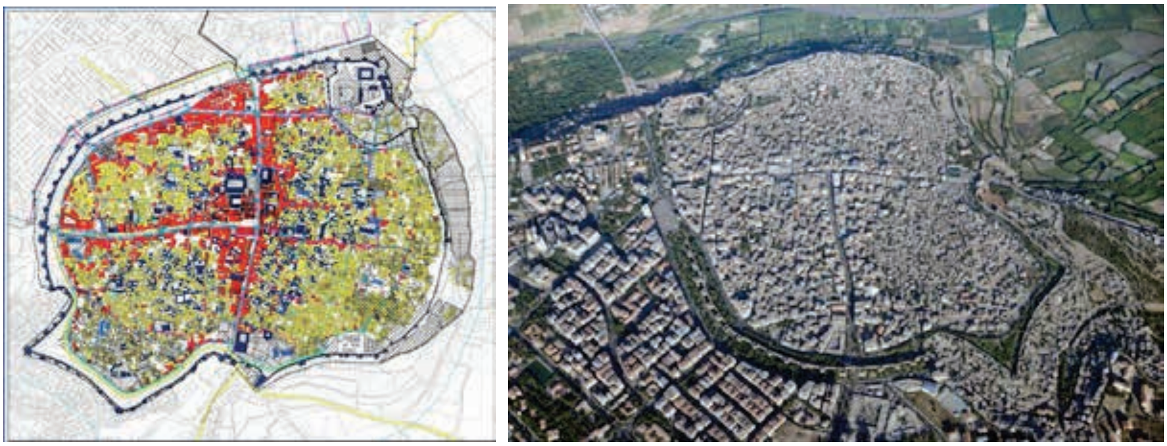


Figure 1. Diyarbakır sur içi (walled city) plan [2] [3]

Traditional settlement orders have been formed as a consequence of organic development integrated with natural and built environment, reflecting the socio-cultural structure of the society in a wide time range.

It is seen that architectural formation of traditional houses at the region of Diyarbakır Suriçi have also been formed with an organic development order in which climatic factors, socio-cultural elements, topographic characteristics and materials are effective. Moreover, another important factor in architectural formation of traditional houses is the castle walls surrounding the city. The castle walls have become a factor that limits extension of the city with a circumference of 5 km. The fact that the city is surrounded by castle walls has prevented the city to expand out of the walls by reason of safety and necessitated settlement units to develop in this narrow area. This necessity has resulted in concentration by the increase in the number of structures at the settlement area. Having been formed by displaying an organic development by the effect of these factors, houses have been effective in the formation of a traditional house pattern in Suriçi region (Figure. 1).

Many factors are effective in the formation of Suriçi settlement, while the predominant factor is climatic conditions. Having been determinant in formation, shaping and development of traditional Diyarbakır houses in the region, climatic factors are apparent in planning and detailing characteristics.

This article addresses the effects of climatic conditions as the most distinct factors in the formation of architectural identity of traditional Diyarbakır houses in terms of architectural characteristics of houses.

2 CLIMATIC CHARACTERISTICS

Diyarbakır province located in the Southeast Anatolia region is positioned on 37° 55' north latitude and 40° 12' east latitude. Its altitude above sea level is 670 m. According to the average values occurred in long years in Diyarbakır (1950-2015), the average temperature is 30.4 °C, the average highest temperature is 38,5 °C and the average lowest temperature is –2,3 °C. [4]. Hot dry climate characteristics are effective in which continental climate conditions are dominant. Summer is very hot and dry; winter is cold and moderately rainy. Cloudiness ratio and relative humidity is low. Temperature differences between day and night are high in summer and winter months. The period characterized as the warmest term during which solar rays are undesired, namely which requires protection is longer than the period that is characterized as the least warm term during which solar rays are needed in terms of climatic characteristics of Diyarbakır city. It is apparent the fact that the warmest period is effective for a longer time in one year time interval is the determinant factor in construction designs [5].

3 PLANNING CHARACTERISTICS

It is seen that designs with different characteristics are developed for summer and winter months in the formation of Suriçi house architecture. The region has hot-dry climatic character, which has ensured the formation and development of structures by being shaped around a yard.

Even though the parcel geometry is in different shapes, structure masses create the yard by combining with perpendicularly or with little deviations to each other. Yard geometry is in the form of quadrilateral. They are positioned perpendicular to each other even in the most deformed parcel in spite of little deviations to cardinal points. The masses forming the structure by being shaped around the yard (one, two, three or four masses) are usually in east-west, north-south direction [6]. According to positioning types of masses around the yard; external yard (L type, U type, Interim type), internal yard and medium yard plan types are formed [7].

Spatial functioning in the masses, which forms the plan types, has been determined according to seasonal characteristics. The masses around the yard are composed of one, two or three layers. Basement floor of houses has been used for cellar purpose. Some spaces such as iwan (vaulted or domed space recessed from a central hall or court), room, kitchen, toilet and barn are available at ground floors. There are rooms and iwan on upper floors. The connection between ground floor and upper floors is ensured with the stairs located on the yard, iwan or space units, the connection of ground floor is ensured with stairs descending from the yard [7].

Most of the spaces, which form houses, are fronted to the yard they surround. Even though the number of spaces fronting to street is low, they are just used on upper floor of houses. All spaces on lower floors are fronted to the yard and they have no front to the street. The exterior door that provides connection of lower floors of houses to street is connected with the yard. Closed or semi-closed spaces shaped with climatic factors are formed around the yard. Most spaces have direct connection with the yard.

The structure masses surrounding the yard have been positioned by considering the characteristics of climatic factors. The section located on the south of the yard is composed of summer spaces. All places and spaces on this section front to the north. Frontal surface of this section faces the shadowy area and is not subject to solar rays. For this reason, the section located on south of the yard is named as summer section and used during summer time. The section that is usually on north of the yard is used as winter spaces. Places and spaces on this section front to the south. It is aimed to ensure that these spaces fronted to south benefit from solar radiation. However, the section located on east of the yard and receiving western sun in the houses which do not have north mass and the section located on west of the yard and receiving eastern sun in the houses which do not have north and east mass constitute the winter spaces. These units are named as winter spaces and used throughout winter. The masses on the east or west of houses which both have winter and summer sections are used as spring section (Figure.2).

South surface is the construction surface that gets sunlight for the longest time throughout a year in terms of sunbathing period of construction surfaces. For this reason, east and west surfaces are colder in winter and warmer in summer time compared to south surface [5].

Building masses have been constructed as adjacent as possible to neighbor building in order to diminish frontal surfaces with the aim of reducing effect of sun radiation during summer and being protected from wind effects and cold during winter time.

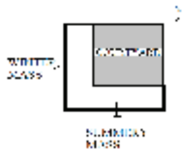
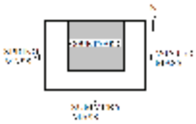
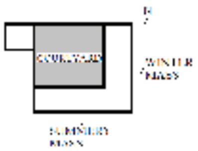
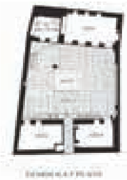
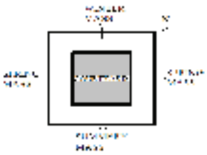
PLAN TYPE		SEASONAL USE	PLAN	COURTYARD
OUTSİDE COURTYARD	L TYPE			
OUTSİDE COURTYARD	U TYPE			
OUTSİDE COURTYARD	INTERMEDİATE TYPE			
INNER COURTYARD				
CENTRAL COURTYARD				

Figure 2. Residence types in traditional Diyarbakır houses [7] [8]

Winter section is usually single-floor while summer section is 2-storey. The hip plate viewing the north of the winter wing fronted to south stands leans to the two-storey summer section of the house on adjacent parcel. Two-storey summer section is fronted to north and the hip plate viewing the south becomes shield on the north wing of the adjacent parcel. South wing is predominant in houses. The fact that south wing is used more than the wings on the other points is a consequence of climatic factors. The fact that the hot and dry summer period causes more discomfort compared to cold winter conditions is understood from the situation that climatic solutions predominantly orient to summer period. The number of wings may be 3 or 4 according to economic situation of home owner [6].

The narrow streets which display an organic formation with high walls of houses are in nature of creating shadowy and cooling effect in hot period. It is seen that bay windows are used with bulges made for enlarging the space on upper floors of some houses. Window apertures do not exist on wall surface of bay windows viewing the street in general; there are window apertures on side wall surfaces. Windows located on opposing side surfaces ensure benefiting from air stream (Figure 3.).

Figure 3. Bay window and archway usage

The lower parts of rooms overflowing to the street by expanding enlarged spaces reciprocatively have ensured formation of gates named archways. Opposing windows which form these gates create air stream in rooms. These sections, having a cooling effect by creation of shadowy areas in hot summer months, provide sheltering from rain and wind during winter time. The fact that door of houses which creates an archway is opening to this area is a detail considered in climatic sense.

4 RESIDENCE UNITS AND CHARACTERISTICS

All details such as direction, functioning, qualities, determination of each space that constitutes Suriçi houses have been designed and considered according to climatic conditions of locality. Formation and characteristics of units which form a house in terms of climatic factors are as follows:

Yard

Being the most important factor of traditional Diyarbakır houses, yard is a common area that provides connection between house units. The section surrounding the yard and/or high yard walls decrease sun effects during summer time and wind effects during winter time. Some elements used in the yard such as pool, water channels and trees create a cooling effect during hot period.

Iwan

One of the most important units constructed in houses against hot climate effects is iwan. The surface of iwan that is directly related with the yard is an open surface and other surfaces are closed. Its connection with the yard is on the same ground level or a bit heightened. Heightened structure of iwan mostly aims to provide lighting and ventilation depending on the size and number of basement floor windows on its lower floor [6].

Figure 4. One compartment iwan, two-compartment iwan, three-compartment iwan

Passage to adjacent rooms is provided with the doors on closed side or back surface of the iwan. Being a semi-closed unit, iwan is an area shadowy against sun effects during hot summer period and offering shelter against rain and wind effects during winter time. Door connections provided to adjacent rooms from iwan ensure decreasing negative external factors during hot and cold period in room entrances. Since the discomfort caused by hot climate characteristic is higher compared to the cold period, iwans located on the south wing and fronted to the north have been planned larger and more elaborate than those located on other wings. Iwans are categorized as one-, two- or three-compartment according to their sizes (Figure 4.). Iwans have 2 or 3 compartments and are larger on the ground floor, while they are also used on the upper floor. Connection to upper floor iwans is provided with stairs inside the building or from the yard.

Serdap (underground storehouse)
This is a space designed for negative effects of hot dry climate and only used in hot periods. This is inherently available in an independent basement floor space lower than the ground level and opening to the yard. It is located on the section viewing north point of houses. Water draining inside with a water flow setting located on one of these space windows and named as "selsebil" is collected on a pool in the room. Serdaps, the sole function of which is to create cooling effect on the air inside the room during hot and dry summer tim,e are located in large houses (Figure 5.) [6] [5].

Figure 5. Use of serdap inside room

Hall
This is an indoor area to which room doors are opening and have a connection with the yard. Avoidance of direct connection between rooms and the yard by ensuring a connection of room doors to the hall provides protection in room entrances against negative conditions caused by rain and wind effects during cold periods.

Room
Room is a unit in which daily activities of household such as sitting, sleeping, eating and guest welcoming are made. Room is not a living space by itself in Diyarbakır houses; rather it is in nature of a part of iwan and other units. The doors on masses located as summer, winter and spring according to sun effect of seasons are indoor spaces.

Figure 6. Summer and winter rooms

Seasonal function changes are made in rooms according to the direction to which the wings around yard are fronted. The main room located on the upper floor and fronted to the street with a bay window and other rooms are used in winter while rooms located on the ground floor are used in summer time. The rooms with a front iwan on the south wing are cooler during summer time. Window apertures of summer rooms with high ceiling and larger size are also larger and a great number. Since the summer rooms have high ceilings and are large, upper windows are used in order to ensure sufficient lighting for spaces. Winter rooms located on the north wing and directed to the south have low ceilings and are small; window apertures are smaller and fewer. The use of wooden elements such as cabinets and cupboards is apparent on indoor wall surfaces of winter rooms. The wooden material used contributes to indoor temperature of rooms (Figure 6.).

The rooms may be directly connected to the yard and also associated with the yard with connection of the hall or iwan. Since the presence of direct door connection with the yard could not provide protection against rain and wind effects, the rooms having connection with the hall or iwan provide more sheltering during winter time.

5 SERVIVE UNITS AND THEIR CHARACTERISTICS

Kitchen
Kitchens in houses are quadrilateral planned and their surface connected to the yard is arched. They are semi-closed structures directly connected to the yard (Figure 7.). They are exposed to the effects of hot periods because one of their surfaces is open.

Open surface is closed with woodwork and thus, protection from external effects is provided in current usages. In terms of direction, it is usually located on north wing while it may also be located on east or west wing according to parcel geometry. The reason why kitchen units are mostly located on the north wing and fronted to south is for decreasing wind effects of winter periods on the space [6]. A furnace and chimney is available in kitchen units. Winter room of houses is located near the kitchen.

Figure 7. Kitchen yard connection

Cellar, Bath, Toilet
Cellar units, where household supplies are stored, are buried on earth on a level lower than the yard level. For this reason, this space is always cool during hot periods. Ventilation of cellars is provided with a small spacing located on the yard front. Toilet (lavatory) is planned as directly connected to the yard and adjacent to the entrance that is the nearest location to street because of

health concerns. A unit used only as bathroom is merely located in large houses. Bath needs were previously satisfied in Turkish baths, which were abundantly available [6].

Gezemek (Corridor), Balcony

Gezemek is an open corbel unit, resembling a balcony, located on upper floors of masses and fronted to the yard. It has connection with stairs to the yard. Their length varies according to the number of spaces to which they provide connection. It is seen that they are used all along on the front of some houses. Floor of gezemek made of sconce stones is flagstone. Gezemek contributes to better ventilation of spaces by means of doors opening from spaces they are connected to (Figure 8.).

Figure 8. Use of Gezemek

Use of balcony is seen in a considerable few number of houses. The balconies overlooking the yard of houses are small as an open corbel structure. They are suitable for sitting or resting function because of their size, but contribute to better ventilation of any space by means of doors opening from the space they are connected to. Their construction technique is the same with gezemek.

6 BUILDING ELEMENTS AND THEIR CHARACTERISTICS

Walls

Walls are composed of carrier/load-bearing or divider walls in Suriçi houses. Wall material is basalt that is abundantly available in the region. Basalt is formed by solidification of fluid and basic lavas as perpendicular to cooling surface in the form of five and six sided columns. Moreover, external parts and flow edges of such kinds of lavas that are in contact with air may be porous. This gives a clinker appearance on stone. Gas particles released from cooling lava result in the formation of such pores. Pores become smaller and the number of pores decreases towards the inside of stone. This type of basalt is called as cellular basalt. This absorbs more water and its absorption capacity is high. It is easily processed. On the other hand, nonporous basalt has a flat structure. Having a stiffer structure, nonporous basalt is strong against impacts and its bearing capacity is high [9].

Load-bearing walls are made of nonporous basalt stone with thicknesses ranging between 0.50 cm and 0.80 cm. On the other hand, partition walls are thinner and used as a replacement for basalt stone or wood frame with mud-brick filling. A thick external wall in houses ensures a long period of time in which external environment temperature affects the internal surface [5]. When this period is longer, external air temperature affects internal environment temperature, so thermal comfort conditions achieved in spaces are preserved for a longer time.

Flooring

Upper coating of basement floor is made of wooden beams or flagstones. On the flooring made of wooden beams, wooden beams placed in parallel with short edge of the space are coated with one layer lath. This was laid out by shiver, sawdust and then filled with rammed earth (clay) and finished with brick dust mortar. Moreover, the use of flagstones having a porous structure is seen on basement flooring. These stones are covered on depressed arches placed seating between basement windows and determine the room or iwan level. Other stones are placed between these stones perpendicularly as a bridge. Their spaces are filled with thickened mortar in order to avoid water intake and ensure cold proof. [6]. The flooring made of flagstones was particularly used on upper coating of basements under iwan (Figure 9.). Iwan flooring is frequently washed in order to increase cooling effect as a result of hot dry climate. Water absorption capacity of porous flagstone is high. For this reason, its use in iwan and yard flooring helps in creating a microclimatic effect in the environment, especially during summer [10].

Figure 9. Use of flagstone in upper coating of basement

Upper coating of spaces in ground floor and other floors is wooden beamed (Figure 10.). On the upper roof paneling that is open to external effects; wooden beams are covered with board and then coated with shiver, straw or withe.. And then compressed earth and barren clay are applied.

Figure 10. Wooden beamed flooring

Eaves are used approximately 50 cm away from the exterior wall on the housetops. Grooves (gargoyles) are used in order to prevent rain water flowing down from eaves from affecting the wall surface.

Roof slab of all houses is used as earth housetop. When the hot period effects of the locality are considered, flat roof solution is more appropriate than an inclined roof solution in order to decrease the effects of solar rays. Since bringing sun radiation on inclined roof surfaces back to the normal level provides greater absorption, it results in increasing temperature effect of sun beams. Moreover, coating the roof with earth-straw mixture, as a good insulation material with low thermal transmittance, is another important factor in reducing temperature effect of sun radiation [5].

Windows

Climatic factors of the locality are not only effective in positioning the masses, which constitute the houses, but also in size and the number of windows used on fronts of masses. Window apertures, which differ in size on different points, are used in a range of widths such as 90 cm-100 cm-115 cm [5]. Window apertures on the front of summer section are large and a great number. Since the storey height of closed rooms on this section is high, skylights are used in order to ensure sufficient lighting in spaces (Figure 11.). Window apertures are smaller and fewer in the section located at the north wing, orienting towards the south. Wooden windows, which are not very large, are divided into excessive records and transparent surface area is reduced. Reduction in glass surfaces, in which thermal conductivity of glass is high, helps in decreasing thermal loss. Another detailing in terms of climatic factors is seen on window joineries. Window joineries on the summer section are located in internal surface of the wall and thus, the effect of sun radiation affecting the transparent surfaces on the summer section is reduced. Window joineries are used on external surface or in the midst of wall in the winter section. The aim is to benefit from temperature effect of sun radiations affecting transparent surfaces in winter spaces. Moreover, the use of some elements such as lids and shutters is seen on room windows of winter and seasonal flappers of some houses. Shutters provide protection against negative effects of the cold period such as rain and wind.

Figure 11. Use of window in summer mass

Doors

The main entrance door of the house is opening to the yard. In some houses, entrance door is opening to the hall and transition to the yard is provided through the hall. Space doors may be connected to the yard or linked with halls. The connection of room doors to the hall prevents rooms from directly being exposed to rain and wind effects of the cold period.

7 CONCLUSION

The most determinant factor in the formation of traditional houses of Diyarbakır Suriçi has been the climatic conditions of the locality. Climatic factors have directed the planning of houses at design stage as a significant design criterion. The plan types, use of directions, positioning of masses, usage and functioning of spaces, use of building elements and materials in houses have been planned and detailed according to climatic parameters of the locality. The traditional houses,

which constitute Suriçi settlement, are the unique examples that reflect construction models in compliance with the climate.
Designing houses in compliance with the local climate offers protection against negative effects and enables benefiting from positive effects of the climate during hot and cold periods in a year.

Planning of houses in compliance with climate has significantly contributed to ensuring that residents have minimum energy requirements and climatic comfort conditions in such spaces.

Climate oriented solution methods in traditional house examples in Suriçi are significant for creating a resource for newly developed houses in the locality in terms of climatic planning principles and ensuring energy economy in houses.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Approach on Preservation of Cultural Heritage against Disasters


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ABSTRACT

Identified as the incidents that result from nature, technology and human, which lead to severe troubles in social life and disrupt the daily life such that they result in human, material, economical and environmental losses and that go beyond the control of community to cope with such circumstances with their own resources, disasters have significantly increased in frequency and sizes recently. Taking a toll on cultural heritage areas as well, disasters, which are experienced today, has once more emphasized the importance of preservation and grasped our attention. Given the cultural heritage**,** it becomes the most important phenomenon not only to protect the building or assess the extent of the damage on the basis of area but also protect the spirit of the place as well as the traditions which make culture itself.

The objective of this study is to shed light on preservation procedures by seeking the answer for what can be done to produce the cultural heritage before, during and after a natural disaster. With this in mind, an analysis sampling was conducted through risk analysis on the basis of Haydarpaşa station, a sample of cultural heritage, for the precautionary works before the disasters and disaster prevention and reducing the impacts of the same was elaborated.

Key Words: Cultural Heritage, Disaster, Preservation, Haydarpaşa Station, Risk Analysis

1. INTRODUCTION

Until recently, the phenomenon on the preservation of cultural heritage has been discussed on the basis of monuments and tangible heritage; and in a sense, it has been based on the idea of preservation of such elected buildings as an object. The impact of disaster has been considered as the damage to the building and the actions taken in this respect have focused on damage assessment. However, it is rather insufficient to identify a cultural heritage in this manner.

According to the definition in Article 3 of Turkish Law No. 2863 on Preservation of Cultural and Natural Properties, cultural property refers to tangible or intangible properties, bearing scientific and cultural value, which are subject to social life and associated with science, religion, fine arts and culture [1].

As can be understood from this definition, cultural property constitutes the whole of scientific, artistic, religious or cultural products that build up a culture and that is formed of tangible or intangible values.

Especially in the areas close to disasters, it is required to take lessons from any and all disasters and incidents experienced, and take some precautions to be ready for upcoming events. Damages encountered during disasters, their reasons and developing recent techniques to prevent the same must be a course of action, developed instinctively by a community suffered from a disaster. At this very point, it becomes more of an issue, the holistic approach of protecting the traditions of a community, cultural identity, interaction of the same with the social environment that shapes the community, rather than the cultural heritage itself, i.e., protecting the process, itself, which sustains cultural heritage against disasters.

2. PRESERVATION APPROACH BEFORE DISASTERS TAKE PLACE

In recent years during which severe natural events, occurring more frequently, started to turn into a catastrophe, these events pose a threat to the major cultural, architectural and natural heritage areas in the world. Apart from the disasters arising out of nature and people, wars and local conflicts, large-scale projects ruling out cultural heritage, the impacts of mass tourism, legislative regulations not focused on cultural heritage and their outcomes threaten cultural heritage in short or long terms, either directly or indirectly.

Earthquakes, floods, moisture, fire and vandalism are some of the factors that pose the biggest threat to cultural properties. It is also important to consider the preservation measures and techniques regarding the buildings, categories and materials, which are cultural formations. i.e., analysis of water weakness of an adobe building and consideration to ensure production in compliance with construction technique such as planning and building in accordance with the measures to be taken therewith [2]. Risk management is an important step in preventing the loss of cultural property against such elements of risk or depreciation of the same. Identifying the elements of risk, observing and assessing the features such as the impacts and impact areas of elements of the risk are significant steps to be taken in prevention of this process. The first step of risk management process is identifying risk elements and the potential risks, posed thereof as well as performing a risk analysis in accordance with the data, obtained through identifications and observations, performed in risk analysis stage.

Before Disaster: Identify, prevent or reduce the effects of the **risks** and **hazards** likely to result in disasters…

Hazard refers to natural or man-made disasters likely to result in loss of life and property, injuries, social and economic destabilization or environmental damages regarding people, nature and settlements at a certain period of time and place.

Risk refers to potential losses to take place based on the level of damage to be suffered by the elements, which are under threat in case of occurrence of any threat at a certain time and place. This is identified as loss of probability in insurance and engineering. When it comes to disasters, it is referred to as disaster risk. In other words, it refers to the possibility of occurrence of a loss, injury or any other detrimental outcome to arise out of hazards.

Vulnerability
The degree of potential damages likely to be suffered by the elements, which are close to the sources of hazards in case of appearance of a hazard. It is also identified as fragility and weakness.

Manageability
The degree to mitigate the losses of the affected community in case of disasters.
Disaster = Hazard x Vulnerability

$$\textbf{Risk} = \frac{\text{Hazard x Vulnerability}}{\text{Manageability}}$$

Risk Assessment includes the actions, which are required to be taken in order to identify the hazards existing in areas such as construction site, workplace etc., or those likely to come from outside, analyze and grade the risks arising out of the factors and hazards that lead to transformation of such hazards into risks and determine the control measures.
As for the risk concept appearing in the preservation of cultural heritage, it refers to impairment of natural and/or man-made disasters as well as the values subject to cultural heritage and threatening the integrity of the same [3].

The background of institutionalization of preservation of cultural heritage regarding risk concept at international level dates back to the end of the World War II. At the end of the war, the countries whose cultural heritage had been destroyed came together and organized in order to take the required measures in this respect. Accordingly, United Nations Educational, Scientific and Cultural Organization, i.e., UNESCO was founded as a private organization of the United Nations in 1946.

UNESCO published its first convention (Hague Convention) in 1954 that draws attention to the risks encountered with cultural properties due to armed clashes. However, it is possible to consider the first international document extensively dealing with cultural heritage within the scope of risk as the convention on world heritage, which was approved by UNESCO [4]. In the convention, it is stated that cultural heritage and natural heritage are at risk not only because of customary impairment reasons such as corrosion but also social and economic changes [5].

Furthermore, signatory countries undertook obligations regarding risk management for cultural heritage with the UNESCO's Convention on the Protection of World Cultural and Natural Heritage [6].

In Article 4 of the Convention, it was stated that signatory countries are initially assigned to determine, protect and display the cultural and natural heritage in their homeland as well as transferring the same to the next generations.
Later in 1992, once it was recommended in UNESCO's expert reports that cultural heritage should also be considered in terms of "risk preparation", a new era has started for the cultural properties included in world heritage list [4].

In 1996, International Committee of the Blue Shield - ICBS was founded in order to work for protecting cultural heritage against the risks of natural disasters 6].

The risk issue, which has been diversified since 2000s, became a direct decision as adopted in the meeting of the World Heritage Committee in 2005. In the World Heritage Implementation Guidance, which was improved through revisions in 2005, 2008 and 2011, the risk issue was included under the title of "Preservation and Management" and it was recommended to make a "risk preparation'' study as an element of training strategies and management plans, prepared for the World Heritage.

Afterwards, innovative technologies in risk reduction were discussed in the Preservation of Cultural Property in case of Risks: Opportunities and Threats International Symposium held in 2012 by Yıldız Technical University, Risk Preparation Committee of International Council for Monuments and Sites (ICORP-ICOMOS) and Governorship of Istanbul, Special Provincial Administration Istanbul Project Coordination Unit.

Any and all studies, conducted for reducing the risks regarding the cultural heritage and getting prepared for the risks, are among the current problems of preservation organizations such as UNESCO, ICCROM, ICOMOS, IUCN and ICOM, etc., which perform extensive studies regarding the risks in preservation of cultural heritage.

In recent years, risk discussions included in preservation disciplines in a vital way further include risk analysis and risk management. **Risk analysis** is a part of **risk management** process in preservation-implementation procedures for buildings of historical cultural heritage. Performed in such process, risk management refers to any and all actions performed in order to determine, identify, control, remove or reduce the risks likely to affect the process negatively as well as the losses and damages caused by such risks.

In consideration of the developments, experienced in the field of cultural heritage after 1950, it was asserted that cultural heritage should not only be protected due to the artistic or scientific value it bears, but also due to the fact that it is the "**common heritage of humanity.**"

In risk management for cultural heritage it is essential to:

- make early preparation and planning,
- deal with cultural heritage as a whole with all tangible and intangible aspects while planning,
- take measures which will have the minimum impact on the values of cultural heritage,
- perform risk assessment regarding cultural heritage in consideration of the risks encountered in the past,
- give priority to the heritage under risk in the maintenance and repair programs
- include the users in emergency action plans directly,
- give priority to the elements of cultural heritage in emergency cases,
- take any and all required measures for improving and repairing the cultural heritage after disasters,
- be integrated with risk planning, reaction and improvement studies in any stages of preservation principles.

In consideration of these principles, risk management consists of **3** stages; i.e., **preparation, intervention** and **improvement**.

Preparation (before the disaster)
1. To identify and map the risks,
2. To reduce the sources of the risks,
3. To certify all of the cultural properties, especially those, which are at risk and strengthen the same against anticipated outcomes of the disaster,
4. To develop insurance systems,
5. To develop and implement early warning systems,
6. To prepare and implement exercise plans for emergencies included in the actions to be performed before the disasters.

3. PRESERVATION APPROACH DURING DISASTER

During the Disaster: Apply the right course of action acquired in training and exercises…

That is to say;
Intervention (during the disaster);
1. To implement emergency plans,
2. To mobilize conservation experts.

During the disaster, essential measures and preservative actions are immediately taken in consideration of the trainings and exercises performed before the disaster.

In fact, the things that are likely to be performed by the public, official organizations and relief agencies are limited during or immediately after a disaster because the majority of the injuries and loss of life as well as damages to the buildings during a disaster take place within the first few hours. The first and efficient intervention assistance made by the local public and the officials who are responsible for the cultural heritage once again emphasizes the importance of preparation and training before the disaster.

As it takes as long as 24 hours to make the outsourced assistance available in the disaster area, local community in the areas at risk must be trained in advance about what should be done during disasters, whose orders must be followed, where the stocks should be kept etc. In this process, it will be reasonable if the tasks to be performed at the time of disaster are performed by the person who conducts that task in daily life (i.e., the cooker is assigned in the kitchen of the disaster, fireman is assigned in rescue and safety personnel is assigned with keeping the order). During the disaster, the houses of these officials may also suffer or their families may be injured. In this case, the officials will have a dilemma between their responsibilities against their families and the tasks. The families of these officials must be included among the disaster victims to be recovered and secured in the first place.

It is especially important that discharge and emergency exit routes be enabled in cultural properties within a short time during the disaster.

When it comes to associate pre-disaster and order of the same;

Risk management (pre-event / proactive action): Actions to be taken for protection from the incident before it occurrence, eliminate the risks and prevent /mitigate damages. Here, the aim is to eliminate the disasters and the risks of the disasters.

Crisis management during the disaster (after the incident / reactive action): Actions to remove the disaster / crisis once the incident takes place and mitigate the damages of the crisis. Here, the aim is to minimize the losses.

4. PRESERVATION APPROACH AFTER THE DISASTER

After the Disaster: Minimize the losses thereby intervening in the event in a timely, quick and efficient manner, prevent the potential successive effects or secondary disasters and restore the normal life as soon as possible.

Improvement (after the disaster);
1. To destroy and ward off the negative elements of disaster (to remove floodwater, to stabilize moving parts, etc.)
2. To conduct all the necessary work to reconstruct the physical and social components,
3. To oversee preparation and intervention efforts and create a better risk management model.

It should be underlined that for those three stages, people who will intervene and be in charge (local users and community, local administration, regional, national and international institutions and organizations) and to what extent (single structure, historical environment, cultural landscape, archeological site, etc.) should be defined and implemented.

Management following the disaster is a very important stage. The **objective of disaster management** in the period after disaster is to minimize the economic and social losses likely to occur from the disaster or correct the effects of the same within the shortest time and create a new, safe and enhanced living environment for the communities affected by disaster [7].

When it is considered in terms of cultural heritage, it is of capital importance to ensure the security of movable and immovable cultural assets. If needed, movable assets should be transferred to the pre-determined safety areas and safety barriers should be established for the immovable ones, and measures of conservation must be taken for plunders or secondary hazards.

Figure 1. 2016- 2017 Post-War, Palmyra Cultural Heritage, Syria [8].

<u>After the Disaster</u> Rendering services and outcomes such as renewal and safe settlement bear importance with both for taking the society back to normal life and increasing the resistance against disaster.

Following the fulfilment of the tasks regarding the emergency case taking place with the disasters, the most important issue is to ensure that local communities and individuals return to their normal living conditions as soon as possible. It is the main objective of improvement studies to shorten such normalization process as much as possible. Any and all activities, which start immediately after the occurrence of a disaster and that may last for a few years based on the scale of the disaster, are a part of the improvement phase.

Figure 2. 2016- 2017 Post-War, Syria (Market entry-Aleppo, Old market place, Aleppo) [9].

<u>Some of the principles to be followed in improvement phase are outlined as follows:</u>
• Local communities must be included in improvement studies,
• In improvement process, local authorities must undertake responsibilities,
• Principles must be developed with respect to source utilization balances between improvement and damage mitigation,
• Extensive improvement planning must be made and the risk analysis, conducted in preparation stage, must be reviewed, which will be the most important stage and solution for risk management.

Figure 3. 2016- 2017 Post-War, Syria (Ömeri Mosque-Dera, Ümeyyed Mosque, Aleppo) [9].

5. CONCLUSION AND RECOMMENDATIONS

In order to prevent disasters and mitigate the damages, it is essential to manage the resources in accordance with the common objectives with any and all institutions and organizations of the society so that the actions, required to be taken **before**, **during** and **after** a disaster, could be planned, directed, coordinated, supported and implemented.

Earthquake, fire, armed clashes, vandalism, terrorist attacks, global climate changes not only impair the ecologic balance of natural areas but also result in damage to archaeological areas, historical buildings.

According to the findings in recent years, there have been significant losses in World Heritage Assets due to natural and man-made disasters. For instance, **Bam town (Iran)** and **Prambanan Temple** (Indonesia) suffered from earthquakes in 2003 and 2006 and **Edinburgh Old Town** (England) suffered from fire in 2002.

In 2001, Bamiyan Buddha's in Afghanistan were destroyed due to armed clashes and vandalism; Tooth Relic Temple in Kandy (Sri Lanka) was destroyed due to terrorist attacks in 1998 and Sundarbans forest (Bangladesh) was destroyed by hurricane in 2007, fishermen wild life disappeared and salty waters spread all over the area. As for cultural climatic changes, they not only impair the ecological balance of natural areas but also result in damage to archaeological areas, historical buildings due to disasters such as earthquakes, floods etc.

On November 28, 2010, the roof and the fourth floor of Haydarpaşa Train Station were severely damaged in a serious fire.

Figure 4. Haydarpaşa Train Station Fire-2010 [10].

Samples of risk analysis and preservation approach through Haydarpaşa Train Station, one of our immovable cultural assets, were analysed in the Table below.

Table 1. Haydarpaşa Train Station Risk Analysis- 2017 [11].

<table>
<tr><th>POSSIBLE RISKS</th><th>HAZARD</th><th>IF RISK OCCURS</th></tr>
<tr><td rowspan="2">FIRE, EXPLOSION, BEING UNABLE TO INTERVENE IN FIRE</td><td rowspan="2">*Handmade power tool usage, *Forgotten electric heaters still on the plug at the resting places of employees, *Failure to intervene quickly during the fire *Storage of chemical materials, *Storage of materials outside the warehouses, *Flammable materials, *Failure to intervene in case of emergency , *Leaving the tubes open when there is no work on the site, *The absence of a flame rear vent in the tubes, *Storage of the tubes in the open area, *Use of cables in poor quality , *Working in the vicinity of flammable materials, *Use of oxygen tubes with greasy hands or gloves, *Stacking of flammable materials, *Failure to clean material debris, *Furnace used in the workshop, *Smoking during work, *Forgotten electric heaters still on the plug at the resting places of employees, *Failure of the electrical panels due to overload, *Sparks during the cutting of puntos, pins etc.,* Exacerbation caused by the burr, *Lack of adequate fire extinguishers in the workshop,</td><td><u>From the perspective of people;</u>

Injury and loss of life in the event of explosion and fire</td></tr>
<tr><td><u>From the perspective of the building and the environment;</u>

In the event of explosion and fire, burning of the building, irreparable damages, destruction of valuable resources and documents in it</td></tr>
<tr><th colspan="3">DISASTER RISK MITIGATION</th></tr>
<tr><td colspan="3">*Continuous control of electrical appliances and machines, using them after their suitability is evaluated, *Availability of a sufficient number of fire extinguishing tubes in the construction. *Carrying out periodic annual inspections, *Storage of chemical and inflammable materials away from fire, *Hanging warning signs and specifying appropriate storage conditions in accordance with material safety data sheets, *Not storing materials outside the areas designated as warehouse, *Placement of fire extinguishers where necessary, *Operations with a commercial ABC type chemical fire extinguishing device on the site, *Placement of one flashback arrester vent on each valve inlet and blow torch inlets of the tubes, *Storage of the tubes in a closed iron cage, after separating them as full and empty, *Hanging of 'do not approach with fire' warning signs, *Checking the on-site availability of fire extinguishers, *Making sure the cable sections used are suitable, *Not working in areas where flammable materials are present, *Not using greasy hands or gloves with the tubes, creating awareness in this regard, *Collecting production wastes at the end of the work, *Periodical maintenance of the furnace on the site and provision of instructions, *Prohibiting smoking, *General control by a worker after each break. *Having leakage current relay on the electric panels present. *Having a system suitable for electrical needs. *Annual periodical checks to be carried out by an electrical/electronical engineer. *Attention to be paid to the maintenance of the electrical appliances used without being cut off from the electricity. *Laying fire blankets on the cutting areas. *If areas that were not evaluated to have burrs or sparks are detected during operation, the operation should be stopped and the area should be cooled and the work should be resumed afterwards. *At the end of the operations, cooling should be carried out and controls should be done in every 2 hours. *Checking to make sure there are no flammable, combustible, explosive materials in the work area. *Work should be started after the area has been cleaned. *A 6 kg dry chemical powder fire extinguisher should be available at the carpenter's workshop in the premises. * They should be installed in a wall 90 cm high and should be periodically maintained.</td></tr>
</table>

POSSIBLE RISKS	HAZARD	IF RISK OCCURS
INTERACTION AND VULNERABILITY OF THE STRUCTURE, ENVIRONMENT, AND PEOPLE	*Earthquake *Terror, *Vandalism	**From the perspective of people;** Injury and loss of life
		From the perspective of the building and the environment; Irreparable damage on the building, destruction of the valuable resources and documents contained therein, collapse of the building
DISASTER RISK MITIGATION		
* Making necessary controls against earthquake risks, * Protocols etc. with related institutions for managing the crisis situation, * Architectural and technical measures to reduce threat elements, * Function change (if possible), * Cooperation with intelligence agencies		

POSSIBLE RISKS	HAZARD	IF RISK OCCURS
Slipping, falling, falling from high-up, materials falling from high-up, falling from scaffolding etc.	*Slippery floors, lack of or inadequacy of lighting, *The outer surface of the building not cleaned or covered with a covering, *Failure to mount the crossings of the scaffolds completely, *Breakable staircases, *No safety rails on the stairs, *No safety belts used on the high level, *Materials falling down during the removal of the scaffolding, *No personal protection used when working at high-up levels, *Mobile Crane-Slings not being sturdy enough *Falling of the clock and stone columns on the exterior of the building, *Materials falling down from the scaffolding, *No safety rails on the operational scaffoldings, *Scaffolding (Feet of the scaffolding not lodging onto the ground properly)	**From the perspective of people;** Injury and loss of life
		From the perspective of the building and the environment; Damages on the building,
DISASTER RISK MITIGATION		
* Installation of necessary anti-slippage equipment in areas where there is danger of falling and slipping, * Keeping the working environment under constant control and ensuring adequate illumination, * It is necessary to clean the building exterior with the help of a mobile crane or similar work machine, * Not starting the work without the scaffolding cusses are full, starting the work after the fit of the crosses is satisfied, * Use of solid material in construction of stairs, support of stairs with pillars, * Surrounding the work area with safety tapes, *Fencing of the scaffolding with safety area curtains, * Avoiding working with old and worn slings, *Controlling the floor to be installed and taking all necessary precautions before starting work, * The clock and stone columns outside the building must be suspended before starting to build the roof, and proper anti-fallout systems should be installed. * A curtain (net) must be stretched around the scaffolding.		

Cultural asset buildings that constitute cultural heritage are today's tangible reflections of past civilizations, different cultures, forgotten lifestyles, and deeply-rooted architectural traditions. For this reason, it is a cultural necessity to protect the wealth in question with scientific methods, principled and sensitive approaches, and to pass it down to future generations.

It is assumed that the fire broke out due to negligence during the isolation works in the roof of Haydarpaşa Train Station. The risk analysis, which was conducted for not experiencing such a fire again that turned into a catastrophe, should be made for all movable and immovable cultural assets. Removing the current hazards and the risks, which are likely to take place in the analysis, through the measures to be taken:

-Strategically
-Tactically (individually)
-Operationally in order to prevent the disasters and minimize the losses in accordance with the risk analysis conducted thereof; a safer and more conscious preservation would be ensured on the buildings.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Sustainability Indicators: Geothermal Energy in Iranian Architecture (Showadan)


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ABSTRACT

In the past, people managed to build their buildings in harmony with the climate and local culture of the area without any knowledge on modern scientific techniques or developments in contemporary design and architecture. Nowadays, thanks to the progress of science, the mystery behind this successful architecture can be solved through ancient designs.

Showadans is an example of such successful designs applied in cold regions such as Hamedan city to allow people to live in these spaces, seek shelter from cold weather and enjoy the warmth of the underground. Showadans are formed by a series of underground corridors used by people in cold areas. In this research, we intend to use these Showadans as thermal tunnels in order to benefit from geothermal energy. Showadans are planned to be designed as before but will be placed deeper below the ground as a basement to take advantage of the warmth of the earth. This heat is channelled into the buildings in cold seasons, which in addition to saving energy, serves as one of the architectural elements from the past.

Key Words: Sustainability, Geothermal, Iranian Architecture, Energy, Showadan.

1. INTRODUCTION

One of the principles of buildings in the past has been to pay particular attention to heating and cooling requirements and to find a way to meet this need in architecture, which ultimately led to the creation of a unique and indigenous architecture of the region. One of these cases is the man-made cave spaces of Dezful, Iran, which is called "Showadan". Showadan is considered one of the man-made cave spaces in architecture of Dezful. Considering the principles of architecture, the traditional architects, due to the challenging land of Dezful which consists of conglomerates, caved these underground spaces without building any wall and roof, sometimes with a depth of more than 10 meters above the surface of the earth. The slope on the stairs ceiling that connects the yard to the apron is also decorated with bricks and thus, prevented the fall of rocks from the natural texture of land. It should be noted that the digging of Showadan was performed because of the high strength of the natural texture in Dezful, which comprises of conglomerate rocks. Conglomerate is a sedimentary rock that acts as a very strong mortar in the presence of particles of lime and binds these particles together [1].

2. THE NEED TO SAVE ENERGY

Iran is one of the fifteen countries in the world with high consumption of petroleum products, and among the OPEC countries (the countries exporting oil), it is the largest consumer of such

materials. Given the country's consumption figures, it can be said that while the West has reduced its consumption by implementing optimization policies of energy consumption, Iran has almost tripled its petroleum consumption in less than two decades. Considering the consumption growth by more than 5% in Iran, it can easily be observed that every ten years, our energy consumption will be double [2].
Due to the global energy crisis and increasing environmental pollution due to the excessive use of fossil fuel, the need to use sustainable energy, especially in the construction industry, which accounts for 40% of energy consumption in the country, has been considered [3].

2.1. Geothermal energy
The thermal energy that is present in the solid crust of the earth is called geothermal energy. The center of earth is a huge source of thermal energy that hot water or conductivity in various forms, including volcanic eruptions, emerge to its surface. At present, geothermal energy is used extensively in many parts of the world and in various forms. Researchers have evolved new energy supply practices along with the use of old technologies of energy supply. The exploitation of geothermal energy, as a potential energy source in the depths of the earth, is independent of the conditions of atmosphere and can respond to the current and future need of mankind (Fig. 1)

Figure 1. The amount of geothermal energy consumption by people

The depths of earth are a huge reservoir of heat caused by the pressure of small amounts of natural radioactive elements in the rocks. When this heat reaches the surface of earth from its depths, this thermal energy can be used for human well-being and human consumption. Earth not only supplies us thermal energy but also is a good place to save energy. However, the use of geothermal energy, known as durable renewable energy, is not new, but the storage of energy, the heat and cold inside the earth, below the surface that building is built on, is innovative more than any kind of renewable energy. In the past, people in our country used places called glaciers and Shawadan to meet their cold and heat energy needs during the warm and cold seasons [4].

The benefits of geothermal energy

The use of geothermal energy has many advantages over the use of fossil fuels. But its main advantage is the lack of fuel costs. Also, from an environmental aspect, the amount of undesired gases produced in these plants is little. Other advantages of this group of power plants include the constant amount of energy extracted in all seasons and the possibility of operating these power plants on 24-hour basis. From an economic aspect, the use of geothermal resources also reduces the dependence of the price of electricity on the price of fossil fuels [5].

2.2. Earth depth energy
For centuries, the "heat of earth" has been exploited. Even the ancient Romans used it to warm their bathrooms. Building on land is a response to many of the climate-related needs and problems. Climatic factors and temperature fluctuations on the underground buildings have a slight impact, and the earth's crust, like a buffer, protects the building against these changes. Hurricanes and

winds cannot penetrate into the earth and the earth's crust, acting as a thick thermal insulation, prevents heat transfer to the earth. The deeper a building's foundation is built, the lower temperature fluctuations will be due to thicker soil. From a depth of 6.1, the earth's degree of heat is almost constant and is equal to the average annual temperature in the outer space of that location. [4].

"Underground buildings" have a great performance in acquiring and maintaining energy because they get light and heat from the south of the sun. Because of the thick covering of earth around them, this heat is well maintained inside the building and does not require a high number of mechanical facilities such as radiators and heaters to provide heat in winter. Just a fireplace or a small handy stove will be enough in this type of building. In the cities and villages of Iran, there are many buildings that are located within the earth due to climate issues in order to utilize the energy from its depths such as baths, mosques, water cisterns, glaciers, and underground villages. It can be said that the traditional architecture of Iran has shown a clear and promising example of the proper use of geothermal energy and has achieved a sustainable architecture. Two examples of these underground architectures are the cellars and Showadan.

3. DEZFUL CITY IN IRAN

It is located in the southwest of Iran and is a city of Khuzestan Province, which is located along the Dez River. This city is located on the hillsides of the central Zagros, and its history dates back to the Sassanid period. Dezful's weather is warm and humid. Dezful city is at the center of Dezful. The city is surrounded by Andimeshk and Aligudarz (Lorestan province) from the north, Khavar and Lali (Masjed Soleyman) and Gotund (from Shooshtar) from the south and Shush from the west. (Fig. 2)

Figure 2. Dezful's geographic location

Dezful has a moderate climate, but the weather in this city is generally warm. It is a tropical region of the country. This city has dry winters and hot summers. The hottest and coldest months of the year are July and January. The survey of a climate period indicates that the minimum relative temperature of Dezful is 2 degrees and maximum 50 degrees Celsius.

4. EXAMPLES OF TRADITIONAL BUILDINGS IN THE DEPTHS OF EARTH

The indigenous architects of each region of the planet have thought various measures in creating a better environment and a better life. Although coordination with the cruel nature was very difficult, it was used wherever possible.

The Chinese stored ice from thousands of years ago. The Ancient Greeks and Romans cooled their wine with snow covered with straw in holes. In the study of sustainable architecture in Iran, there are several evidences of genius and creativity of Iranian architect:

• Special wind for hot and dry areas
• Cistern dispersed in many regions of Iran
• Glacier in depths of earth to keep and preserve ice and use it in the summer [6].

In the ancient architecture of Iran, there are buildings where the main purpose is to use the thermal energy of the depths of the earth. Some examples of these buildings are:

• Underground houses (Showadans)
• Cistern (cellar)
• Glacier

By studying these buildings, patterns can be obtained to be used in new buildings.

5. SHOWADAN

Showadan or Shawadan was common in the architecture of southern and western parts of Iran due to climatic conditions there and was used to provide comfort and balanced temperatures. It was used as a cellar space in the underground in the days when the temperature was very low and the temperature for daily activities was not favorable. "Shawadan" includes rooms that are about 6 - 7 meters below the courtyard. The temperature in these rooms is equal to the average temperature during the year. Thus, the temperature of Shawadan is kept around 25 degrees Celsius throughout the year. Shawadan had vertical channels for lighting, and the channel lighting was located at the courtyard level. Some of the Showadans were ventilated by natural wind, which sometimes functioned as ventilator [7]. (Fig. 3)

Figure 3. Showadan, a residential house in Dezful

5.1. Definition of Shawadan

The word "Shawadan" is rooted from "Shoutapuata" used in the book titled "Cities of Iran during the Parthians and Sassanids periods". This word is found in the oldest texts on underground spaces in Pahlavi's language. It means "partnering in caving Kat". Shawadan is an underground space in traditional buildings where due to the extremely hard ground of the earth, "conglomerate" is created with a depth of more than 10 meters from the ground by digging the ground (without the use of walls and ceilings). Cellars, including Yazd cellars, are similar examples with a slight difference located in other parts of Iran. [8].

5.2. Introducing Shawadan in Dezful

Showadan is a space dug under the buildings of the old part of Dezful, at a depth of 5 to 12 meters and access to them is possible through numerous steps. Due to the specificity of the Dezful soil and the rocky nature of the earth, there was no need for scaffolding and the ceiling did not fall during digging the holes. Shawadan is merely an excavated space in the earth without any building materials, and in most cases, parts of the wall are coated with plaster. Many of Showadans do not have decorations but have underground connections (Figure 4). Thus, a neighborhood relationship is formed in the ground. This part inside the building connects a large part of the old houses of the city [9]. (Fig. 4).

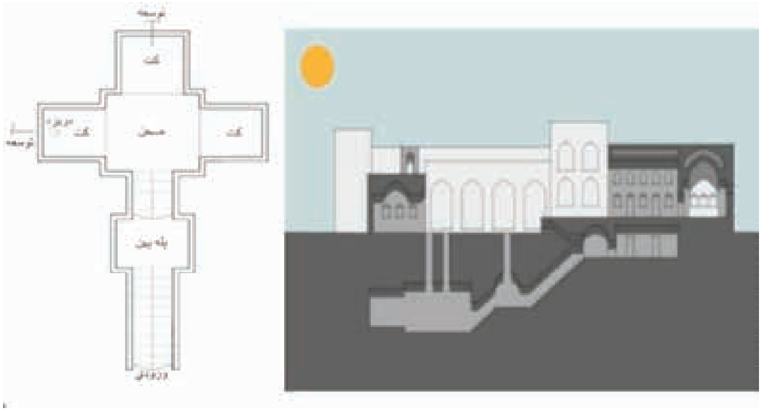

Figure 4. Shawadan plan in Dezful, Shawadan section in Dezful

5.3. Stair and Palapem

Staircase is an element that connects a building to Shawadan. In some Shawadans, the number of stairs reaches 40. The stairs from the porch, alcove, rooms or the courtyard lead to Shawadan. The staircase of Shawadan is diverse. The size of the property is the most important factor for the staircase form. The straight, winding or two-way staircase is a common form of access to the lower levels of the ground. Palapem or wide stair is a wide plate or surface that is built after the main stairs, and thereafter, there are further several stairs reaching the floor of Shawadan. Large Showadans can have two or three stairs. In some Palapems, another exit was embedded in the underground spaces. The depth of these spaces was not high, and sometimes the ceiling of these spaces was up to one meter above the yard. These spaces are called Shabestan that has a higher temperature than Shawadan and is used when the air is not too cold [6] (Fig. 5).

Figure 5. A view of the stairs in Shawadan

5.4. Apron

All Showadans include a major hall. This main hall is called apron. Apron is the center of daily activities of living in Shawadan, and sub areas are connected to it. Due to the material and specific strength of Hamedan soil, the ground can be excavated without any arch, which result in the operation in the space of Kats and aprons (Fig. 6).

Figure 6. View of apron in Shawadan

5.5. Tal

They are low-width horizontal canals providing underground connection between neighboring Showadans. These tunnels, in addition to access, enable air flow. In some occasions, these Showadans also provide the connection between several neighborhoods and districts [6] (Fig. 7).

Figure 7. View of Tal in Shawadan.

5.6. Ventilator

A cylindrical aperture about 1 meter in diameter is available to provide light and vertical ventilation of Shawadan. The channel links the spaces in the house to Shawadan and allows the flow of warm air from the Shawadan to the home spaces. Also, ventilators dug inside the courtyard, which, in addition to providing lighting in Shawadan, are used to transport the soil during the construction, but for snowy and rainy days, their roofs are covered to prevent snow and rain penetration into the ventilator. In some instances, the valves of ventilator are connected to the streets and passages and even the roof of the houses, and as a result, air is in constant circulation [6] (Fig. 8).

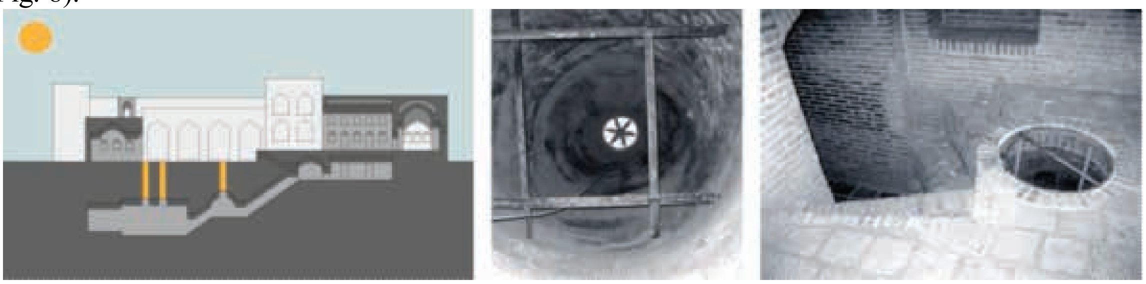

Figure 8. A view of ventilator in Shawadan

5.7. Kat

It is referred to fovea in soil. The term "Kat" means several rooms and various fovea that are branched out of the main apron. Kats are considered more private spaces in Shawadan. Each Showadan has Kats depending on its size [4](Fig. 9).

Figure 9. A view of Kat in Shawadan

6. REUSE OF SHAWADAN

The challenging land and the location of the construction of Shawadan in the soil enabled the survival of Shawadan to the present day. The way Shawadan works and the movement of air inside it and its fitness to the cold climate of Hamedan sets an example of a coherent and self-static architecture, which is often failed to be noticed by hot-flow generating technologies. Although the world needs a smaller amount of energy for the not too distant future, the prospective architecture will face energy problems, and a group of modern architects, called Echo Tech, use natural opportunities and existing potentials to save energy.

An obvious example of the existence of self-static architecture but with isolation is found in Iran (the architecture of Shawadan). Therefore, the recreation of these principles in conformity with contemporary architecture will create a new approach in the contemporary architecture of Hamedan. In 1992, the sustainable development discussions were the critical agenda in the World Conference on Sustainable Development, known as the Earth Summit, in the city of Rio de Janeiro, Brazil, which later became known as the Rio Conference. In this Conference, a statement was issued to set sustainable development strategies for countries in the world, and these countries were obliged to comply with this statement. The most important definition of sustainable development at this Conference is the development that meets the current human needs without compromising on the needs of future generations and takes into consideration the environment and future generations. Preserving the culture, indigenous characteristics and past experiences, using renewable energies and avoiding the use of non-renewable energies are the principles of sustainable development [6].

7. REUSING AND UTILIZING GEOTHERMAL ENERGY

7.1. Home heating

With the help of plumbing or special radiators such as existing radiant heaters, it is possible to transfer warm water obtained from geothermal energy to house, to the floor of Showadans, and utilize the heat of these hot waters to provide heating for the environment. To heat homes, groundwater should have a temperature of about 50 to 100 degrees centigrade. It can be plumbed from the floor of Showadans to reach deeper levels of the ground and the heat of the ground can be utilized to heat the plumbing water. It can also be transported through pipes on the floor of Showadans and inside the building so that the heat obtained can be used for heating the house (Fig.10).

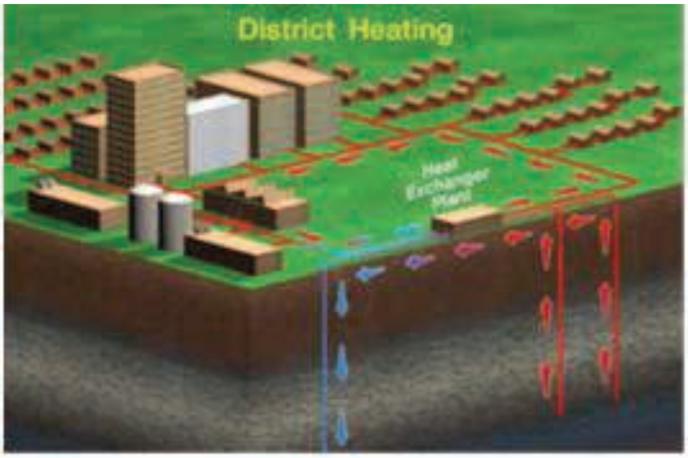

Figure 10. How to use geothermal energy to heat homes

8. PROVIDING SOLUTIONS FOR USING GROUND ENERGY

Geothermal potential exists in different parts of the country, which can contribute not only to the economy and the environment, but also to job opportunities, tourism, increased production, etc. [4]. Due to the energy crisis, its potential should be used to the full extent. Geothermal energy has been replacing fossil fuels. In order to meet the energy need and heat buildings, it is possible to use the heat inside the earth directly, especially in winter. For this purpose, geothermal heat pumps can be used. Geothermal heating pumps for heating the living space, water therapy and swimming in spa springs are different from greenhouses, fish breeding, and drying of fruits and so on [5]. In underground spaces, the cost of heating and cooling is about 80% less than the costs incurred in conventional buildings, and thus, damage to the environment is less [9].

9. CONCLUSION

Architecture should be in harmony with its environment and climate. It should honor the indigenous architecture and experiences of local builders, utilize renewable energies and smart and eco-friendly materials. In the present paper, capabilities of geothermal energy are described with an emphasis on its role in Iran's ancient architecture as a basis and pattern for utilizing this energy. By studying and analyzing traditional architectural elements, we came up with some solutions to use new energies in the context of today's buildings. It is recommended that we try to preserve this smart and beautiful technique. The solutions proposed in this paper can pave the way for future applied research. Some of these cases may also become the title of new research. The expansion of modern underground houses, covering external walls with soil, heating residential buildings with geothermal pumps, using spa springs for factories, generating electricity, building large buildings, etc. are practical measures that can be taken. Hopefully, with the help of these strategies, we can take an effective step towards achieving the climatic principles and optimizing energy consumption and, of course, preserving our environmental life.

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Hasan Kalyoncu University, Turkey, 1-2 June 2018

Evaluation of Cultural Architectural Areas as "Archaeopark" Projects

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ABSTRACT

This paper presents the protection of the cultural architectural heritage of Anatolia, which has a special geography in the world as a country with rich civilisations based on thousands of years of history, according to the content of the ICOMOS statute.

The main topic of this study is the changing living conditions of today, and these have also changed the meanings of spaces. Reclaiming the meaning of urban elements and re-establishing the network of urban relationships will be the greatest legacy we will leave for future generations. In Turkey, we see that institutionalis institutionalisation is increasingly adopted in order to protect natural and historical resources.

The research method was applied on an urban area with a high quality of life and aesthetic quality in the context of Sustainable Life/Environmental Conservation. Archaeological/historical/ etc. programs for the research of urban identity, and future designs were evaluated together with the environment in the urban dimension, which is an important urban problem, and in the framework of the value of the city as a public space. This cultural archaeocide was mentioned as a valuable asset in terms of historical value for better understanding of the world, in which our society lives, as well as regarding economic prestige in terms of archaeopark and archaeotourism potential.

As a result of the existence of cultural continuity and the formation of settlement localisation of Anatolian cities, it is a vital necessity to evaluate past accumulation as the most important data in the design of the future. In urban sustainability, there is a close relationship among urban spaces and new spaces, reinterpretation of conceptual recreational spaces, and the design of urban spaces.

Keywords: Anatolia, Protection, Cultural Architectural Heritage, Public Space Planning, Archaeopark

1 INTRODUCTION

Given the formation of Anatolia in the historical process, it was shaped and developed by various approaches through various layers of culture. Depending on historical, geographical, economic and social factors, local architecture is created within the framework of building traditions, and localisations constitute the main topic of the study. In terms of cultural history of constructions, it is necessary to grasp the importance of issues such as the effects of trade and architectural remnants.

The existence of a cultural continuity up to 13,000 years ago with archaeological excavations of present settlements and the important consequences of different phases of a long period of time are emerging. The concept of Archaeological Cultural Heritage Management was developed with the development of archaeology, a collection of rules and principles that became a scientific discipline in this framework.

Such research has two goals. Anatolia has various cultural, political and other aspects. As a country that is rich in civilisations based on thousands of years of history, Turkey has universal responsibilities for preservation of the cultural heritage of humanity. Firstly, it is thought that the archaeological evaluation of antique settlements containing historical data in the Anatolian surroundings will contribute to original studies concerning this subject. It is also aimed to provide concrete information about the general characteristics of the plan and the common characteristics of the obtained stratigraphy. How has a synthesis with existing cultures been achieved by combining traces of cultural components?

Secondly, the protection of cultural heritage should facilitate passing our past values to future generations. In order to develop an identity as a community, integration of the cultural identities of the nations with the new environment of life should gains importance. It is expected that studies and programs will be formed within the framework of the value of the city as a public space after evaluation alongside existing residences in the urban dimension, which is an important urban problem for research on the identity of the city and future designs.

In this context, modern formations in architecture and urbanism without regard to national and historical values are accelerating alienation in the society. Today, the architecture that makes up the cultural history of societies, developing technology and the inability to orient itself according to the needs of the age cause the destruction of cultural memory. It is aimed to increase the forecasting capacity for the future with the help of ecosystem modelling by developing a managerial plan for Anatolia. Projects, monitoring programs and events should be organised around the redesigned natural environments, which will make them accessible for the public.

Culture Heritage Management Practices in Protected Areas: Protecting the architectural heritage of different cultures with the same awareness and respect will not only deepen the feelings of peace and unity in the globalising world, but also act as a driving force in the development of cultural mosaics that interact with each other. It must be a vital necessity to evaluate past accumulation as the most important data in designing the future. As a result of the literature survey, landscape design principles in archaeological sites were determined, the design elements that were used in their implementations were examined, and recommendations were made accordingly.

2 HISTORICAL GEOGRAPHY OF ANATOLIA

2.1 Historical Development

Anatolia is an important settlement in terms of world cultural history in the process of living urbanisation. Geographically, cultural connections between the East and the West and their position in the habit of obtaining commercial clues are archaeological sites with a special design because of the residential areas that sample the city type. The third millennium BC in Anatolia and the Near East is the period of urbanisation, the beginning of city states [10].
**At the end of the EBA, the mining trade in Anatolia is now institutionalised, and mining gained strategic significance [11].

**Bronze, which consists of a mixture of tin and copper, was seen at the end of the Chalcolithic period. The Bronze Age in Anatolia started in the 3000s BC. In these days, writing was not used in Anatolia [3]. The Bronze Age (3000-1200 BC) in Anatolia and Trakya were seen in three periods: agriculture-based village life, Old (Early Bronze) Age (BC 3000-2500), the use of bronze tools, the development of trade and economy among the regions, the use of pottery songs and the establishment of the small city states of the Middle Bronze Age (BC 2500-2000), the encircling settlements around the walls, the use of writing, and the Late Bronze Age (New Bronze Age) of the Hittite Empire (2000-1200 BC) [2].

The Old Bronze Age, dated to between 3000 and 2500 BC, developed, organised and protected independent city states with temples and administrative structures. The number of settlements also increased due to the fact that in the year 3000 BC, more food was produced, and a larger population was born. Social, religious and technological developments were seen in this age. Gifts made from precious metals such as gold and silver, which appeared in the graves, and this shows that the society developed and changed. The development of trade led to the establishment of a broad trade network that included the Aegean and the Middle East [19].

We must not return to the dark ages of *homo sapiens'* ancestors, which were more backward than their registered history. When we do this, we uncover the origins of human society and institutions. We also discover that we are shaping the structures we build this way only to perform a certain functional use; we may see that architectural constructions were built from the very beginning as a social belief symbol. Architecture meets the psychological needs of basic social institutions, perhaps as physiologically as the one million-year-old human family. Therefore, during the last century, architecture was considered in terms of only a small part of the broad social and cultural functions it had undertaken [1], with the understanding of architecture as a solid "utility or function" as defined by modernity.

2.2 History Reflected in Mahal Names
If history will look at the process of its development; the discovery of humanity has resulted in the formation of shelters for protection of the natural environment. The conception of the local architecture, which started with the transition from living in tents to living a migrant-settler life, has continued to live and survive for centuries with development of the understanding of various cultural components. In the Palaeolithic, Neolithic and prehistoric periods, the works that were produced were formed in different forms and structures in terms of climate, geological structure and vegetation, social factors and economic structure. Topographic structure, slope and view; we may see that the characteristics of the piece of nature that was experienced in the region significantly affected the civilisation developing in that region and influenced the forms, concepts and stages.

According to Kılıç (2001), as one of the important elements affecting the development of cities, integrating with the city and giving it identity play a major role in the formation of development process dynamics such as geography, defence, economy, technology, transportation, social and cultural life, and confusion emerges [13].

The bed of civilisation: water. We have been set up beside rivers and waterways of every continent.
Water is the oldest, most unifying, most common account of humanity...
Water makes geography meaningful, not just geographical... [12]

Rivers, streams, lakes and dam basins are fragile parts of nature that need great precaution in urban ecology. These are the only places in the city where nature can survive. Waterways and lakes that are protected along with their natural surroundings are also important areas for air quality and the microclimate of the city as well as areas containing breathable recreation facilities for urban residents [16]. In the natural geography where humankind has settled in the foundation of the first settlements, it has been observed that place form, climate, water, soil, rock, vegetation cover and transportation have been influential throughout the history. Geography examines the interaction between people and the natural environment; history reveals the relationships of the civilisations that emerge in the geography where people are settled. There are thousands of ruins, mounds, fortresses, flat and sloped settlements that will support this relationship in the Anatolian geography [6].

We see that the regions around the Anatolian Metropolitan Area are directed to the parameters including the form of land use, the cover of the land, the properties it has and the settlement areas. We may perceive the deep story of human beings through waters and flat settlements of the witnesses of the past, which are seen on the edges of waters in almost every voyage around Anatolia. According to the natural environment, time and cultures, soil is transformed into different forms by the shaping of the human hand, leaving a trace and reaching the present . Describing the ways in which today's civilisations came from, the unity of Anatolia's civilisations from different periods and their accessibility, it is firstly necessary to identify and examine the cultural assets and historic roads along the river bed routes. We see that, in the establishment and development of civilisations, a network of interconnected links is formed around the sound of the first found water. It is an important aspect that water, like capillaries, feeds everywhere and changes the cultures where they arrive. Waterways pass through the places where they flow, while the city is also a privileged landscape element with linear features. With the efficiency and efficient traceability criteria of the ecosystem network of Anatolia, it is thought that the mound and settlement areas that have remained from ancient times have been geographically located in regions that will increase people's living possibilities geopolitically. They have made the concept of the structure they have shaped for hundreds of years by shaping spatial organisation according to climate changes and topography. Today, most skyscrapers have been rehabilitated, and roads have been closed.

Archaeology is a tool for reinterpreting the chronological and stratigraphic sequence of the events that take place in the process and the social, economic and political life of prehistoric and post-historical eras. The information obtained at the end of excavations is related not only to archaeology but also to the wider public. Good presentation of an *archaeological excavation is an important source of income and support for the continuation of the excavation work. Archaeologists can appreciate the present role of the archaeologist by following the excavation sites. "Cultural heritage is an important market vehicle of this century.*" [21].

3 CULTURAL HERITAGE LAWS IN TURKEY

The concept of the site comes from the French word for "location". The French word has evolved from the word situs that has the same meaning in Latin. A dictionary is literally the product of various civilisations coming up to date from before history, regarding the social, economic and architectural aspects of the periods that they lived in. Urban remains that reflect the characteristics of the city are places where important historical events take place, and areas that need to be protected due to their natural characteristics [18]. As another definition, they are a piece of urban or rural environment, made of natural or manmade, with a special physical character, which must be preserved, bringing it to existence completely [15].

When we look at the historical process on legislation related to protection of cultural heritage in Turkey which came into force in 1869, Asar-i Atika expanded the regulation of the changes that were published in regular intervals. Founded in 1951 with the law numbered 5805, the Supreme Council for Antiquities and Monuments became the first institution to make decisions both for protection and implementations.

The scope of the definition section of the Supreme Council for the Supervision of Cultural and Natural Property in the Law on the Protection of Cultural and Natural Assets, No. 2863, 1983 in the national legislation, was amended by amendments to Law No. 5226 dated 2004 and 3386 dated

1987: "*city and city residues reflecting the social, economic, architectural and similar characteristics of the periods they have lived in were products of various civilisations, and they were the subject of social life in which cultural assets were intensively preserved with the places where important historical destruction took place and with their determined nature properties"*[1].

In 1976, the concept of the expanded monument of the Venice Charter Constitution was put forward by UNESCO in a different terminology, with the term "cultural property" encompassing all tangible assets related to cultural traditions. Geological formations, vegetation, water elements, wild life zones and historical gardens which are aesthetically and scientifically valuable are within the scope of "natural property". According to our acceptance in Turkey, the values to be preserved in the world are gathered under the concept of "natural and cultural property" [1].
Management and operation of the archaeological heritage was first described in the early 1970s as a concept of cultural resource management in the United States (King 1998, 18). In 1967, the report on the "Preservation and Utilization of Monuments and Sites with Artistic and Historical Value", known as the "Quito Norms", was published. According to this report, archaeological, historical and artistic monuments are the economic resources that make up the wealth of the state [5]; for this reason, they should be included as inputs to development-oriented plans and considered together with the surrounding archaeological assets in conservation and development. All archaeological, historical and natural environments should be protected from the destructive effects of modern development and tourism. In other words, cultural and economic projects should be considered as a whole, and they should be enriching, not destroying each other [9].

Legal Administrative Framework in Landscape Design Applications in Archaeological Sites; UNESCO recommended that *"historic or traditional areas and spheres should be protected effectively from any damages that would destroy the identities of such areas as inadequate use, unnecessary additions, misguided and insensitive changes" in the Recommendation on the Protection of Historical and Traditional Areas and the Roles in Contemporary Life. Any renewal work to be done should be based on scientific principles. Similarly, attention has to be paid to the harmony and aesthetic sensation created by the union or opposition of the various sections that make up these building groups and confer their own particular qualities to each building group" (*UNESCO, 1976 to Kortanoglu, 2013) [21]. Presently, presentation and reinterpretation of archaeological landscapes within the concept of "Archaeological site" have been described as *"public disclosure of cultural heritage with multiple meanings, values and prominence"* in the statute of ICOMOS (International Monuments and Sites Council) [7]. Shalaginova (2008) defined management and presentation activities of cultural heritage as "a process of communication" with the aim of increasing public awareness in order to obtain public support and explaining the presentation function of cultural heritage [21].

"Guidelines on the Procedures and Principles to be followed in the Arrangement, Restoration and Conservation Projects and Applications to be Made in Archaeological Excavations and Excavation Areas" were published for the work to be carried out in the scope of preservation and exhibition in archaeological sites. In the relevant directive, the protection technique was detailed by referring to the methods of protecting the excavation finds against natural and anthropogenic influences (Directive 31) [21]. In this article, archaeological sites are referred to as *"ruins"*, and the practices to be carried out to highlight the archaeological potentials and tourism potentials of the ruins are discussed. In this context, the general technical specifications of the landscaping project for the ruins were determined [8].

The main principles for the perception and presentation of cultural heritage have been defined in the "Regulations on Perception and Presentation of Cultural Heritage Sites" that was signed in 2008. Under the heading "landscaping project" mentioned in the regulation that was prepared based on Article 17 of the Law on the Protection of Cultural and Natural Assets numbered 2863, it is stated that ruins should be prepared in order to broaden the archaeological potential of them in a controlled way, to provide presentation, solve the problems arising from the current use and circulation and prepare the needs of the area with the facilities required by contemporary technological developments [20].

4 INVESTIGATION OF STRUCTURAL DOCUMENTS USED IN THE PRESENTATION OF ARCHAEOLOGICAL LANDSCAPES

With the preservation of archaeological and cultural remains in place, people's interest in culture has created the concept of tourism.

The word tourism comes from the French word tourisme. Activities such as those for recreation, entertainment, sightseeing and publicity mean a trip to the destination [17]. Along with the changing sociocultural structure in the light of technological and scientific developments in the world, this has also caused changes in consumption patterns in tourism. UNWTO (World Tourism Organization-the international organisation commissioned by the United Nations to develop and promote tourism, has reached the status of the *United Nations Special Rapporteur* with the decision of 58/232 on 23 December 2003), the cultural tourism sector emerged as the most developing product in the sector [22].

Since archaeological assets are non-renewable resources, the issue that they may be destroyed without protecting the selected method of preserving the assets is the first thing to be considered. For this reason, it is aimed that the protective structure to be designed conforms to the conditions, resources and character of the region [21]. Today's contemporary approaches recognise that excavation of an archaeological site is not the end of the process but the beginning. Registrations can be made by preserving the original residues for the collection of the sites [4].

Presentation of cultural heritage sites is interpreted as cultural resources' accessibility through cultural landscapes. Presentation means that protection measures of the physical environment are integrated into the principles of landscape architecture. The concept of integrated planning is directly proportional to the development of long-term archaeological resources around their own landscape. Cultural forms have a key role in defining the landscape's character. Archaeological sites are not only the physical environment but also the cultural forms that promote the development of the social, cultural and ecological zone. For this reason, archaeological sites can be regarded as an open space system which requires landscape planning and spatial organisation (Mosler 2005) [20].

The design and organisation of archaeological sites vary depending on the perception and interpretation parameters in that area. Puren et al. (2006) considered the concept of "the spirit of the place" while designing and organising three spatial principles on the project proposal for improvement of an archaeological site in South Africa. According to Norberg-Schulz (1980), the spirit of the place (genius loci) is a concept belonging to the ancient Roman period which means that the individual's soul is guiding the mind. "The spirit of the place gives life to humans and places, follows them from birth to death and determines their nature." The first principle the researchers set out is to emphasise the emotional direction rather than the logic of design. *The feeling of arrival*- the feeling that you have come to another place is important. According to researchers, this feeling is linked to the identity of the field and increases the visual readability of it. For this reason, the entry points of the archaeological site should be emphasised as the passage of visible items from outside to inside, and this design should be compatible with the character of the natural environment (Puren et al. 2006) [20].

The second fundamental principle is the behavioural aspect of design. *Directional feeling*-Arrangements with high readability qualities should be placed in public areas (squares, social areas, etc.) and on hiking trails or motorway routes in order to navigate within the archaeological site. In the orientation of the visitors, local people should be provided with appropriate road names to be identified and located at appropriate points. Walking trails and intermediate roads are components that reflect the identity of the area. A height difference must be established between the main roads and the secondary roads. Furthermore, the use of different flooring materials at the intersection and change points and the starting points of the roads is an important element in guiding the visitors in the archaeological site. In particular, emphasis should made on the edges of the roads using specific plants. In the design of new areas, the content of social life is a knot point. The main nodes are education, culture, economy and information content. The characters of the knots must be appropriate to the position of the designed area. Outside the city, the archaeological site should be of a more rural character and scale than the urban lines (Puren et al. 2006) [20].

The third fundamental principle is the reflective aspect of design- *the outward appearance of feelings.* According to Norberg-Schulz (1980), while modern tourism encourages experiences in different places, the limits of human perception and interest are expanding. The natural elements must be emphasised so that the visitor of the field, that is designed according to Puren et al. (2006), can feel 'the spirit of the place' stronger. Archaeological sites must be in harmony with the physical or architectural theme in order to create a strong public structure throughout the archaeological site. For example, in the entrance of the area, the routing signs, the vegetative design on the roadside and the operation of the materials that are used in the park should be smooth. In the spatial organisation of the site, the inter-park roads should be designed as connecting points between cultural and service units (Norberg-Schulz 1980) [20] as transitional elements among the historical stages, the intersection points and the needs of the users.

In archaeological sites, landscape design is primarily aimed at defining the current state of archaeological heritage together with historical use and moderated development to define planning policies and management decisions [20]. Other principles included by Schmidt (1993) are conservation, recreation and heritage;

- To create a sustainable environment for scientific studies,
- Landscape character, protection of landscape ecology and ensuring the sustainability of natural resources,
- To create an educational environment by means of information,
- To support the realisation of economic growth with tourism activities,
- To support the preservation of the archaeological heritage of the archaic and functional side,
- To emphasise cultural identity,
- Supporting the development of the rural area,
- To ensure the preservation of historical resources,
- To protect the aesthetical and historical values of the skyline as well as its authenticity,
- To connect the archaeological heritage site to the historical texture and spatial qualities of the region it is located in,
- To provide accessibility of archaeological sites,
- To allow experiencing the area to be visited by presenting the archaeological works addressed to the senses [20].

Cultural River Corridors and Historical / Cultural Sources When we look at the irresponsible use of natural resources are the most likely to be seen one among the negative effects of urbanisation, which cause it to be consumed rapidly, mostly on water resources. As a result of pollution by various wastes, these resources have become unusable for their purposes and are almost in danger of extinction. Moreover, with all these developments, climatic changes, which made the effect more and more felt day by day, brought global water crisis to the agenda. However, high-quality water resources are important determinants of quality of life. There are several international studies to solve environmental and water-related problems. The priority topic identified in the programme called "Environment 2010: Our Future, Our Choice" within the scope of the 6th Framework

Programme, which the European Union has been implementing since 2001 for the environment, is the European Union harmonisation process.

- Prevention of climate changes,
- Protection of biological diversity,
- Sustainable use of natural resources and development of waste management,
- Preventing environmental pollution from harming human health.

The green roads, urban and rural areas, which are used in the solution of these problems, based on the park roads of the old Olmsted and described as a model in National Geographic magazine, as a new and important landscaping phenomenon in the United States and have been used regularly in planning policies, are mechanisms that provide countless contributions to regions. According to Spirn (1994), although problems arising from urbanisation may vary from city to city and country to country, these problems have several common characteristics (Arslan 1996). With the thought that the approaches of the countries that have succeeded in the use of green roads in solving these problems, these may also be successful in solving the urban problems in Turkey by seeking ways to create urban recreational opportunities, linking open green spaces and historical / cultural resources by providing protection and development of river corridors in urban areas and taking advantage of green road planning principles. Green roads may be created along man-made corridors, such as railway tracks, as well as natural corridors such as rivers or ridges, as planned for ecological, recreational and cultural uses and managed as a whole for this purpose (Ahern 1995, http: //www.ece .aucland.ac.nz /~ sinnen/VasconcelosSilva2006.pdf., 2006). The linearity of the natural conditions, the water supply the area contains and river corridors are some of of the unique sources of green roads [13].

5 CONCLUSION

Although the archaeological landscape of today's potential in the process of changing living conditions, inability to integrate Turkey into the modern environment has also changed the meaning of venues. We see that archaeological sites usually turn into areas that cannot be integrated into the surrounding environment. However, the cultural and natural heritage sites bearing the traces of the past are not idle places but places where dynamic, strong relationships can be established. Renewal of urban consciousness may be achieved by the establishment of the spatial context of the social structure and structures that have passed. Hence, landscape design is very important for integration of archaeological sites in the hinterland of Anatolia, which is a composition of cultural landscapes with the modern.

Finding the ancient areas in the archaeological excavation area, creek and side branches may be taken to the light by the understanding that Turkey is a part of cultural heritage, and being a part of human cultural history and searching new areas where new mounds and antique cities may exist by integrating the structure of river corridors in the urban area. It is envisaged that determination of the historical road networks will also shed light on the urban environment and research on the historical city. Places for urban residents in the urban sustainability of Anatolia, preserving biological habitats, neglected streams, valleys, etc., which are the centres of nature, the cultural and historical settlements of the green road network and the design of re-conceptual recreational areas will add value to the city.

The rivers and streams of Anatolia are passing through the centre as in Europe, and many people do not know. When all of them are covered, they are quietly and secretly carrying their water. Can these not be opened by reforming these levels? Urban development provides a beautiful image with cities containing in the middle natural rivers, streams and canyons with features of topography that have protected water resources. Today, we see many successful examples of cities when we visit them abroad that make these cities more liveable. Many cities in Europe are located on the banks of rivers. For example, the River Vltava Valley in Prague, the River Danube in Budapest the and the River Spree in Berlin are the first European rivers that come to mind. Activities such as sweeping boats, duck floats, gulls flying and river colouring provide great benefits both in the touristic sense and the commercial sense.

It should be provided that the bases of building a conceptual open green road plan should be revealed by investigating the architectures, the topographical settlements and settlement plans determined in river corridors and bringing all the cities together again. Urban recreation areas will be provided through the planning and design processes that establish the relationship between open green spaces and historical/cultural resources, rejuvenate the rivers and streams that overlie their upper reaches and allow the natural environment to meet the city again through water as much as the transformation of the urban environment.

In the context of transforming archaeological sites into living spaces through landscape designs, reintegration of the meaning of urban elements and reestablishment of the network of urban relationships will be the greatest heritage we will leave for future generations. It is also worthy of economic importance in terms of archaeological parks and archaeo-tourism potentials, as well as models that will show local coexistence, cultural archaeoceses, wealth of historical value, better understanding of the world in which our society lives. Turkey has proposed that one of the oldest open-air museums of the region will be held on campus, again, drawing attention to areas of life to be incorporated into the project design should be made to shed light on cultural tourism as an important consideration.

In the context of Sustainable Life/Environmental Conservation, it is aimed to protect all kinds of natural and cultural assets by developing environmental consciousness for an urban area where the quality of life and aesthetic quality of Anatolian cities are high. The necessary legal arrangements should be made by developing a managerial plan for the cities with integrated approaches to be developed on the urban scale and the integrity of the distorted ecosystem should be protected with sustainable options. Future scenarios for determining good environmental conditions should be aimed at increasing the forecasting capacity for the future with the help of ecosystem models.

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Kerpic'18 — Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized 6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Adobe Use in the Eco-Village of Buyukkonuk on the Karpaz Peninsula

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ABSTRACT

Urban identity is shaped by the geographical and human resources, historical, aesthetic and artistic features, and local architectural fabric that is formed over time. The preservation and transmissibility of the genuinely tangible and abstract features play a crucial role in sustaining this identity. In this age of rapid technological advances, social, economic and physical developments transform cities in many different ways. While technological advances improve the construction methods, and urbanization techniques modernize cities, they also have negative effects on local urban identity. The traditional architectural fabric in regions that are not parts of metropolitans has been deteriorating for the last quarter century.

One solution for this is ecological living based on fixing these negative physical effects, creating self-sustaining living conditions, benefiting from natural resources and living with only local resources. Eco-villages fit in this description, and also play an important role in the sustainability of environmental resources, preserving historical heritage and ensuring social equality.

Buyukkonuk is an eco-village on the Karpaz Peninsula in Northern Cyprus. It is included in the list of internationally recognized eco-villages and has an old, village fabric with traditional adobe and stone houses that have courtyards and arched porches. The inhabitants of Buyukkonuk still use natural materials such as stone, soil, straw and clay in their daily life to preserve the traditional architectural fabric of the place. This leads to new architectural implementations that respect the nature, the environment and the village's traditional way of living.

This research investigates the traditional construction techniques that are still used today and the stone and adobe houses that create the local Buyukkonuk identity, and discusses the experience of building a bus stop made entirely of adobe.

Key Words: Adobe, Eco-village, Sustainable design, Architectural heritage

1 INTRODUCTION

Adobe is an ecologically re-usable material because it decomposes in nature when not used for any other purpose. This means one can have re-usable and sustainable construction materials. Buildings constructed with such materials not only save energy, but can also provide the users with adequate living conditions for every season of the year. According to building biology, constructions made of adobe have bioclimatic feature that is good for human health. These buildings, which do not need heat insulation and are able to balance humidity naturally, have natural heating and cooling. The inhabitants of Büyükkonuk, which is the case study for this research, use this material for construction. This is why Büyükkonuk was chosen as a case study as there are many buildings that are made of adobe. As part of the research, a bus stop made entirely of adobe was built.

2 ADOBE USE IN BÜYÜKKONUK

Büyükkonuk is located in the İskele province of Cyprus/Magosa region and in the foothills of the Beşparmak Mountains. This village was known as a place where Turks and Greeks lived together when Cyprus was a British colony. According to old records, this village used to be known as Komi, and later in Ottoman times, became Komi Kebir. Cartographer Lord Kitchener drew the map of Cyprus in 1882 and used the name, Komi Kebir. In 1958-1959, its name was changed to Komi Kebir Büyükkonuk, and in 1999, its name was officially changed into Büyükkonuk (Bağışkan, www.yeniduzen.com). The inhabitants of Büyükkonuk, which is located at the start of the Karpaz Peninsula, are usually occupied with gardening because of all the water resources surrounding the village. Fields and carob groves and olive groves surround the village.

The south part of the village is informally known as the upper neighborhood and is the Turkish side. The north part is informally known as lower neighborhood and is the Greek side. The village has preserved its traditional architectural features and has both stone and adobe houses. There are narrow streets in the Turkish side, and houses opening towards streets and little shops on the main street in the Greek side.

Climatic conditions and land structure play an important role in deciding on the construction material for the village. The houses are often one story (see Figures 1, 2 and 3). Many houses have gardens that are big enough for daily use. Some houses are located in a big courtyard with a large porch in the front. An arched porch is not only an important part of a house that keeps the strong sunlight away from the main wall and the entrance of the building, but also a significant feature of the traditional architecture (see Figure 3). Houses are usually covered with flat roofs. In the production of adobe houses of Büyükkonuk, clay and straw are common materials. Clay is acquired locally. It is kept in wooden moulds and pressed quite strongly. After a while, the clay is taken out of the moulds (Benli, Kan, 2013, 107). In five-six days, the adobe bricks are ready for use. The inhabitants of Büyükkonuk say that adobe houses are the most comfortable to sleep in during all seasons because this material balances out the humidity of the environment.

Figure 1. Examples of Adobe Houses in Büyükkonuk (G. Benli archive, 2016)

Figure 2. Examples of Adobe Houses on Komililer Street, Büyükkonuk (G. Benli archive, 2016)

Figure 3. Abandoned Houses in Büyükkonuk (G. Benli archive, 2016)

3 TRADITIONAL PRODUCTION OF ADOBE IN BÜYÜKONUK

Soil is the main material humans have used for sheltering purposes. The soil is easy to acquire and mould shape, which are the reasons why it has been very popular as a building material. Adobe is made from soil and is again a topic of research due to its positive ecological and biological features (Tuğun and Karaman, 2014, 322). In Büyükkonuk, there are many houses constructed from adobe and stone. Stone made plinth walls not only fulfil their original duty, but also protect the adobe from the rain.

An agreement signed between Büyükkonuk Municipality and Istanbul Medipol University's Faculty of Fine Arts and Architecture aims to revive the use of traditional construction methods in the village and re-introduce adobe for current construction practices as an ecological material. The construction planned in this agreement is intended to be in public space and for public use. Upon the demand of the public, the municipality determined that the construction would be a bus stop.

4 THE CONSTRUCTION OF AN ADOBE BUS STOP

As part of the "Design and Build" workshop held by Istanbul Medipol University's Faculty of Fine Arts and Architecture, a bus stop that is 150x250 cm and 320 cm high was designed by the team of President of the Büyükkonuk Eco-village Association Ismail Cemal (Güner et al., 2017, 68686870).

4.1 Preparation of the Adobe Pools

Water is an important resource in Cyprus since the island is quite dry, and there are no underground water resources. For this reason, İsmail Cemal made the pools for adobe water impermeable. The first pool is for the preparation of the adobe, and the other is for cleaning.

4.2. Preparing the Adobe Filling

Soil taken from approximately 30 cm below ground level is accumulated in an area. Straw acquired through natural ways is cleaned and stocked in the same area. One wheelbarrow of soil and 5 wheelbarrows of straw are mixed together in a pool with enough water. Then, the filling is mixed by stomping on it (see Figure 4).

4.3. Casting and Drying Adobe

Producing adobe bricks requires wooden moulds. Ismail Cemal used moulds that he designed himself. These moulds can be used to cast up to three adobe bricks. The area for the casting of the bricks is cleaned beforehand. The moulds are shown in Figure 5. They are humidified with some water, placed on a surface that is covered with straw and used for casting bricks. After this, the brick is removed from the mould with a little shake and left outside to dry. To keep the bricks from cracking, they are covered with straw. After a while, the bricks are placed in a diagonal direction so that all their surfaces dry evenly. The best time of the year for making adobe bricks in Cyprus is May and the first half of June.

Figure 4. Wooden Adobe Moulds, Mixing Adobe with Straw, Stomping on the Mixture (G. Benli archive, 2016)

Figure 5. Removing the Adobe from the Moulds, Drying the Adobe (G. Benli archive, 2016)

4.4 Laying Wall Insulation

To protect the adobe bricks from rain and ground water, the foundation is prepared with impermeable material. To make the wall stable, poles are placed in the corners of the construction. The bricks used for the bus stop were 35x45x7 cm, and the thickness of the walls was 35 cm. Wall pointings are made of half-sized adobe bricks when necessary. To cut the bricks in half, a steel saw personally designed by Ismail Cemal was used. The filling to stick the bricks together and wall pointings are also made of adobe by wetting the original brick mix.

Figure 6. The stages of the laying of the bus stop wall (G. Benli archive,2016)

4.5 Window Bay and Headstall

To ensure that people waiting for busses can see them coming and for ventilation, there is a window on each short wall of the bus stop. These windows are 70 cm wide with beams made of small trees. The beams with a 9-10 cm diameter are located in a wall that is 35 cm thick and located 40 cm away from the window bays. A headstall made of egg-shaped stones is placed in between these beams. The headstall keeps the adobe material from falling to the ground and gives the construction a more architecturally significant look.

Figure 7. Window Bay and the Production of the Headstall for the Bus Stop (G. Benli archive, 2016)

4.6 Placing the Wooden Beams

The gap that should be in the façade of the bus stop is created with wooden beams. İsmail Cemal prepared these in his workshop from two old wooden lamp posts.

Figure 8. Re-using Lamp Posts as Wooden Beams for the Bus Stop (G. Benli archive, 2016)

4.7 Making the Roof

Beams made of small trees are located 40 cm apart from each other, parallel to the short side of the bus stop and on top of 5 layers of adobe that are on the wooden beams. To keep the roof soil from falling to the ground, straw is placed in the middle of the layers. The straw is tied in bundles and to each other with sailor's knots. Various types of plants (i.e., rose bay) are placed on top of the roof to keep bugs away from it. On top of the plants, they put adobe filling, a layer of soil and finally, plaster with cement filling.

Figure 9. Making the roof construction (G. Benli archive, 2016)

4.8 Making the Facade and the Floor

The floor is covered with square-shaped, unvarnished marble from another site. The outside of the bus stop is covered with adobe filling applied by hands that was prepared in the pool.

Figure 10. Making the Facade and the Floor of the Bus Stop and Preparing it for Use (G. Benli archive, 2016)

5 CONCLUSION

Compared to other materials that can be used in brick or stone buildings, the production of traditional adobe is quite limited because of current regulations. Many studies have observed that the adobe building tradition, which has existed in Büyükkonuk for a very long time, has begun to disappear. For that reason, this study was intended to revive the use of adobe material with the construction of the bus stop.

This study concludes that adobe as a natural and sustainable construction material should be used more often in the present day since its technical features have been improved and awareness about this needs to be raised (Çavuş et al., 2015, 190). After the construction of the bus stop, at the demand of the local inhabitants, the municipality decided to build another adobe bus stop in the village.

To raise awareness and spread the use of adobe as a construction material, architects should participate in workshops such as "Design and Build" more often and start seeing adobe as a material for the architecture of the future, rather than just an old-fashioned way of constructing buildings.

6 ACKNOWLEDGEMENTS

We thank our students: Azra Ahsen Özyurt, Ayşe Berre Eroğlu, Bedirhan Bedir, M. Zubeyr Tel Uğur Yüksel, Şeref Özcan, Kübra Yıldız, Hace Ayşe Gönülalan, Elif Şelal Alpaslan for their contribution. We also thank our research assistants: Güliz Kabasoğlu and Mine Çağlar for their contribution and support.

We thank İsmail Cemal and his wife, Lois Cemal, for their technical input and support for this project. We especially thank the Cyprus Büyükkonuk Municipality for providing us with accommodation, transportation and overall support for the project.

A. Ferrah Güner, Gülhan Benli, Pelin Karaçar and M. Adil Kasapseçkin are the researchers responsible for this project of constructing a bus stop entirely made of adobe.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Differences in Construction Standards and Regulations of Earthen: Cases in Northern Cyprus, New Zealand and Europe

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ABSTRACT

Adobe is one of the oldest and most widespread forms of construction. As the time passes, there have been some improvements in materials and techniques used in earthen constructions. Although earthen construction has not been used in recent decades, researches show that these materials may still be used in construction industry, especially for the arid climatic regions. Earthen construction has simple technology needs and natural materials. Adobe is an environmentally-friendly material that does not require additional energy resources for its production and application. In this study, use of adobe in Northern Cyprus and also their main causes of deterioration are explained to clarify the need for new materials. Building materials and environmental resources are also investigated to check socio-cultural, economic and ecological sustainability.

Since Northern Cyprus is located in the third earthquake zone, since 2007, changes have been done on standards and regulations on earthquake. There was a need to improve classical earthen to satisfy earthquake requirements. Earthen materials have been improved by adding gypsum which shows better physical and mechanical properties with respect to standard adobe and it is named as Alker. This mixture has been studied to meet the needs of sustainability and ease of construction. Their physical and mechanical behaviors have been studied previously and results are commented here to show the applicability of Alker in earthquake regions. Changes in standards and regulations show that earthen construction may be used nowadays just like in the past simply with due care to materials and application techniques. In different countries, researches are conducted on mechanical properties of adobe, methods of improving its performance and behavior against earthquake.

This study focus on the changes in the earthen construction standards and regulations of 1997 and 2007 applied in Northern Cyprus. European, New Zealand and Turkish standards and regulations have been studied and with this study, differences among them will be clarified.

Keywords: Alker, Earthen construction, Earthquake, Standards and regulations

1 INTRODUCTION

Earthen constructions from different countries have different standards. This study focuses on changes made after 1997 earthquake in earthen construction and compared those standards with Peru and New Zealand standards. Northern Cyprus uses Turkish standards for earthen construction as massive structures.

2 COMPARISON BETWEEN 1997 AND 2007 EARTHQUAKE REGULATIONS FOR TURKEY

Table 1. Comparison of 1997 and 2007 Earthquake regulations

1997 EARTHQUAKE REGULATION	2007 EARTHQUAKE REGULATION
□ Single storey height • The height of the mudbrick single storey will not exceed 2.70 m on the floor over the floor. In the case of basement, the height of this floor will not be more than 2.40 m.	□ Single storey height • Single layer height with mud brick floor will be 3.0 m above the floor over the floor. In mudbrick masonry buildings, the single storey height may not be higher than 2.70 m, and the basement storey height may not be more than 2.40 m.
□ Load-Bearing Wall Material • The mudbricks to be used in the bearing walls shall be manufactured according to TS-2514 and the mud brick which is rested in the wall construction shall be used.	□ Load-Bearing Wall Material • Adobe or similar pile units may be used.
□ Load-Bearing Wall Gaps • Door gaps shall not be more than 100 cm horizontally and 210 cm vertically. More than one door opening will not be left between the axes of the bearing walls that are stuck perpendicular to the wall.	□ Load-Bearing Wall Gaps • Door openings in mud brick buildings will not be more than 100 cm in the horizontal and 190 cm in the vertical.
□ Minimum Total Length of Load-Bearing Walls • The ratio of the total length to the gross floor area (excluding console upholstery) of the supporting walls extending along each of the perpendicular directions to each other shall not be less than 0.25 m / m^2, excluding window and door openings. • The length of the full wall part to be left between the window or door space closest to the intersection of the walls perpendicular to each other, except the corner of the building, and the gap between the walls shall not be less than 50 cm.	□ Largest Unsupported Length of Load-Bearing Walls • Unsupported wall length of mud brick masonry buildings shall not exceed 450 cm. • If the maximum unsupported wall height condition mentioned above cannot be ensured, the reinforced concrete vertical laths shall be made on the building corners and in the said wall, the planar extensions shall not exceed 400 cm. However, the total length of walls supported by such vertical beams can not exceed 1600 cm.
□ Bond Beams	□ Non-Load-Bearing Walls • The height of the balustrades constructed on the terraces with the masonry wall material shall not exceed 60 cm. Precautions should be taken

• Reinforced concrete beams will be at least 15 cm in wall width and at least 15 cm in height. The quality of the concrete to be used shall be at least C14 (BS14) (minimum dosage: 250 kg / m^3). 6Ø10 longitudinal reinforcement together with Ø8 eternally with a maximum interval of 25 cm. • Wooden beams are made by placing two external faced squares of 10 cm x 10 cm, which are tarred to overlap with the inner and outer wall surfaces. These cadres will be studded together with vertical cadres of 5 cm x 10 cm at 50 cm and filled with stone crumbs. □ Bases • Masonry building bases will be reinforced concrete walls under the supporting walls. The depth of the underground foundation; ground characteristics, groundwater level and local depth of the frost. The upper level of the stone or concrete walls to be built on the bases will be at least 50 cm above the pavement level. • The concrete quality of under-wall bases shall be at least C16. • Horizontal spacing on both the top and bottom of the longitudinal fixtures to be placed on the under-wall bases shall not exceed 30 cm; overlapping at the corners, intersection points and stepped base conditions to ensure continuity.	to prevent the fall of such balustrades under earthquake loads. • The height of the garden walls constructed with masonry wall material will be maximum 100 cm from the pavement level. □ Horizontal beams • Wooden beams can be made from adobe masonry walls. For wooden beams, two cadrons of 10 cm × 10 cm cross section shall be placed in the range where the outer faces coincide with the inner and outer surfaces of the wall. These cadres will be pegged with vertical cadres in a 5 cm × 10 cm cross section at 50 cm in the longitudinal direction and filled with stone crumbs. □ Bases • Masonry building bases will be reinforced concrete walls under the supporting walls. The depth of the underground foundation; ground characteristics, groundwater level and local depth of the frost. The upper level of the stone or concrete walls to be built on the bases will be at least 50 cm above the pavement level. • The concrete quality of under-wall bases shall be at least C16. • Horizontal spacing on both the top and bottom of the longitudinal fixtures to be placed on the under-wall bases shall not exceed 30 cm; overlapping at the corners, intersection points and stepped base conditions to ensure continuity.

3 COMPARISON OF TURKISH PERU AND NEW ZEALAND STANDARDS

TURKISH STANDARD (TS 2514)	PERU STANDARD (NORM E.080)	NEW ZEALAND STANDARD (NZ 4298)
There are two groups for cubic block: Group 1 – 12 x 19 x 40cm Group 2 – 12 x 18 x 30cm	The block of square adobe should not exceed 0.4m and the height should be between 0.08 and 0.12m.	Regular shaped bricks around 300 x 300 x 130mm
The minimum compressive strength should be 8kp/cm^2 (0.8Mpa)	The minimum compressive strength should be 0.6Mpa	The minimum compressive strength should be 0.5Mpa
Earth should contain 30 – 40% clay and 40% should pass through the 0.063mm sieve. It should not contain stones bigger than 3cm.	The earth should contain an adequate quantity of clay	Earth should contain 5 -50% clay
Mixing water should be clean	Mixing water should be clean	Mixing water should be clean
The hydration process is allowed for 12hours	The hydration process is allowed for 48hours	The hydration process is allowed for 24hours
One to two storeys in seismic zone	One to two storeys in seismic zone	It shall not exceed 6.5m in height from the top of the footing to the top of the earthen wall.
Minimum wall thickness of 40cm for single storey buildings and upper storey of two storey buildings. Wall thickness at the lower storey of the two storey buildings should be 50cm	The minimum wall thickness for one storey is 0.4m	The minimum wall thickness should be 250mm thick.
Minimum depth of foundation is 70cm	Minimum depth of foundation is 0.6m	Maximum depth of foundation is 600mm
Minimum width of foundation is 50cm for single storey, 60cm for double storey.	Minimum width of foundation is 0.6m	Maximum width of foundation is 450mm

4 CONCLUSION

Each country has their own standards regarding materials used and earthen construction procedures. Developments both in earthen materials and technological equipment should be considered carefully to improve earthen construction, which has some disadvantages regarding water absorption and earthquake resistance.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Traditional Adobe Houses Project in Van-Kalecik

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ABSTRACT

The first examples of residential architecture in Van developed in the old city of Van, located in the south of the historic Van Fortress, until the early 20th century. After 1920, new houses were added in groups to the structures that were built as vineyard houses in today's Van city. These houses, which were built as single-storey and two-storey structures, were built in an adjacent order with flat earth shelters and adobe brick material.

Houses in the old city of Van were completely burned down in 1918 during the retreat of the Russians and Armenians from the region. In the following years, the development process of the residential architecture has continued in the various central neighborhoods of today's Van city. Due to the vastness of the land and this development, each house was independently constructed in a detached order within a street, house, courtyard, orchard and garden relationship.

Since 1970, the rapidly changing and developing social life conditions in today's Van city have resulted in the abandonment and/or demolition of traditional houses as a result of the demand of people for concrete houses. As a result of disrepair and neglect, first the traditional Van houses which are the examples of civil architecture that created the unique urban texture of Van city, and then the streets and neighborhoods were demolished and destroyed. Four traditional Van houses, Van shops and Van neighborhood that make up the street structure were planned of different plan types in order to conserve the traditional Van houses, which were destroyed and demolished, to offer them to the cultural tourism, and to teach and introduce them to younger generations.

With the financial support of the Ministry of Development, it was completed in 2015-18 by the Municipality of Tuşba, in the district of Kalecik, which is the most dominant region of Van province. The project was awarded with the winner prize of Turkey by the Anatolian Local Administrations Organization in 2015.

Keywords: Adobe, Earth Shelter, Detached Order, Mud, Traditional

1 INTRODUCTION

Domestic architecture of Van has been developed in the Old City of Van where located in the southern part of Van Castle until the last quarter of the 19th century. The City was surrounded by walls from the east, south and west and by the Van Castle from the north. *(Figure-1; Figure-1)* (Öztürk, 2001: 32-34).

Figure 1. Layout Plan for Old City of Van (Ş. ÖZTÜRK)

Architectural formation lasted incessantly until mid-XIX century in the Old City of Van. Territory outside of the walls expanded to Edremit in the south, to Akköprü in the north and to skirts of the Erek Mountain. People of Van settled in vineyard-houses at the territory outside of the Old City of Van and created the base of modern day's Van city (Kömürcüoğlu, 1945: 27-29).

Most of the architectural buildings located in the Old City of Van and modern day's Van city were destroyed while Russians and Armenians were receding in 1918. Most of the traditional houses in the modern day's city of Van were renovated and some of these renovated houses were used until 1990. Even the ruins of the Old City of Van survived to the present day. The majority of the 33 historical Van houses in the modern day Van city were ruined until 1994 as a result of disrepair. Also five houses were severely damaged during the Van-Erciş earthquake of 2011 and three houses survived partly to the present day (Öztürk-Bekiroğlu, 2013: 223,224).

Apart from fast changes in social life circumstances, ferro-concrete buildings have rapidly expanded since 1970 around current Van city, causing traditional Van houses to demolish.

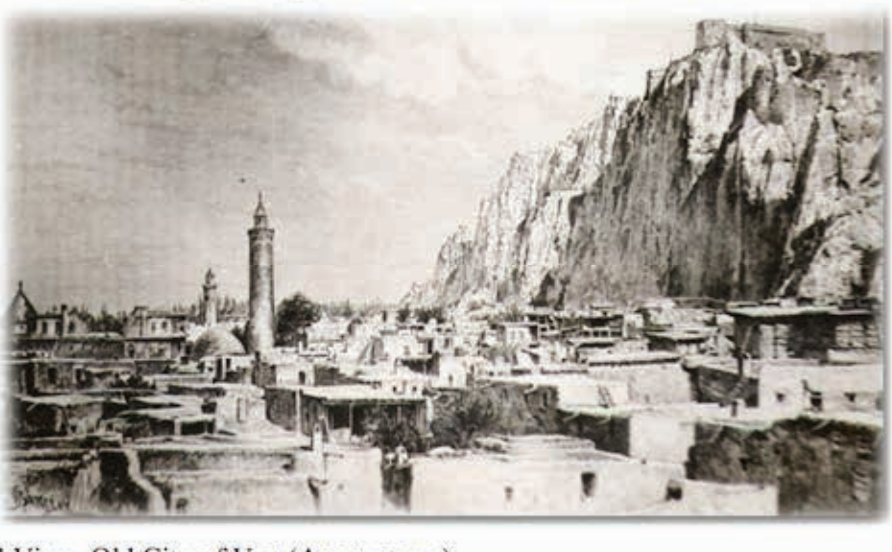

Figure 2. General View, Old City of Van (Anonymous)

Traditional houses were either abandoned or demolished as a result of the popular demand for ferro-concrete houses. The failure to strategize a *Conservation Plan* in time and keep a close eye on registration and observation accelerated this unfortunate process. The *"Van House Model"* which was rebuilt in 1998 on the north -eastern part of the Van Castle has been used for hosting many events during the last two decades *(Figure-2)*.

Figure 3. Van House Model, Front View (Ş. ÖZTÜRK)

Today, the *Van House Model* contributes to the culture and tourism of the province by attracting domestic and international tourists. Sponsored by the Ministry of Development - Eastern Anatolia Development Agency in 2015, *"Traditional Van Houses Project"* was completed in 2015-2018 in Kalecik, which is located at a high ground on the northeastern part of Van's Tuşba district.

2 LAYOUT VIEW

After the observation and land analysis by Musa Sarı, the District Governor of Tuşba, Emin Demirci, the Secretary General of DAKA, supervisors from Tuşba Municipality and the project's author, Kalecik was determined to be the site for Traditional Van Houses Project. The Project's entire area comprises of a rocky and slope land of 9385 m^2.

The Ministry of Finance - National Properties Directorate allocated the project area to Tuşba Municipality. The Western part of Kalecik, a scenic location overlooking the city, has taken the form of a quite declivitious shoulder as it is used as a quarry. This rocky land's eastern, northern and southern parts have taken slopy forms inherently. *(Figure-3)*.

Figure 4. Kalecik's Traditional Van Houses Project Area, General View (Ş. ÖZTÜRK)

The Project area, which is located in a fairly high ground of the city, has been flattened by earth movers, and thus, the architectural project has been applied. It is possible to see modern day Van city, historical Toprak Kale (castle), Erek Mountain and a spectacular area with the best sunset view in the east, Van pier, historical Van Castle-Old City of Van, Edremit district, Artos Mountain, Lake Van with its entire beauty, Akdamar Island, Çarpanak Island on the Lake, another spectacular area for the best sunset view, Süphan Mountain and Van Yüzüncü Yıl University campus area in the south and Kalecik Campus and the range of mountains in the north of the Project area, which was located panoramically at the top of the city.

Figure 5. Kalecik's Traditional Van Houses Layout plan (Ş. ÖZTÜRK)

Kalecik's Traditional Van Houses Project consists of a parking lot for 55 small and 5 big vehicles, Entrance Gate, eight traditional shops, four traditional two-story houses, a cafetaria, an amphiteatre with a capacity for 1000 people, a square, an observation tower *(spectacle),* a fountain and complementary buildings such as a water well etc. *(Figure-2)*.

All constructional parts of the Project were completed in May 2018 in line with the construction Project, except the observation tower *(spectacle)*.

3 KALECIK'S TRADITIONAL VAN HOUSES

Four houses were built in the scope of the Project, reflecting the layout, frontier, flat roof and other civic architectural features of the traditional Van houses in the Old City of Van and modern day Van city.

Four traditional houses under the Project have the following features: "*two storied, having indoor hall, two fronted, having more than two rooms, chalet layout type*" and are used by economically and culturally upper class local people. Houses are named after renowned pre-Republic period governors who are remembered affectionately and respectfully by locals and for whom many poems and songs are devoted.

3.1 Hüsrev Paşa House

The house is accessed from the south of the square with an entrance hall that has two-steps, three sided stairs. Rectangular planned indoor hall in the ground floor is accessed through a double-wing wooden door with knob located in the middle of the stairhead. *(Figure-3)*.

Figure 6. Hüsrev Paşa House Ground Floor Layout (Ş. ÖZTÜRK)

Each of the eastern and western sections of the ground floor hall has one rectangular layout room On the north-east door of the hall, there is an entrance to the furnace place, which is built adjacent to the house. There are two furnaces in the furnace place: one for daily use and one for weekly use. Furnace place extends to the upper story and its fume is released by a circular chimney in the middle of the flat soil roof. The ground story of the furnace has ten embrasures and each of the upper story's north and west walls has five embrasures.

Each of the north, east and west walls of the furnace place has five alcoves and ground is slate-covered. The kitchen section of the house is accessed from a door in the north-east corner of the hall. There is an oven, two alcoves and four embrasures in the kitchen.

Sink and toilet section of the hall located between the kitchen and the room is planned in the east-west direction. A door in the north axis direction from hall's access door provides way out to house's yard. Upper story is accessed through a wooden and one-armed stair on the eastern wall of the hall *(Figure-4,5)*.

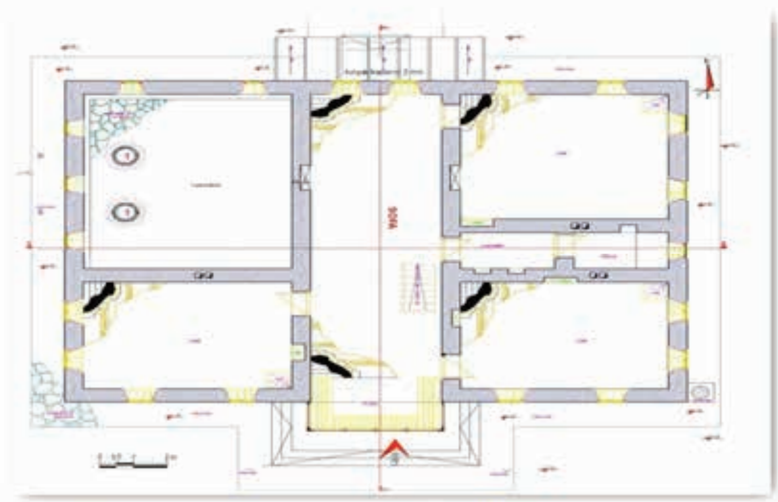

Figure 7. Hüsrev Paşa House Upper Story Layout (Ş. ÖZTÜRK)

Figure 8. Hüsrev Paşa House A-A Longitudinal section (Ş. ÖZTÜRK)

Upper story's hall section is planned as rectangular in the north-south direction. The South of the hall cantilevers extends out 1.20 m and makes a chalet section. The room is accessed by a door on south-west corner of the hall. A sink and a toilet are placed between two rooms, as shown in the ground floor layout. A wooden extension ladder in the sink section provides access to the roof entrance and soil flat roof.

3.2 Ali Paşa House

Ali Paşa House's entrance stairhead is accessed through two steps which have chamfered corners. Rectangular planned indoor hall is accessed by a double-wing wooden door with knob located in the middle of the stairhead *(Figure-6)*.

Each of the north and south sections of the ground floor has a rectangular planned room. Each room has five embrasures and one alcove. The kitchen is accessed by a door in the south-east of the hall. There are an oven, four alcoves and four embrasures in the kitchen. A sink and a toilet are placed between the kitchen and the room.

Figure 9. Ali Paşa House Ground Floor Layout (Ş. ÖZTÜRK)

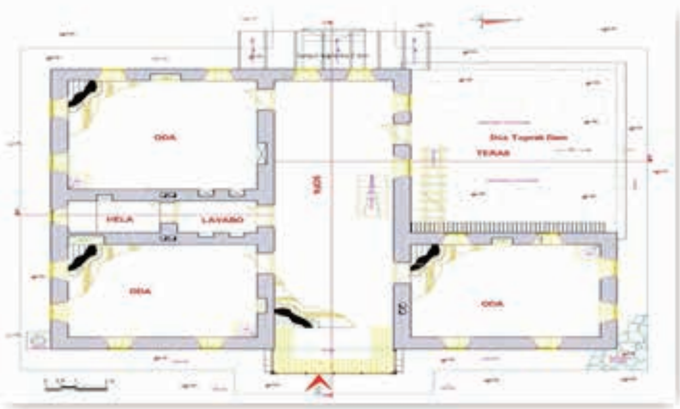

Figure 10. Ali Paşa House Upper Story Layout (Ş. ÖZTÜRK)

A fairly big planned room is accessed by a door in the north-east section of the hall. There are four alcoves and five embrasures in the room. A door in the west axis direction from the hall's east access door provides way out to house's yard. Upper story is accessed by a wooden and one-armed stair on the northern wall of the hall *(Figure-6,7)*.

Figure 11. Ali Paşa House A-A Longitudinal section (Ş. ÖZTÜRK)

Upper story's hall section is planned in the east-west direction. East of the hall cantilevers extends out 1.20 m and makes a chalet section. A door in the north-east of the hall provides access to the room. An alcove, six embrasures and a shower *(Çal)* are placed in the room. A door in the north-east of the hall provides access to the flat roof terrace. Wooden stairs provide access to the upper story's soil flat roof.

Two rooms and sink-toilet areas in the south of the hall are planned complying with ground floor layout. Indoor illumination is provided by four embrasures, i.e. two in the west and two in the north of the hall *(Figure-8)*.

3.3 Mehmet Emin Paşa House

Mehmet Emin Paşa House's entrance hall is accessed by two-steps, three sided stairs from the east of the square. Rectangular planned ground floor is accessed through a double-wing wooden door with knob located in the middle of the stairhead *(Figure-9)*.

A door in the north-west corner of the ground floor hall provides access to the room. There are seven embrasures, two alcoves and a shower *(Çal)* in the room. There are five embrasures, an alcove and a shower in the room which has an access through a door in the south of the hall. The sink and the toilette are accessed from a door in the south-west of the hall. There are two embrasures and two alcoves in the southern wall of the hall. A double-wing door in the west wall on the main entrance door's axis provides way to the back hall area.

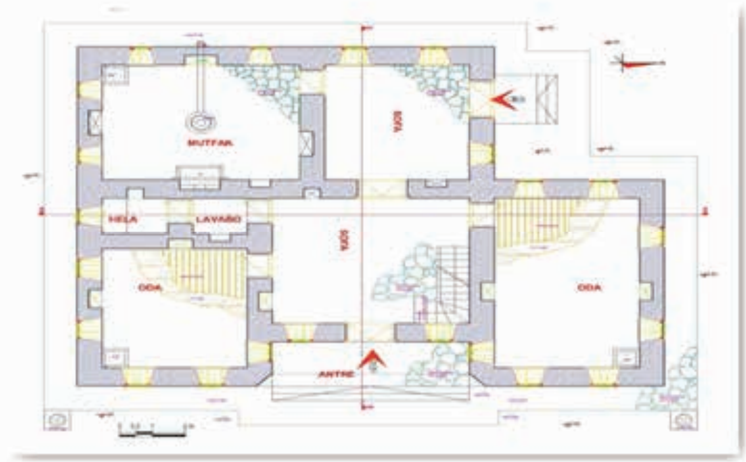

Figure 12. Mehmet Emin Paşa House Ground Floor Layout (Ş. ÖZTÜRK)

A door in the south-east of the hall provides access to the kitchen. There are an oven, four alcoves, four embrasures, a furnice place and a shower *(Çal)* in the kitchen *(Figure:1)*. Two embrasures are placed in the southern wall of the hall and a window and an exit to the yard are placed in the northern wall of the hall. One-armed wooden stairs on the northern wall of the hall provide access to the upper story's hall *(Figure-9)*.

Upper story's hall section is planned in the east-west direction. Eastern part of the hall is designed to be 0.50 m. recessed. The hall has four windows in the east, two embrasures in the western wall and two opposing alcoves and wooden sofas.

Figure 13. Mehmet Emin Paşa House Upper Story Layout (Ş. ÖZTÜRK)

Flat roof terrace is accessed by a door in the middle of the western wall of the hall. A door in the South-east of the hall provides entrance to the sink and the toilette. A room is accessed from another door in the southern wall of the hall. Four embrasures, two alcoves and a shower *(Çal)* are placed in the room.

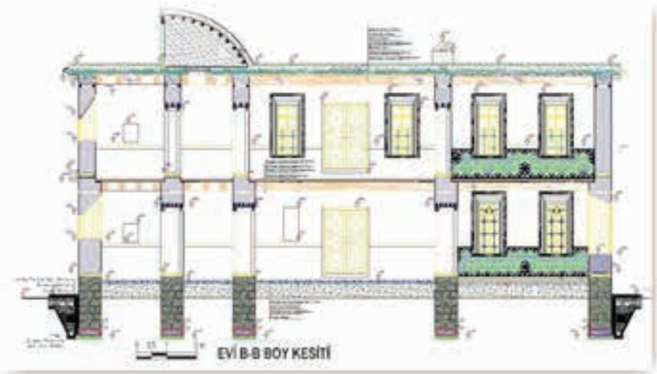

Figure 14. Mehmet Emin Paşa B-B Longitudinal section (Ş. ÖZTÜRK)

Six embrasures, three alcoves and a shower *(Çal)* are placed in the room, which has a door in the north-western corner of the hall. *(Figure-10,11).*

3.4 Cevdet Paşa House

Cevdet Paşa House's entrance hall is accessed from the east of the square, by two-steps with chamfered corners. Rectangular planned ground floor is accessed through a double-wing wooden door with knob located in the middle of the stairhead *(Figure-14).*

Figure 15. Cevdet Paşa House Ground Floor Layout (Ş. ÖZTÜRK)

Each of the north and south sections of the ground floor has a rectangular planned room. Each room has four embrasures and one alcove. Rooms are accessed by doors in south-west of the hall. Four alcoves and four embrasures are in the kitchen. A sink and a toilet are accessed by a door in the northwest corner of the hall. Second hall in the western side is accessed by a double wing door in front of the western wall of the hall. Kitchen section is accessed by the door at north-east of the hall. An oven, four alcoves and four embrasures are located in the kitchen *(Figure-12).* Upper story is accessed through a wooden and one-armed stair in the southern wall of the hall.

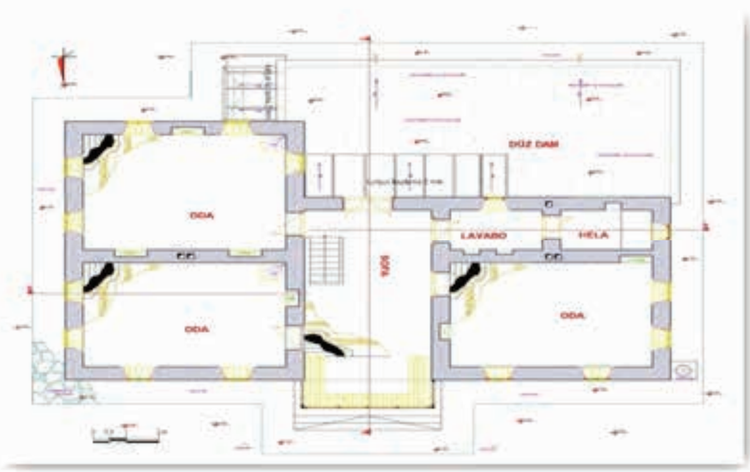

Figure 16. Cevdet Paşa House Upper Story Layout (Ş. ÖZTÜRK)

Upper story's hall section is planned in the east-west direction. East section of the hall cantilevers extends out 1.20 m and makes a chalet. A door in the north-east of the hall provides access to the room. Four embrasures and two alcoves are placed in the kitchen. Sink and toilet are accessed by a door in the north east of the hall *(Figure-13, 14)*.

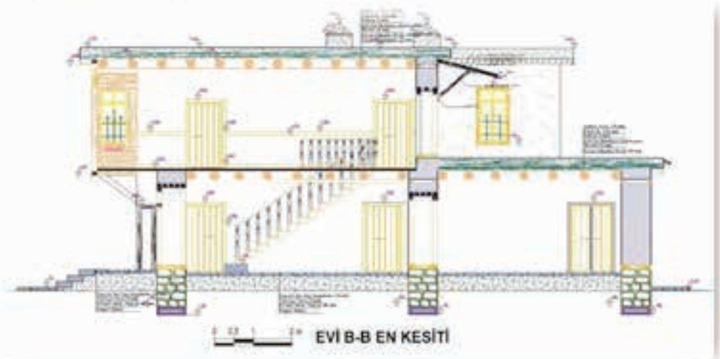

Figure 17. Cevdet Paşa Paşa B-B Longitudinal section (Ş. ÖZTÜRK)

Flat roof terrace is accessed by a double-wing wooden door located in the middle of the western wall of the hall. A wooden stairs on the terrace provide access to the flat soil roof on the upper story. Designs of two rooms in the south of the sofa are planned identical to the one for the ground floor.

4 MATERIAL AND PRODUCTION TECHNIQUES

4.1 Mud-Brick

Walls over the plinth level are built of mud-brick in the four houses under the Kalecik Traditional Van Houses Project. The soil used for mud-brick and clay compositions and for flat roof covering is brought from *Yumrutepe* village, located at 25 km north of Van (Öztürk, 2013: 103-122).

Figure 18. Traditional Van Houses Mud-brick Manufacturing View (Ş. ÖZTÜRK)

The clay pulp, made out of thatch, wood ash, rock salt and water, is used after being kept in this state for one week and dried under the sun in special wooden moulds. The size of mud-bricks is 0.08x0.30x0.30 m for the whole mud-brick, 0.08x0.015x0.30 m. for half *(kuzu=baby)* mud-brick and smaller pieces are called *kret* by the local artisans *(Figure 4&5)* (Öztürk, 2013: 221-232).

4.2 Wood

Pine, spruce and elm are used for manufacturing of doors, windows, closets, roof covers, stairs, timbers and floor covers for houses.

Walnut tree is used for indoor area components such as crates, davenports, coffee tables, special doors and more stable elm tree is used for lower joists of chalets. Circular wood joists which are used between stories are 0.20-0.25 m. in diameter.

Double sided timbers of 0.10 m. width are used for tresholds of doors and windows, plinths and lower joists between storeys (Figure-*5-10).*

Figure 19. Traditional Van Houses, Mud-brick wall Construction View (Ş. ÖZTÜRK)

Figure 20. Traditional Van Houses Floor Pavement Construction View (Ş. ÖZTÜRK)

4.3 Metal

Metal materials are processed by local ironsmith artisans in workshops and used in window and door production for houses.

Figure 21. Traditional Van Houses, Wood Timber and wall View (Ş. ÖZTÜRK)
Figure 22. Traditional Van Houses, Wood Joist and Rafter View (Ş. ÖZTÜRK)

Figure 23. Traditional Van Houses, Wood Floor Cover View (Ş. ÖZTÜRK)
Figure 24. Traditional Van Houses, Wood Roof Cover View (Ş. ÖZTÜRK)

4.4 Brick

Bricks are used as decorative materials especially in the front entrances of Van houses in the scope of the Project. They are used as square blocks on upper and lower decorations of front windows and on front corners in the ground floor entrances *(Figure-11)*.

Figure 25. Cevdet Paşa House Entrance North View (Ş. ÖZTÜRK)

4.5-Stone

Pitch-faced stones are used for plinth levels of four houses in Kalecik Traditional Van Houses Project. Also, slates are used for pavement covering at ground floor halls, kitchens, furnace places, sinks and toilets.

Figure 26. Furnace Place Ground Stone Cover View (Ş. ÖZTÜRK)
Figure 27. General View of Traditional Van Houses in Kalecik (Ş. ÖZTÜRK)

Figure 28. General View of Traditional Van Houses in Kalecik (Ş. ÖZTÜRK)

Figure 29. General View of Traditional Van Houses in Kalecik (Ş. ÖZTÜRK)

5 CONCLUSION

Geographical conditions, customs, traditions, materials, lifestyle and living conditions are the main factors for the creation of Van's domestic architecture. Each house is built as a detached building, having the following architectural features: two storied, having indoor hall, two fronted, having more than two rooms, chalet layout type. Kalecik traditional houses are made of mud-bricks.

Today, Kalecik's Traditional Van Houses Project is particularly appreciated by the local people. This project helped to regenerate traditional Van houses to some extent as civic architecture. It is supplemented by other buildings such as shops, cafetaria, square, amphitheatre etc. and makes great contributions to the domestic and international culture and tourism.

This and similar projects will connect the past and the present to the future and contribute to the original urban civic architectural pattern of Van that has been recently extinct.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

A Study on the Role of Sunken Courtyard in Sustainable Architecture of Iranian Desert Cities (Case Study: Olumi House in Yazd)

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ABSTRACT

The energy crisis, environmental threats and the consumption of fossil fuels and its consequences on human life are among the most important challenges that today's people are facing. Iranian native architecture and urbanization have played a significant role in coordinating the building with the earth and sustainability and have responded to human needs particularly in the hot and dry climate. Architecture today represents a blind imitation of western architecture and urbanization and a lack of knowledge of the values of traditional Iranian architecture. Meanwhile, the traditional Iranian architecture has sought to create an order based on natural gifts and harmony with the order of nature in which to meet the mental and physical needs of humans. Hence, the sunken courtyard was one of the factors that influenced the creation of human comfort in a hot and dry climate and provided interactions and dynamics in the human environment. A little reflection on the sustainable architecture and its principles will lead us to the native architecture of our country's ancestors. The aim of native architecture is essentially the pursuit of sustainable architecture. The purpose of this paper is to study the role of the sunken courtyard and the factors that affect the stability of this kind of building. The research method of this article is a historical descriptive study. The results of this study indicate that this indicator element is a small but exquisite example of a sustainable architecture for the use of natural energies and has created comfort in the houses of this region.

Keywords: Sunken Courtyard, Sustainable Architecture, Traditional Architecture, Yazd

1 INTRODUCTION

The current development process of today's society is not close to any kind of sustainability. The current trend of development in fact reduces sustainability, and this trend or phenomenon is true in the development process of both developed and industrialized countries as well as in developing countries [21]. For decades, the concept of sustainable architecture has been developed and many solutions have been proposed to solve the contemporary crisis, but there are still some problems in creating sustainable architecture. It seems that it can be completed by removing obstacles through studying the values and characteristics of native architecture. Due to the effects of native architecture and library documentation, some social and economic relations with the natural environment and cultural symbols of sustainable architecture can be seen in the native architecture. Sustainable development is a development that will meet the needs of the current generation without compromising the ability of future generations to meet their needs [16]. According to this definition, native architecture itself is a sustainable architecture because this architecture is interwoven with the nature that exploits it, without causing it to collapse [5]. In this study, sunken courtyards are considered as one of the most valuable factors in the architecture of traditional Iranian buildings that have been forgotten over time and should not be overlooked. The case study was conducted at the Olumi House in Yazd, which has a 7-meter high sunken courtyard.

2 RESEARCH METHOLOGY

The research method is historical descriptive method with qualitative study. The research span is the hot and dry architecture of Yazd and it expands to study the sunken courtyard of the Olumi House of Yazd in Qajar era. Purposeful sampling method and tools for collecting information are obtained from library studies, written sources, documents, maps and objective observations. The method of data analysis is content analysis. In the research path to explain the role of the sunken courtyard in the phenomenon of sustainable architecture, at the outset, the expression of sustainability, sustainable architecture and the principles of sustainable architecture have been addressed.

3 CONCEPTS AND RESEARCH LITERATURE

3.1 Sustainability

Sustainability as a descriptive aspect of development is a situation in which the desirability and facilities are not reduced over time and it comes from the word Sus (Sustenere, meaning 'from the bottom' and Tenere, meaning 'keeping') meant to be kept alive, which implies long-term protection or durability. The term sustainability was first introduced in 1968 by the World Committee on the Promotion of the Environment (confronting the needs of the present age without compromising the resources of the next generation to meet their needs). In this world, architects are also in line with other practitioners to find new solutions for human well-being. Since the strengths and weaknesses of a building will have a direct impact on the biomass of the world, it is clear that ecology knowledge with the help of natural resources, ecosystems and attention to climatic characteristics plays a key role in the development of the concept and the nature of sustainability and in the future, it will still play the most important role in achieving this concept [10]. The term sustainability is defined as stable, durable, that is, what stays constant. In the sustainability among survival and development, stability (for the coherence) and ability to change (for growth) there is an inherent tension, and sustainability belongs to phenomena that can balance and apply this two-way relationship [17].

3.2 Sustainable Architecture

Sustainable architecture is a human architecture aiming to reduce damage to the environment, energy resources and nature [11] which acts as a branch of native architecture and can link its goals and principles. The concept of sustainable architecture is not to create buildings that merely last a long time since a building with several hundred years of age does not fit the needs of the present time. Sustainable architecture is a method of design and reduces the use of non-renewable resources and optimizes the use of renewable resources, and states that what we need to survive can be obtained from the environment. Sustainable architecture is a large term that describes architectural design techniques that are consistent with environmental considerations and are constructed with the idea of respecting nature. This architecture is not a new trend since it has fundamentally existed in many different ancient civilizations and traditional architecture, including traditional Iranian architecture. Today, in the face of the negative consequences of the industrialized world, for example, the increasing pollution of the air and environment, the reduction of natural resources and the energy crisis, sustainable architecture has become one of the most important concerns of man in the present day. The Iranian traditional architecture has a strong backing of various aspects of Iranian sustainability, art and culture, and represents on its own a special contribution to art and culture.

Exploring these features can serve the planning, design and popularization of the present living environment. The residential needs of people in cities and especially in traditional cities today are independently and without the recognition of its side effects, especially on the environment [18]. The study of Iranian desert cities such as Yazd, Kerman and Kashan shows that the physical characteristics of the historical and traditional parts of these cities are significantly compatible with the new scientific findings. It also seems that the environmental coordination is a product of a long process of repeated tests and errors that have taken place throughout history with the design and construction of buildings and urban textures [12]. The lack of attention to the sustainable foundations of traditional Iranian architecture and its various influential factors has left a worn-out and unstable body of urban construction. Undoubtedly, technological advancement is a necessity that cannot be neglected, but this factor should not endanger our values, especially in terms of environmental sustainability. In this regard, forgotten solutions have to be identified in the design of a sustainable residential environment, and they should be used in the design of sustainable buildings by updating them according to existing technologies [12]. In general, sustainable design represents a kind of architectural attitude that points out a few basic points first, qualitative, second, focusing on the future and third, focusing on the environment [12].

3.3 Sunken Courtyard

As previously mentioned, one of the hot and dry architectural elements is the creation of a sunken courtyard. In Old and Middle Persian, they are called purification and washing Padiav [19]. Through courtyards and deep sunken courtyards, one floor of the buildings is located underground and, with the support of the ground, it has subtantially lower temperatures in the summer than the environment around it and is warmer in the winter. Therefore, energy fluctuations are minimized and wasting is prevented [1]. As the Iranian introverted architecture has turned its rounded courtyards to Padiav and sunken courtyards, it has helped to improve Iranian houses. Due to the deepness of the courtyards in these homes, the sun does not shine to the bottom of the house, which is very effective in moderating the air in the lower parts of the house and making it a cool place in this climate. In addition, for the use of aqueducts, the floor of the house should be lower than the ground. The masters of traditional architecture used the excavated soil to build other parts of the house, which in fact was a way of saving time and money. Another reason for building a house in the sunken courtyard was for it to be more resilient to earthquake.

3.4 Historical Background Sunken Courtyard

With regard to the sanctity and water reverence for the Sassanid Persians, according to the available evidence and existing structures, the sunken courtyard dates back to the Sassanid period, which continued to the Qajar period, in Iran's architecture. Examples of these sunken courtyards are Anahita Temple, Firooz Abad's Castle, Pirnia House, Abbasian House, Aqa Bozorg Mosque of Kashan, Grand Mosque of Bafgh and etc.[8]

3.5 How to Build a Sunken Courtyard

The sunken courtyard was in the middle of a courtyard, and a floor fell into the ground [9]. Due to the small size of the courtyards and the use of humidity and chill of earth, in addition to the humidity of the plants and the coolness of the water, the atmosphere here is much more climatic than a normal courtyard [24].

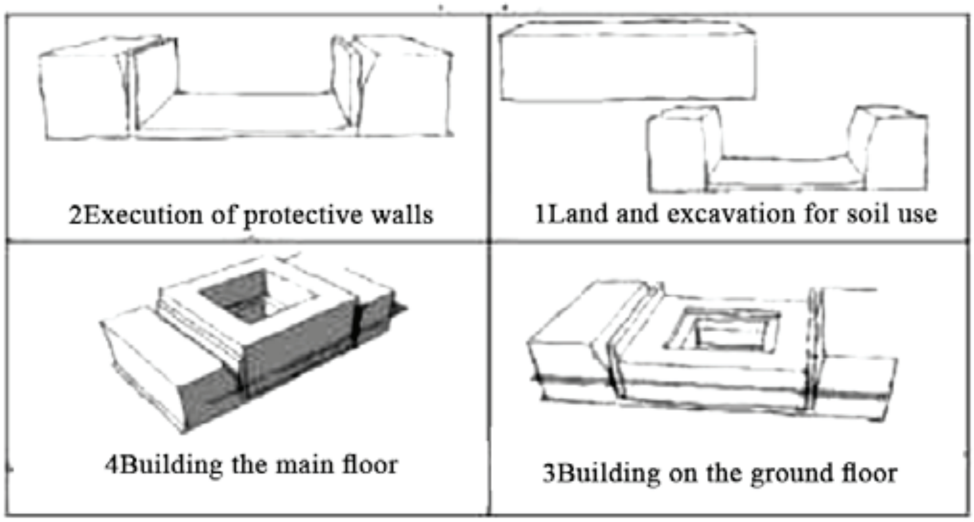

Figure 1. How to build a sunken courtyard

4 THE PHENOMENON OF SUSTAINABLE ARCHITECTURE IN SUNKEN COURTYARDS

4.1 Sunken Courtyard and Energy Conservation

In these buildings, the warmth of the day is stored for use in the cold winter nights and the night's cold for use in hot summer days. Another aspect of sustainability is the use of energy by the earth depth in these homes. In fact, the earth's crust, like a buffer, protects the building's immense thermal insulation against atmospheric changes and atmospheric factors, the storm, and the wind cannot penetrate into the earth [7]. The sunken courtyard has a significant impact on total energy consumption and thermal energy in residential buildings in Yazd. It can be said that the sunken courtyard provides a moderate temperature for the adjacent main spaces in different seasons of the year.

4.2 Sunken Courtyard Materials

The sunken courtyard is created by digging the courtyard. The spaces around the sunken courtyard are the same as the surrounding areas of the dwelling house, the main materials of which are clay and brick. The groundcover of the sunken courtyard is also built of bricks [15].

4.3 Sunken Courtyard and Climate Considerations

Environmental protection is at the forefront of global priorities and different fields of science and engineering are looking for solutions to balance technological designs with environmental parameters. In this regard, one can refer to ancient patterns used in Iranian architecture, which create a harmonious architecture in line with the climate and the environment, in which buildings act as a part of a complex set of interactions between human and environmental needs. The traditional Iranian architecture has sought to create an order based on natural gifts and harmony with the order of nature in which to meet the mental and physical needs of humans and in this regard, Iran's architecture in different climates and environments has provided effective solutions that have evolved over the centuries. In this context and taking into account the principles and concepts above, the environment is one of the most important elements influencing the design of urban spaces architecture, including residential buildings, which should be considered from different aspects. These include the role of the sunken courtyard and its impact on the architecture of residential areas of hot and dry climate [4].

In the central courtyards of the sunken courtyard, all the elements of the house come together and provide microclimates that can be used for living. They act as an intelligent element in the face of cold, humidity and wind and as a natural oasis of light, wind, and plants in order to provide residents with a comfortable environment [20].

4.4 Sunken Courtyard and Meeting the Needs of its Residents

Sustainability in architecture is not possible without regard to the physical, psychological, and spiritual needs of humans. Providing human needs in the context of the environment created for its growth and perfection, it is consistent with the requirements of sustainable architecture as its mental and physical efficiency increases. The type of response to these needs will change over time [14]. The sunken courtyard is an example of the native architecture of hot and dry region that represents the customs, morale and emotions, thoughts and beliefs, taste and art of the people. 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.

4.5 Sunken Courtyard and Alignment with the Site

The sunken courtyard is accompanied by nature and its productivity [6]. The important cultural and geographic features of Iran have caused a great deal of variations in its architecture. If we want to follow the existing geographic divisions, to review the architecture of different regions, we will see that even a limited geographic area offers a variety of architectures in its various locations. The sunken courtyard is formed as a component of the whole house, coordinated with the internal structure of the house. Materials, organizing the proportion of spaces, the climatic conditions, meeting the needs etc. should be taken into consideration for the house, urban texture and the desert region. In fact, the sunken courtyard is not only unobtrusive with the site, but also more coherent and more appropriate than other desert houses [20].

4.6 Sunken Courtyard and Reduction of Losses

Contrary to contemporary architecture, traditional and native buildings live longer than people do. Lifespan is a capital itself. Obviously, their low quality will impose a public expense on future generations. These buildings save energy with their lifespan [3]. This type of production, meaning the rotational sequence of consumption, corresponds to the economic pattern of traditional societies, and reflects the deep connection between places and human constructs [22].

4.7 Sunken Courtyard and Integrity

In addition to geographical issues, cultural issues and beliefs of builders and residents of the house have been effective in arranging spaces. On this basis, introversion has been improved and the space has been separated by the use of interesting methods [13]. In addition, the role of adobe and earthen materials is everywhere, both inside and outside the house. In fact, the use of earthen materials in desert areas, especially Yazd, has had climatic, practical and technical reasons. Perhaps it can be safely stated that the presence of sunken courtyard in native houses of Yazd city has been shaped in relation to climate, materials, energy consumption, and to meet the needs of its inhabitants and its site. Coordination of the sunken courtyard with the whole (house, historical context of Yazd city and desert architecture) is indisputable [20].

4.8 Vegetation in the Sunken Courtyard

One of the elements in the sunken courtyard is the greenery garden. Today, physicians believe that the presence of green space in homes, in addition to providing residential health, has a positive effect on the health of the residents. The plant, in addition to the important role of setting the hot and dry climate conditions, gives a shadow and aesthetic appeal to the home and has a symbolic meaning [23].

5 CASE STUDY

5.1 Yazd

The city is 18 ° longitude, 11 minutes to 11 degrees and 87 minutes, and latitude 86 ° 18 'to 88 ° 87'. The climate of Yazd province depends on two fundamental factors. First, it is located on a dry world belt, and secondly, it is far from the Oman Sea and the Persian Gulf, and the lakes and inland sea winds.

The important factor is the relative weather moderation of Yazd, which has provided relatively good bio-potential. The heights of mountains, which surround it, are used locally to improve the weather and so, the areas with a height of more than 2500 meters are more moderate and have more relative humidity. The average temperature in the province is 18.9 degrees Celsius. The absolute maximum temperature is in July reaching 43° C and it is at minimum in January with 7.2° C.

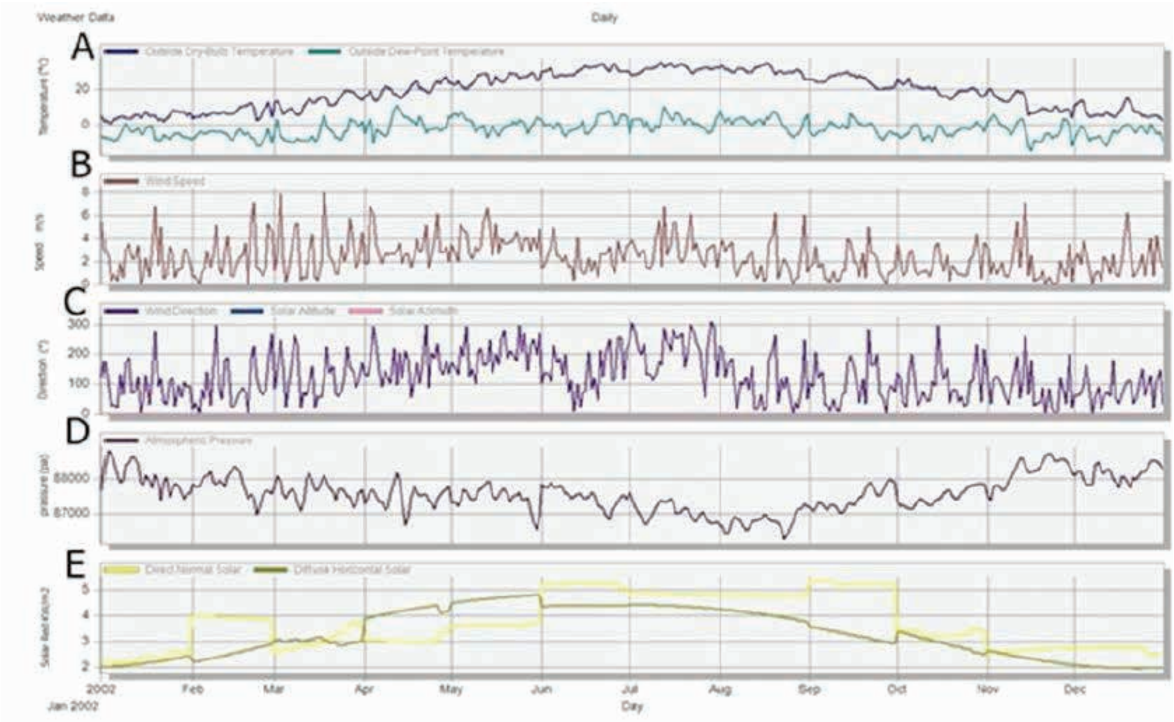

Figure 2. The climate of Yazd city; A: Temperature; B: Wind speed; C; Wind direction; D: Air pressure; E: Sunlight

The city of Yazd, with its hot and dry climate, has been able to perfect the architecture in harmony with its land and adjust the architecture as if they were born together. Our ancestors were so busy in the living space that they valued the day, the night, the seasons and the hours. At daytime, they would escape from the summer heat by taking shelter in the underground and at night, they went to higher heights to appreciate the beauty that God created.

This perception of the earth in order to reach a living space consistent with the climate lies within the native architecture. Many architectural elements such as the central courtyard, Badgir (wind catcher), sunken courtyard, etc. are shaped by the climate. In order to better understand this phenomenon, we will study the Olumi house in Yazd.

5.2 House Location

Yazd, southeastern side of Amir Chakhmaq Square, Shahid Kazem Ahdi Alley

Figure 3. Oulmi House Location

5.3 Architectural Description of the Olumi House

The Olumi house is linked to the Qajar era, and its location to the historical context of the city and the city is nearby the historical complex of Amir Chakhmaq. When it was occupied, the Olumi house had two courtyards, but now it is divided into two separate sections. Since this research is dedicated to the courtyard and western front of the house, this section will be introduced:

The entrance to the house is located in the northwest corner of the house, through the Hashti entrance to the house and yard is available.

Western Front: It consists of a five-door room in the middle and three-door rooms on the sides, which are separated by corridors with a ventilated ceiling. The ceiling of the rooms is also in the form of a song. Part of the underground is also home to this front. The ceiling of the rooms is in the form of barrel vault. Part of the underground is located in this part of the house.

South Front: Includes a porch. On one side of the porch, there is an entrance to the basement and on the other side; there is a kitchen and a toilet. The Olumi Basement is located in the southern and western frontiers.

Eastern Front: The eastern side of the courtyard has not been built, except for the installation of several arches on the front wall of the eastern side of the courtyard. The large house of Olumi, as described above, is divided into two parts. In the past, these two courtyards were linked to the northeastern corner.

Northern Front: Includes a "T" shaped room.

5.4 Plans and Sections of the Building

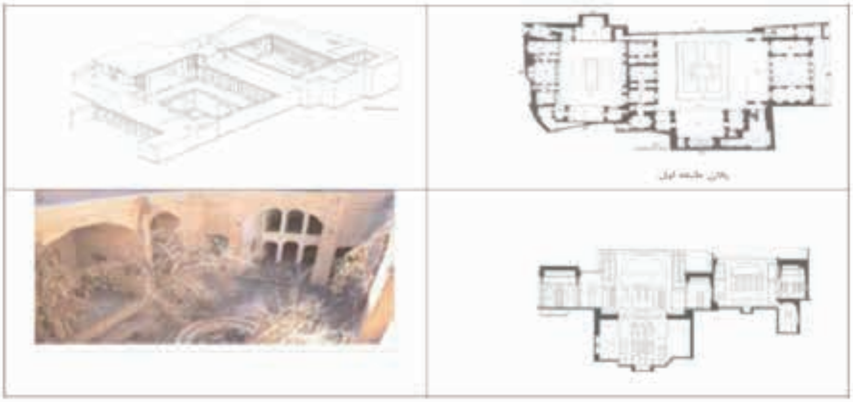

Figure 4. Plans and section of Olumi House

As previously mentioned, the sunken courtyards have been adapted to the conditions of the land in this region. The ancestors tried to find out about the secrets as well as the hidden waters within the land and tried to solve the mysteries. With the discovery of the sunken courtyards, one of the secrets of the Earth has been solved and managed to establish a solid bond between the land and its sustainability. The Olumi House managed to use the courtyard and the sunken courtyard, which respects the principles of sustainable architecture -conservation of energy, climate change, reducing the use of new resources, meeting the needs of residents, coordinating with the site- and it improves the bond between the house and the earth. A review of the assumptions and analyzes indicate that the Olumi sunken courtyard was built for reaching groundwater as well as using its soil to build the building.

In Table 1, these items are generally referred to:

Table 1. The connection between sustainable Architecture and Olumi House sunken courtyard

The principles of sustainable architecture	*Evaluation of the role of the sunken courtyard of the Olumi House and the principles of sustainable architecture*
Energy conservation	-Use of sunlight in the porch and the summer and winter spaces -Use of sheltering soil capabilities -Shades of the walls
Climatic compatibility	-Preservation of the building against the winds -Resistance against the temperature differences between the day and the night -Creating a shadow against heat -Suitable for sunlight
Reduce the use of new resources	-Use of excavated soil -Re-use of recycled materials
Meeting the needs of residents	-Beauty and sense of belonging in space -Raising the quality of life of residents -Creating green space
Coordination with the site	-Tailored to the type of cultural and social issues -Paying regard to the body and type of performance
Integrity	-Coordination with the environment -Creating a memorable surprise

6 CONCLUSION

As noted in the early sections of the research, traditional Iranian architecture from the distant past has played an important role in assuring sustainability of the buildings and meeting the needs of humans in each climate, especially the hot and dry climate. Sustainable architecture is part of native architecture, one of the most important issues of the contemporary era. It has been considered as one of the most important measures in today's architecture due to increased use of fossil fuels and environmental pollution. The theory of sustainable development and, consequently, sustainable architecture is one of the most controversial issues of contemporary architecture. In fact, sustainable architecture is inclusive and does not lead to architectural style like previous styles. The main concern is the environment and it takes advantage of all previous tendencies that focus on reducing the use of materials and energy. Sustainable architecture can be said to be a type of architecture that maximizes environmental talent for the benefit of consumers, and uses smart tools and solutions for this purpose. One of these solutions for the native houses in Yazd is the presence of a sunken courtyard. Due to the hot and dry climate of Yazd, this opening inside the cube, or in other words, the courtyard, provides shadow from the wall, the trees as well as the pond of water and the fountain to cool the air, which helps to moderate the air for the interior of the house. Additionally, the sunken courtyard is a place for the use of natural energies. Its coordination with the cultural, social and spiritual needs of the inhabitants of the house as well as its compatibility with the site and the native architecture of Yazd create comfort and tranquility in the houses of this desert region. Therefore, there is a good balance between human lifestyle and nature. It is an indicator of a small but exquisite example of the sustainable architecture of this region, which is based on the harmony of the natural quality and human respect for nature and it is amazingly consistent with the principles of sustainability.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Earth and Bamboo: Experience from Nepal


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ABSTRACT

Nepal lies in a seismically active and subtropical climatic zone. Yet according to Nepal's Living Standard Survey, 82% of the Nepali houses are made of earthen material [1]. In order to tackle the challenge of earthquakes and high moisture, people in Nepal have used earth and bamboo/wood combination to create reinforced structures and high pitched yet light weight roofing system to tackle high rainfall. Using these techniques, people have built earthen structures as high as five stories. For the last three years, the author has been revisiting these old techniques so that they can be used in modern design practices. Author has designed and supervised more than a dozens building using the combination of bamboo and earth. In this paper, author will describe the unique bamboo and clay construction techniques, including earth and bamboo stitching techniques, post-compressed structures, and many other architectural elements.

Keywords: Bamboo, Adobe, Rammed earth, Reinforcement historic buildings, Nepal

1 INTRODUCTION

Diverse climatic, geographical and cultural variations of the Himalayas have contributed to the development of rich architectural tradition like rammed earth, adobe, stones, wattle and daub, wood and bamboo construction. The Himalayan and its neighbouring region is prone to earthquake, landslides, floods, extreme weather and over the centuries, local artisans have developed sophisticated architectural traditions, which have tried to mitigate and adapt to hostile weather and geographic conditions [2] [3]. In many rural regions of the country, buildings made with natural materials are still an indicator of vibrant living traditions. Unfortunately, wherever modern roads are built, modern materials are slowly replacing the old vernacular architectural tradition. In urban areas, vernacular architecture implies poverty and backwardness. It is exacerbated by the fact that there has been professional and academic neglect of these centuries' old traditions. There are very few academic or commercial institutions in Nepal that are encouraging use of the local materials. Modern sanitation, fenestrations, moisture barriers, large room spaces have not been integrated in the vernacular system and moreover need for regular maintenance has encouraged people to deviate away from these centuries old traditions.

Structurally sound earthquake resistant modern buildings are expensive for the ordinary Nepali; therefore, many people build by compromising on aesthetic and structural integrity. Furthermore, the country does not have an industry of its own, which means the construction materials have to be imported from India, leading to increased environmental and construction cost. A reinvestigation of traditional materials can provide solution to the growing housing demand of the country by not compromising structural, ecological, cultural and economical level.

2 STATEMENT OF THE PROBLEM

Bamboo and earth are abundant in Southern Nepal. They have been used as construction materials for centuries. Locals believe that they are warm in winter and cool in summer. Influx of concrete in the last 30 years, especially after a construction of highway that joined the region with the rest of the country has changed the equation. Although concrete is thermally uncomfortable, some of the perceived advantages it has over earth and bamboo buildings such as no need for regular maintenance, ability to construct large span structures, minimum intrusion of rodents and snakes into the house and relief from wet walls due to capillary action make people believe that concrete is a superior material.

3 OBJECTIVE

This paper shows the author's experience in applying vernacular earthen techniques into modern context. Author and his team got an opportunity to construct 10 bamboo and earth houses in a village of Janakpur in the southern regions of Nepal (Fig. 1). The paper presents traditional ways of using bamboo and author's experiment with bamboo and earth (mainly rammed earth, adobe and compressed earth blocks) in order to demonstrate that the traditional material can achieve what the modern materials do.

Figure 1. Map of Nepal showing the houses construction area by red marker

4 TRADITIONAL USES OF EARTH AND BAMBOO STRUCTURES IN SOUTHERN NEPAL

Bamboo construction is primarily done by an ethnic group called Doms. Doms are 'untouchable' Dalit groups who have been working with bamboo for centuries. A Dom family holds an exclusive right to work in a certain community. They can even sell their rights to another Dom family if they decide to leave the area. It is a traditional way for protecting intellectual property. The most popular of their products is granary (locally know as bhakari), which is built out of bamboo and plastered with mud.

4.1 Wattle and Daub Technique

The same construction materials are also used in construction of walls. Split bamboos are first woven into a wall and then connected to bamboo or wooden posts. Many layers of earth are applied on to the wall with a circular movement in order to give a smooth finish (Fig. 2a). Ideal earth plaster consists of clayey soil (2/3 clay, 1/3 sand), cow dung and wheat husk, which are left at least overnight to soak (Fig. 2b).

Using this wattle and daub technique, one can see construction of maximum of two stories (Fig. 3). The columns, joists and beams are generally wood; wattle and daub walls are stitched to wooden poles and can be replaced whenever needed. Houses can be 30-40 years old but the walls are usually replaced every 6-7 years.

It is a ritual in villages to plaster a house with various vegetable dyes after every monsoon (Fig. 3) in preparation to a festival called Chath (held in October) in order to mark the arrival of harvest. Every year for Chath, houses are plastered and maintenance, including replacement of damaged bamboo, is made. On the plaster surface, women create a relief sculpture by using the same materials (clay, cow dung and wheat husk). In the eastern region, designs are hand-sculpted onto a top layer made with a cow milk additive to produce a white 'canvas' [4]. The colors are obtained from natural or artificial dyes.

The houses are plastered with beautiful motifs, mainly for 'art for art's sake' rather than religious reasons. They can be in the form of art of flowers, elephants, old religious characters or modern motifs like airplanes and tractors.

(a) (b)

Figure 2. (a)Wattle and Daub Technique [5] and (b) plaster material (*source*: author)

Figure 3. The same house in different years (*source*: author)

4.2 Some of the Challenges of Bamboo and Earth Houses

In Janakpur, there are many reasons people associate bamboo and earth with poverty. Firstly, most people in the cities, considered to be the yardstick of development, live in concrete houses. This association of 'development' with concrete is a major hurdle for anyone who wants to witness the growing application of these materials to modern uses. There are also some technical limitations, which have contributed to the negative perception of earth and bamboo. Some of them are:

- There are many cavities between the joints between earth and bamboo, which allows entry of rodents and snakes into the house.
- Bamboo is placed directly onto the floors, causing it to decay faster.
- Due to heavy weight of the clay tiles of the roof, walls tend to creep after a certain time.
- Traditionally, due to limited technological means, people were not able to construct structures more than 3 meters in span.

Probably for the above reasons, village elites try to build houses out of cement. This creates an impression that these houses are primitive and unfit in the modern environment. But the people who live in cement houses invariably agree that the bamboo and adobe houses create a very pleasant thermal environment. It is interesting to note in villages that people still prefer earthen floors for thermal comfort even if the walls are made of cement.

5 OUR INTERVENTION

In order to change the perception of people in Janakpur about traditional materials, an international NGO, i.e. CARE Nepal, hired the author and his team to build modern earth and bamboo houses by mobilizing local resources. The objective of the project was to construct modern structures by using traditional materials which are locally available, have low embodied energy, have cultural precedence and are thermally comfortable. In this regards, as a demonstration we designed and built large spanned modern structures, using earth and bamboo as primary building materials. There was a very comprehensive engagement of the locals in the design and construction process. The structures were built as a community hall, a cantina, public toilets and three office spaces for local NGOs. Most of the resources, including material and labor, were obtained locally. Only cement and rods, which constituted less than 10 percent of construction materials were outsourced. Four kinds of earthen technologies were demonstrated: rammed earth, adobe, cob and compressed earth blocks. The fifth structure was a cantina, and it was built predominantly out of bamboo and some adobe.

5.1 Construction methodology

The foundation was the major component that could substantially resolve issues such as moisture intake through capillary action, entry of rodents and snakes, earthquakes and water splash off. Rubble trench foundation, made of small bed rocks, was laid without mortar. The gaps in-between the stones were supposed to act as shock absorber during earthquakes. There was a very high plinth level in order to avoid any splash off from rain. The rugged surface, made of stone, and the height of the plinth would prevent snakes from finding a way into houses. There were two layers of burnt bricks before the actual adobe started, which would also act as deterrent against rodents, snakes and rain splash off.

5.2 Walls

In order to strengthen lateral resistance of earth walls, they were reinforced horizontally and vertically with bamboo. Bamboo posts were embedded into the burnt bricks at 2-meter intervals, followed by layers of adobe, rammed earth and compressed earth blocks (Fig. 4). After every two meters horizontal bamboo tie-beams were placed. In the rammed earth, it was not a problem, as earth could be easily rammed around bamboo. Placing bamboo horizontally in adobe and compressed earth blocks posed a real challenge as the round bamboo surfaces conflicted with the flat bricks, because of its geometry. Finally, the technique of cob, which is earth reinforced with wheat husk, was used to fill up the uneven cavities created by bamboo (Fig. 5).

5.3 Trusses

The wall portions were made of earthen material in order to create thermal mass. Bamboo was embedded into earth in order to provide structural strength. For the roofing, all the trusses were made of bamboo. They were fabricated on the ground and hauled up when they were complete. They were placed on vertical bamboo posts and tied with cement and rebar (Fig. 6). All our connections were done with rebar and cement. Spans up to 8 meters were achieved, using this method (Fig. 7). Some of the difficulty of fabrication in the ground was replacement of bamboo (if needed). Moreover, cracks are more likely to occur if one is not careful as there are possbilities of twisting and turning when one is hauling up to the site.

Figure 4. Bamboo reinforcement on wall (*source*: author)

Figure 5. Cob covering bamboo (*source*: author)

Figure 6. Rammed earth wall (*source*: author)

Figure 7. Bamboo truss being put on bamboo post (*source*: author)

5.4 Roofing

MCR, Micro Concrete Tiles were used for roofing (Fig. 8). They are a cost effective and ecological alternative to galvanized metal sheets and burnt tiles. MCR is mix of cement, sand and micro aggregate (Ø> 10 mm), which are vibrated for 45 seconds and cured in water for 2 weeks. We insulated MCR with flattened bamboo, which are obtained by beating bamboo on its axis. Since the colors could be added on to the tiles, many villagers found them very attractive.

Figure 8. Micro Concrete Tiles (*source*: author)

5.5 Public Perception and Participation

In our intervention, we tried our best to be culturally sensitive. The communities were involved in the design and construction processes. The reaction to the construction process was mixed; initially public were adamantly against the use of earth and bamboo as they represented backwardness. After realizing that the traditional materials could be improved, and when they started to look modern, perception gradually changed. It remains to be seen whether the locals will follow this kind of construction. Interestingly, however, some of the concepts of truss were already being emulated though they were using ropes and not metals for connection.

6 Project with Kathmandu University

After the 2015 earthquake, with a financial support from Common Funds for Commodity (CFC) and with technical support from ABARI and INBAR, a community lab was built in Kathmandu University as a collaborative project with the Department of Civil and Geomatics Engineering to demonstrate a prototype building that could be replicated all over Nepal (Fig. 9). The foundation of the structure is stone masonry with cement mortar of 100 cm, which supports 25 cm of reinforced concrete. Above the footing is unstabilized reinforced rammed earth structure of 40 cm wall thickness. The rammed earth has a full gradation of sand and stone aggregates from 1mm to 25 mm thickness. Rammed earth is vertically reinforced with 12mm MS steel and horizontally with polypropolyne mesh. The top of the wall is reinforced with 25cm thick M20 concrete. The roof of the demonstration structure is built with DOT treated bamboo, with metal bracket joints. A 10 mm thick bamboo insulation lies beneath the roof, which is made of terracotta joints.

With the success of this structure, 20 more classrooms were built all across Kavre Region of Nepal. The walls were, however, modified with compressed earth blocks to save on the logistics.

Figure 9. Rammed earth building in Kathmandu University (*source*: author)

7 CONCLUSION

This project was our humble effort to appropriate natural materials into modern concept by respecting local cultural so that negative association related to the materials could be challenged. Technically, we were quite successful in achieving what we had set out for i.e. 1) achieve large span 2) mitigate moisture, snakes, rodents problem and 3) minimize need for constant maintenance. In terms of cultural acceptability, locals were very appreciative and inquisitive about the process but whether people would adopt the new techniques remains to be seen. Before the process becomes widespread, there are many things that have to be sorted out. For example, there needs to be a reliable supply of treated bamboo. A sufficient number of trained and skilled workers who can use these traditional materials in new context are needed. Awareness on the potential of these materials among architects, engineers and government agencies should be increased. Still much work needs to be done in order to convince people that these materials can solve lots of modern housing problems sustainably, economically and beautifully by maintaining cultural tradition.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Analysis of the Concept of Construction Biology in the Context of Electrification in Modern Architecture

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ABSTRACT

With rapid population growth, the need for housing has become unattainable and rapid building production techniques have been needed. Traditional building production technology has left its place to industrial production. With the development of technology, new building production techniques and new building materials have emerged.

Current building materials have accompanied their positive aspects and their negative aspects. In addition to their easy and fast production facilities, they are harmful to the structure and people because they also hold or produce static electricity. We have proven through scientific studies that the devices we use with static electricity in the buildings have been damaged. This static electricity has not only been found in devices but also in human body. Structural and human health problems have been studied through the concept of building biology. The damage of electrification has been determined by defining the concept of building biology.

As a result, when the electrical loads generated by the structures can be removed by the grounding method, the electrical loads in the structures can be grounded by using the mud brick materials which are made of earth. In this context, adobe material is examined to determine the damage of static electricity. The mudbrick constructions used from the past to the present day are examined in many contexts. In this study, the adobe material, studied in many fields, was examined in the context of electrification. With the development of technology and the improvements in building materials, adobe material has become a favorable building material in terms of ecology compared with traditional materials.

Key Words: Electrification, Adobe, Structure biology

1 INTRODUCTION

With the development of technology, there have been developments in material and building techniques that were used. Today, materials used in building production are generally metal, plastic and imitation materials. These developments have also come with their negative aspects, along with their positive aspects. Starting of radif production in building, production of quality production, forming easy to control structures can be listed as some positive aspects. Negative aspects can be listed as damages to people and buildings in the context of materials and techniques' structure biology used in the buildings. When the damage of these materials is examined in the context of electrification, the damage to the devices used in the structure is scientifically proven. This static electricity's damages not only to devices but also to human health have been detected.

Structural and human health problems have been studied through the concept of building biology. The damage of electrification has been determined and the concept of building biology has been defined. Static electricity is an unusable energy source that cannot be stored. The surplus of this energy damages the building and is harmful for people. Therefore, it should be kept away from constructions and human body.

There are two types of static electricity on the buildings. "Volumetric static electricity and surface static electricity. Volumetric static electricity occurs within the body of the material. If the surface is static electricity, it occurs on the outer surface of the material. Static electricity problems in the industry develop because of the surface static electricity. Static electricity occurs for three reasons. The first reason is the friction between the objects, the second reason is the separation of the objects, and the third reason is induction in the strong electric fields. Harmful effects of static electricity to human health are as follows: The accumulation of static electricity in the human body at an excessive level affects the nervous system by disturbing the normal electrical balance in the human body. Static electric wears out the muscles under the skin by causing the skin to wrinkle earlier. The risk of heart attack is also increasing in people who are exposed to excessive static electricity. Two methods are used to remove the static electricity. These are removing by water and grounding method. This study will focus on the grounding method.

2 PROBLEM STATEMENT AND HYPOTHESIS

The damages of static electricity in buildings were detected. It is aimed to remove this electricity from the structure by using the grounding method.

2.1 Purpose of the Research

With the development of technology and new research, there have been many innovations and changes in the area, from places we eat to the foods we eat. As in every area, these changes have positive and negative in the construction area as well. It is not possible and feasible to escape from development. Instead, one should learn how to live with technology. It is necessary to tolerate the negativities brought by the innovations.

The aim of this study is to solve the problem of electrification, which is formed directly or indirectly in structures, by integrating the grounding method. This method has been used for many years with integration to the modern architecture. The study also aims to examine the effects of soil and soil derived building materials on human health by describing the damage caused by electricity to the structure and man through the concept of building biology.

2.2 The Importance of Research

The adobe structures have been examined in many contexts. As a result of these studies, it has been proved that the adobe material is an ecological material. Studies try to raise awareness in construction production by examining the adobe structures in the context of electrification.

2.3 Method

In this study, first the problem is identified and purpose and scope of study are explained.
Literature review, determinations based on observations and depiction methods are used.

3 BUILDING BIOLOGY

The building can be defined as a facility built to meet specific needs through various materials and construction methods. According to this definition, the building covers all the facilities on the ground and underground. In other words, the building is a built-in building designed and produced to meet the requirements of its residents. The main purpose of the resident is to maintain his/her life in a healthy way whereas the main purpose of the building is to protect the person from the negativity in the external environment, thus, provide a safe and convenient environment, i.e. a healthy life (Korur, 2011).

The developments in the structure are linked to the needs of its residents. A resident has also biological and psychological needs. These needs have been examined in the concept of building biology.

The main purpose of the construction biology is to reach a healthy structure that prevents health problems, which may arise from the construction. A "Healthy structure" is a structure that is designed, produced, used and supervised to avoid any negative effect on resident's health by using the highest level of construction biology science. The main function of a healthy building is to offer the environment that meets the basic necessity of maintaining a healthy life. The healthy structure also allows the resident to have comfortable and efficient living and working conditions (Sarp, 2007).

A healthy person hinges upon to a healthy structure, a healthy structure hinges upon a healthy environment, and a healthy environment leads to healthy people. Structures are affected by the negative effects in external and internal environments. These effects may result in psychological and biological health problems for people. As to the concept of building biology, it examines the health relationship between residents and building.

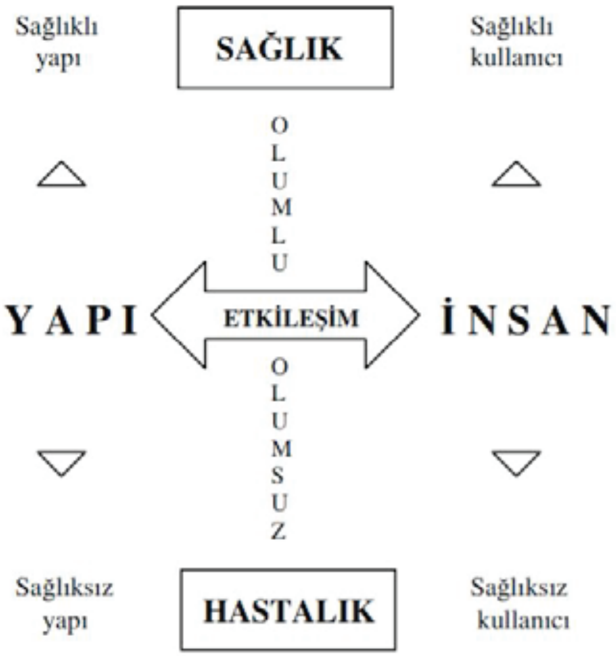


Figure 1. Health interaction between structure and human (Sarp, 2007)

People are exposed to natural or artificial electricity in their surroundings during their lifetime. Due to this electricity, an electric field is created within the structure. If this electricity generated in the buildings is not stable and is moving, it is referred to as a magnetic field. Magnetic field and electric field have different effects on human health.

While the magnetic field harms internal organs by affecting them, electrical field is harmful to the neural system. As a result of a surge of static electricity, psychological and neurological diseases occur. Likewise, the risk of heart attack increases in people, who are excessively exposed to this energy. It is evident that static electricity causes skin problems as well.

Figure 2. Building biology (url-1, 2018)

3.1 Importance of Soil for People's Health

Soil consists of various stages of decomposition of rocks and organic matters. Physical, chemical and biological events play a major role in this composition. Not only does it contain millions of living organisms that provide the continuity of the ecosystem, but also is the main source of resources that many living things depend on. The life of all living things depends directly or indirectly on the earth. Besides, the soil is a dynamic structure included in cultural practices (Güngör, 2016).

We encounter earthen materials in every aspect of our life. The soil we encounter from the birth to the death was examined with different rituals. The soil is used in many platforms from the treatment of diseases to the building materials.

When we look at the widespread traditions of the earth, we can see that humans have praised it as a force that attaches certain holiness to the earth and treats it with respect and as power which is living, sustaining, nurturing, cleansing and healing. For example, there are some beliefs coming from the mythical times in using soil for healing wounds, believing that the soil absorbs negative energy in human body, pouring countryside soil to the tombs of people who died abroad, utilizing mud for healing plants and trees. The survival of these practices is a result of the belief in the power and sanctity of the earth in every period of history. The soil is called "Mother Earth" and is one of the most important natural sources, symbolizing fertility, abundance and sanctity.

Soil is a dynamic ecosystem providing fresh air, water, minerals and various nutrients, sheltering them. It has a self-renewal ability, it is a formation of all the things it shelters, both living and non-living, creating an interaction among them. Simply, the land is actually hosting millions of living organisms (url-2, 2018).

Even if the soil on the earth looks very wide, it is made up of a relatively thin layer, and when its square measure is taken into consideration, it is very limited. In this respect, the land is a treasure full of life that we need to pay attention to. It is a purification system in terms of its proximity to earth's organisms and earth's core.

From the Neolithic Period, human beings have built their dwellings from easily available abd cheap materials in their locations (Güngör, 2016).

Walking barefoot on soil is recommended for nervous and psychological diseases as electricity is absorbed by the soil. Copper wire is used to prevent fault currents on the buildings. This wire leakage current is used in the grounding, but not in the grounding of the static electricity. A different system should be used to remove static electricity from the buildings.

4 STATIC ELECTRICITY IN BUILDINGS

Static electricity (or stagnant electricity) refers to the steady state of electricity and is the electrical imbalance in the surface of the material that interacts with the surrounding materials. This imbalance occurs when an atom or molecule loses or gains electrons. Normally, the number of protons and electrons in an atom is equal to each other, but electrons can easily pass from one atom to another (Toktaş, 2018).

Static electricity occurs automatically because of two materials' coming into contact with two conductive or insulating materials and then separate or friction them, which are different or identical to each other in nature. Electron transfer occurs across the contact surface between the materials in contact with each other. The electrical characteristic of this boundary layer is different from the characteristics of the materials in contact with each other. If these two substances are separated from each other, the boundary layer is lifted from the center, resulting in the electron excess (negative charge) in one of them, and the electron deficiency (positive charge) in the other. As a result, these two separate loads attract each other and they want to discharge by sparking through a layer of insulating material, such as air, to compensate for load differences. This arc formation can be very dangerous in some environments (Toktaş, 2018).

Electro Static Discharge undoubtedly shows up in every field where static electricity exists. Electrostatics analyzes a wide range of physical phenomena from the function of our heart to lightning and the interactions of charges within the atom. Lightning is the best example of static electricity. As known, when the + and - loaded clouds approach each other, the greatest static electricity discharge of nature comes into play. In studies conducted in Japan, the average lightning energy that can be measured is around 15-20 mega-volts (MV). The tingling of our feet is because of the static load as we walk on the carpet with barefoot. Furthermore, frequent contact with the materials in our workplace causes pulling out the load on the materials.

Static electricity holds the human body in a certain balance. The static electricity in the human body is high and the current is low. Depending on the severity of the current in the body, human health can be endangered. For example, a heart attack due to high flow through the heart indicates that this factor should be considered carefully.

There are methods that can be considered to be effective for ensuring the electrical balance in the human body. These are possible with water and soil. We can drain excess static electricity by touching a bare limb of us (hand or foot) to the ground (url-3, 2018).

4.1 Distress of Static Electricity

* As a result of the accumulation of static electric charges on human skin, it is asserted that in the residents - especially in women - skin diseases such as acne (acne) and seborrheic dermatitis occur.

* Static electricity damages communications in buildings, power lines and electrical systems.

* Static electricity is the problem of many industrial companies working with insulating materials such as plastic sheets, paper carbon and textiles. Due to electrostatic repulsion or pulling, the material either sticks to the machine or each other. This leads to serious quality problems.

* Static electricity accumulation at extreme levels in the human body affects the nervous system by disrupting the normal electrical balance in the human body. It plays a leading role in the formation of stress and can cause psychological problems.

* Contacting with flammable or explosive liquids and gases may cause a disaster.

* Electrical shocks occur in case of contact with a material.

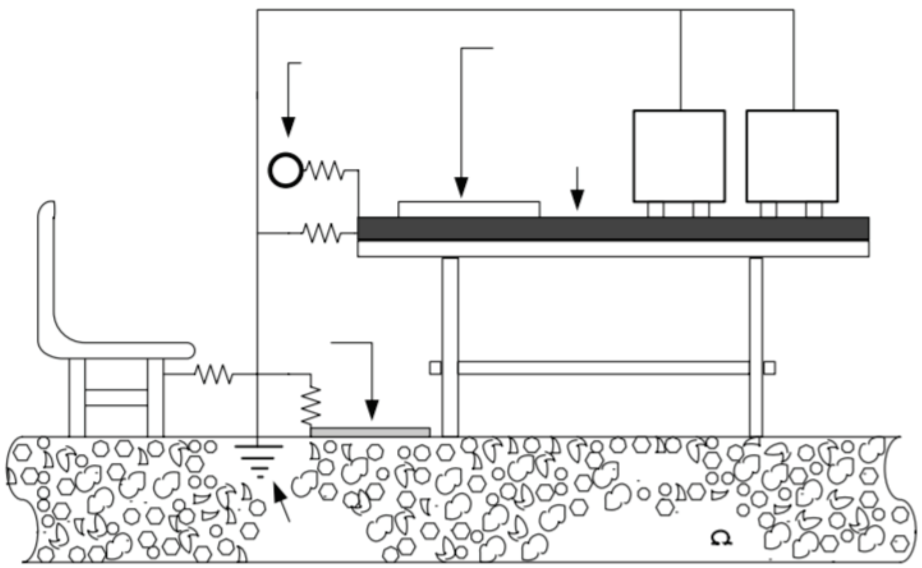
4.2 Static Electricity and Grounding

Man is a 'bioelectric' entity. The distribution of nutrients, heart beats, and the most basic bodily functions that enable communication between the brain and the body work thanks to the electrical flow through the heart, immune system, brain, muscle, and central nervous system.

The human body is 'conductive' and the free radicals that cause disease in our body are positively charged. But, the earth is negatively charged. By combining the two, we will balance our internal electrical systems. When this balance is disturbed, the static equilibrium is distorted and needs to be grounded. It is recommended that people who are exposed to electricity should step on the soil.

The inductive parts, zero conductors and their connected parts in power plants are referred to as "grounding".. The grounding operation is necessary for the safety of the machines as well as the safety of life.

Grounding is generally carried out for three purposes: protection, operation and grounding itself. With this way, the operation facility and people are protected against hazardous voltage levels and plant operation.



5 FROM SOIL TO ADOBE

Granular soil material, smaller than 0.002 mm, is called clay. Two types of materials are produced from the soil.

Pişirilmeden üretilen

- Kerpiç

Pişirilerek üretilen

- Tuğla
- Kiremit
- Seramik
- Künk
- cam

The building material obtained by molding after forming and shaping the sludge with sandy mold formed by kneading with water is called mud brick.

Many advantages of mud brick structures used from the past to the present have been proven by scientific studies. Apart from them, mud brick structures also offer all the benefits provided by soil materials. When it comes to human health, it is proved that adobe structures are ecological and healthy materials.

6 RESULTS AND SUGGESTIONS

In this study, in conclusion, the benefits of adobe, which consists of soil, have been explained by analyzing the soil material. It is known that in the context of electrification the soil removes static electricity from the body. It is thought that the adobe produced from the soil behaves like earth and is healthier than the other building materials. When adobe structures are subject to static electricity, they can act like soil and move static electricity away from the human body.

Because of these reasons stated above,
*Using as plaster or flooring material in interior spaces,
*Use as precast material on facades
*Production of adobe admission system on the facades: these facilities allow us to build more healthy structures in the context of electricity.
When these systems are designed, care should be taken to ensure that the adobe material is connected to the earth.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

An Overview of the Design of Low-cost and Adobe Housing for Afghan Refugees, Ardakan, Iran


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ABSTRACT

Afghan refugees' housing in some of Iranian cities due to dense population and financial disabilities is suffering some problems such as lack of appropriate high quality living space. To solve this problem and minimize costs, vernacular architecture can be a useful assistance. One of these inhabiting areas is located in Ardakan, a city in Yazd province. During a social and architectural research, it was comprehended that to construct an inexpensive house, earthen architecture can be utilized. By considering the refugees' needs, functions were distinguished. Furthermore, we probed soils of region and methods to apply adobe. Finally, some patterns were designed based on inhabitants' requirements and vision of housing development.

Key Words: Afghan refugees, Earthen architecture, Adobe

1 INTRODUCTION

The provision of the shelter is one of the main concerns of refugees in the entire world. High population of the Afghan refugees has been settled in neighbor countries like Iran and Pakistan. Due to three decades of socioeconomic and political instability in Afghanistan, it is not possible for most of the refuges to go back to their country. However, the refugees are suffering due to the unsuitable circumstances of the settlement and economical problems. The emergency earthen shelters they have built with their own traditional methods also are not acceptable due to the lack of technical knowledge and low quality materials while the earthen architecture technique that has been used throughout the long history can be a smart solution to achieve an affordable and sustainable housing for the refugees. It highlights when on-site materials and assistance of the refugees as labour are included.

Sinisterra [1] studied emergency habitats for Colombian refugees. He believes that prompting an environment for the sustainable development as habitat for the refugees, a balanced combination of building technology, material innovation and culture should be created. Azadzoi [2] states that the construction on mud-huts, as the most practical and reliable shelter in the situation of the Afghan refugees (in Pakistan) which is done by the refugees in their traditional ways, can be improved by the provision of building materials by Government. Silva, Oliveira [3] carried out an experimental investigation on the rammed earth construction with granitic residual soils in Portugal. They found that the rammed earth construction was only feasible if these soils went through a stabilising process while the alkaline activation of fly ash as an environmentally friendly stabilization technique improved the performance of the rammed earth. Despite many studies undertaken on earthen construction, a limited number of studies have focused on the stability of the adobe construction using mechanical techniques.

This study intends to improve the strength of earthen materials by applying a combination of traditional and mechanical techniques to achieve the affordable houses for the refugees. In this regard, a thesis research was undertaken with the aim of proposing a model of the affordable house for the Afghan refugees in Mehmanshahr[1] of Ardakan as one of the biggest transitional settlements in Iran. Different activities were carried out such as field survey, including questionnaire and interview, to identify the refugees' preferences, experimental study to examine the resistance of local earth materials and finally, the economic assessment for constructing the affordable house. The present study is a part of thesis study with the objective of increasing stability and durability of earth structure. This study reports the experimental test on stabilizing the adobe construction, using traditional and mechanical techniques, to be used for constructing affordable house for the Afghan refugees in Ardakan.

2 STABILIZED EARTH CONSTRUCTION AS A METHOD FOR AFFORDABLE HOUSE

Earthen architecture as the oldest construction method in civilizations has been forgotten for decades. Recent concerns about natural resource depletion and environmental impacts caused a new reversion to the earth architecture for the new construction. However, the earthen materials should be reinforced to meet the basic strength parameters appropriate to the local circumstances. The central region of Iran with valuable historical earthen architecture is a great proof of the potential of the earthen architecture for the new construction. Using vernacular technologies and raw local materials in construction can be a great movement to achieve the affordable houses in the earliest time [4]. In this regard, Ardakan, located in the central Iran, hosting 3500 Afghan refugees, was selected as a case study (Fig 1). This area with a great traditional earthen architecture, local material resources and presence of refugees as community labour has a considerable potential [5].

Figure 1. A view of alley in Afghan settlement, Mehmanshahr, Ardakan.

3 SETTING UP THE EXPERIMENTAL STUDY

In order to improve the mechanical specification of adobe, this study focuses on investigating the effect of mechanical stabilization on the compression resistance of the adobe as one of the most important factors in sustaining the earthen structures. Therefore, based on the experience of local builders in Ardakan, Yazd, and taking an advantage of modern structural knowledge, six earthen mines in Ardakan (which have been supplying the soil and for earthen structure for long periods of time and are confirmed by traditional professional builders) were selected and the samples of the

[1] The name chosen for the Afghans refugees in Ardakan, It means the place where Afghans people live temporarily and they are like a guest.

adobe were made by two methods, i.e. traditional (Unstabilized Adobe) method and with mechanical compression (Stabilized Adobe). Finally, their compression resistance was examined and analyzed accordingly. All of the experimental processes were carried out in the cultural heritage lab in Ardakan and soil mechanic laboratory of 'Azmapooyan' in Ardakan [5].

3.1. The process of preparing the UA and SA samples

In this study, various tests on the samples were carried out, including grading tests with Sieving under running water, sedimentation, soil moisture content, soil density and compressive strength. In order to guarantee the validity of the method and collecting tools, the authors took consultancy of experts (from National Superior Architecture School, CRATerre/Grenoble/ France, Historic Buildings Conservation, Research Center for Cultural Heritage of Ardakan Historical Area and Technical and Mechanical Laboratory of Soil, Azampooyan-Ardakan). Therefore, all the processes, including earthen mines selection, tests and supporting activities were under the supervision of experts. Furthermore, to prevent the probable errors in compressive strength test, three samples were examined. Based on the preliminary results, a sample with the worst result was omitted and the average results of two other samples were considered for the analysis.

The UA and SA samples with size of 5*5*5 cm^3 were built with the soil of different Ardakan mines (Fig. 2). In traditional method (UA), water (with 28% volume ratio) was added to the soil and mud was allowed to rest for 5 minutes, then the mixture was slightly shaken for 15 minutes. For a better preparation, the mixture was packed with a plastic bag. So, before starting, the moulds were soaked with water, then mud was moulded and pressed manually to ensure that it completely filled the mould spaces. Finally, the mould was flattened manually, by applying partial water. This method is called 'Khesht Abmal' in traditional adobe production in Iran.

According to the literature, applying mechanical stabilization technique has a significant effect on increasing the strength of rammed earth as suitable mechanical resistance of rammed earth is obtained by dynamic force [6]. Therefore, to produce the SA samples, a new mechanical stabilization technique is established which is a combination of global (compressed earth block) and Iranian (adobe) traditional methods. Therefore, for producing the SA samples, at first, soil and water are strongly mixed together manually to make a homogeneous contexture. Then, to ensure that the air is not trapped in the mud, the mixture is divided to three equal amounts in the mould in three stages. A particular tool with flattened section is used to compact the material carefully that occurred through 25 strikes on the adobe. Then, the prepared SA samples are left in the external environment to be air dried [5].

Figure 2. The compression samples.

The experiment was conducted in the autumn to control the environmental conditions. The samples were kept in the laboratory with at temperatures ranging between 20 and 25 °C and the relative humidity of 20% for roughly 30 days of air drying time. After that, to ensure that the drying process is completed, the samples were put to an oven with 60 °C heating and weighted periodically every 24 hours until they reached to the fixed and constant weight [5].

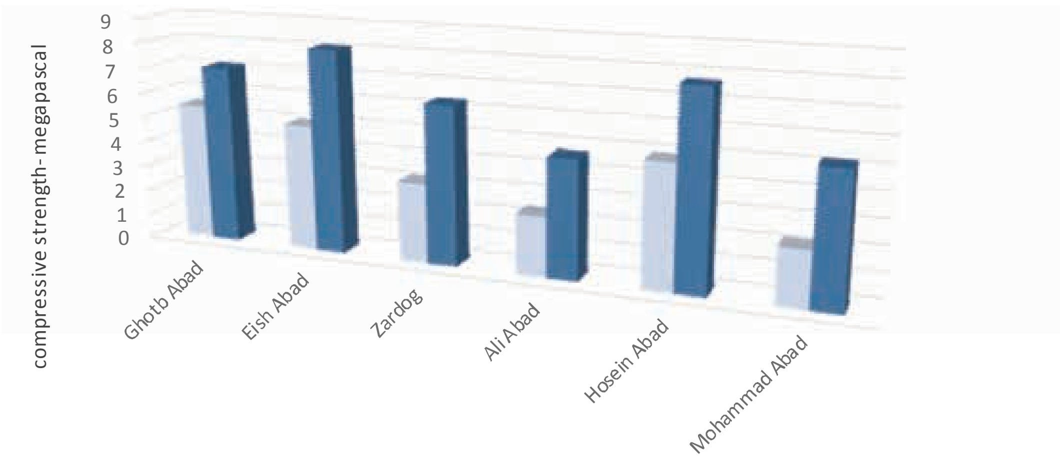
3.2. Comparison of the resistance of UA and SA

Before starting the test, the quality of samples was controlled carefully to ensure all of them were completely dried and had a uniform texture without any visible crack. Then, samples were put in the device one by one to be pressed by compression power via mechanical jack (with 5 tones capacity and accuracy of 1 kg/cm^2). The maximum compression speed of machine (120 kg/cm^2) was set to conduct a constant press on the samples until the breaking moment (Fig 3.). The maximum read pressure before breaking was noted and the average compression resistance of three samples was calculated based on the following equation:

$$\text{Compressive strength (kg/cm}^2\text{)} = \frac{\textit{Maximum compaction force (kg)}}{\textit{The surface area on which the forces is applied (cm}^2\textit{)}}$$

Figure 3. Breaking stage of the samples.

The preliminary test results of compression resistance of samples are illustrated in Fig 4. As shown in Fig 4., the resistance of UA samples ranged from 2 to 5 mpa, which are acceptable especially when their soils are supplied from 'Ghotb Abad', 'Eish Abad' and 'Hossein Abad' mines. However, the compression resistance of mechanical SA is 1.8 times higher than manual UA. It shows the significance of well compacting for improving the mechanical specifications of adobe.



	Ghotb Abad	Eish Abad	Zardog	Ali Abad	Hosein Abad	Mohammad Abad
Traditional Adobe	5.51	5.04	3.18	2.41	4.9	2.23
Mechanical Stabilized Adobe	7.113	8.111	6.343	4.682	7.744	5.237

Figure 4. Comparison of the compression resistance of UA and SA.

4. CONCLUSION

Ardakan, as one of important transitional settlement for Afghan refugees in the central Iran, was selected as the site and an experimental study on resistance of adobe was carried out in April 2016 to identify the most appropriate material for constructing sustainable and affordable houses. In this regard, two types of adobe, normal and stabilized, samples were produced for each local mine in Ardakan, using the traditional (UA) and mechanical (SA) methods and their compression resistance was examined. The results show that both techniques improve the stability and durability of local earthen material with the lowest environmental impact. However, stabilizing the adobe is more efficient in increasing earth compression resistance, particularly when the earth is supplied from the particular local mines such as 'Ghotb Abad', 'Eish Abad' and 'Hosein Abad'.

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6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Land Use and Recognition of Construction Techniques Based on Land Use and Geographical Climatic Conditions


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ABSTRACT

Technology controls our lives to a great extent and thus, is reflected on architecture. It leads us to two results: First, gradually we stay away from the architectural identity in some countries such as Egypt and secondly, prices of building materials and housing prices increase significantly. On the other hand, environment is provided to us a natural material to use. As Hassan Fathy said, "Allah (God) has created in every environment materials for what resists its problems, the intelligent architect who can deal with those materials in a right way". The aim of this research is to use one of the most important materials in Egypt, the Palm Frond, instead of rice straw. The Research Methodology is the knowledge of this architectural style, studying the climatic and geographical conditions for making mud brick (Adobe) especially in Egypt. It also teaches about Hassan Fathi's philosophy and his experience in this field and studies the mud brick content. According to this knowledge, we used Palm fronds. It was chemically analyzed to know the percentage of cellulose, which is important for fermentation process and also analyzed samples of Delta soil from Egypt. After mixing them all together, we got a good result, i.e. the palm frond increased the brick strength.

Key Words: Architecture of poor, Back to earth, Date palm content, Adobe brick fermentation

1 INTRODUCTION

Adobe structures are extremely durable and account for some 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. Due to the low water level of the Nile recently and the low rate of rice planting, we thought about replacing the palm frond with rice straw for making Adobe bricks and testing the same process of rice straw. However, with palm frond, in the fermentation process, brick gains strength. The components of palm frond were also analyzed.

The percentage of cellulose in palm fronds was higher than the rice; therefore, the final result obtained from testing the strength of the bricks made of palm fronds was good and almost the same with rice straw, which meant we could use palm frond as a fabric in adobe.

1.1 Geographical Distribution

Around the world, we will find earthen architecture mainly in the countries that are hot and dry and have rare rains and desert weather, as shown by UNESCO statistics below. The map shows the most popular places across the world with earthen architecture.

Figure 1. The map of global earthen architecture (url-1)

Therefore, mud buildings are located around the Nile Valley, especially in Upper Egypt, Luxor, Aswan and Nubia, and in the delta region, where the soil is fertile with clay soil. The Adobe buildings are also located in the oases due to the dry atmosphere.

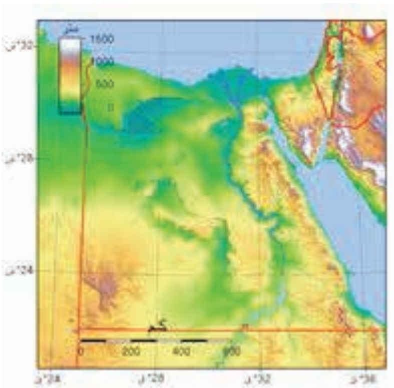

Figure 2. Spread of mud brick construction on the Nile Valley, Delta and oases
Figure 3. In the North Delta, quartz sand (url-2)

Egypt is known for its hot and desert weather; it is divided into three main regions according to the course of the Nile: the Upper and Middle Egypt, Delta region and Mediterranean coasts. It is known that Egypt is an agricultural country, and agricultural life has led to the settlement of the Egyptian man around the Nile Valley and the Delta region.

Among the soil components in the North Delta, quartz sand, containing calcium carbonate ($CaCo3$), is readily available by 4-10%. And the proportion of clay is 5-10% and the percentage of salts is 0.1% based on our analysis of a sample of delta soil, from which we got these results.

Table 1. As a result of analysis of samples of Delta soil in Egypt (authors)

PH	EC	Hco3	Cl	Na	K	Ca	Mg
8.15	1062	143	107	100	11	132	49
N	P	Co3					
5	12	-					

These results show that it is a fertile soil for mud brick production.

1.2 The Historical Background

The word "adobe /əˈdoʊbiː/" has existed for around 4,000 years, with relatively little change in either pronunciation or meaning. The word can be traced from the Middle Egyptian (c. 2000 BC). The word dj-b-t means mud [i.e., sun-dried] brick. As the Middle Egyptian evolved into Late Egyptian, Demotic, and finally Coptic (c. 600 BC), the dj-b-t became tobe "[mud] brick.

Adobe structures are extremely durable, and account for some of the oldest existing buildings in the world. Compared to wooden buildings, adobe buildings offer significant advantages due to their greater thermal mass in hot climates.

Homes of sun-dried bricks were built in Egypt in 3800 B.C. Mud from the bottom of the Nile River was mixed with straw, shaped and dried in the sun until it became as hard and strong as a rock. Adobe homes were the most efficient structures for the hot and dry Egyptian climate. Loamy Nile mud, mixed with straw, resulted in surprisingly strong bricks. A sunbaked mud brick without straw had strength less than 6 kp/cm²; the addition of straw resulted in a brick that was three times stronger (about 20 kp/cm²). As long as groundwater did not dissolve their foundations and floods did not reach them, well tended mud brick walls could stand for generations.

In every location during a building project, brick moulds of equal size were used, which ranged between 30 cm – 40 cm in length and 15 cm – 20 cm in width. The brick size was thus standardized, e.g. 30 by 15 by 7.5 cm during the Middle Kingdom. At Karnak the bricks measured 40 by 20 by 15, at the Late Period Naukratis, they were about the same size. These dimensions suggest that they were generally laid in cross bond (English bond). But other bonding patterns such as running bond, Flemish bond, and stack bond were apparently also used at times.

A modern mud brick maker can produce 1000 - 2000 bricks a day. One may assume that ancient workers were equally efficient. Five days' work should, therefore, have sufficed to make about 5000 bricks needed for a worker's one-storey house of 60 to 80 m² with 40 cm thick walls.

One of the earliest tombs to be opened at Nebesheh was built of red baked bricks and dates back to Egypt's Nineteenth Dynasty.

Figure 4. Ancient mural illustrates the ancient Egyptians method of mixing and building mud (url-3)
Figure 5. Adrère amellal hotel "sewa oasis, Egypt" (url-4)

Figure 6. Form of brick forming molds in the past and the present (url-5).

2 HASSAN FATHY AND ARCHITECTURE OF POOR

His gouaches alone could perfectly describe his work, but we would like nonetheless to hint at the general principles as guidelines to understand them. Fathy believed in the importance of human values, in the use of technology suitable to time and place [that is climate and local economies], in the need for socially-oriented cooperative construction techniques. He assigned an essential role to tradition and hence, to the re-establishment of a national cultural pride, a goal to attain by means of the act of building he was intellectually stimulated by the art of the Pharaonic period and was directly influenced by vernacular architecture. He studied the buildings of the old city of Cairo and Nubia in order to create a national architectural language based on the employment of traditional elements and building techniques.

Both for the value he attributed to manual work and for economical and ideological reasons, he resorts, for the realization of his projects, to traditional techniques that extremely reduce the use of machinery and exploit what is available in a cheap way: earth, straw, man's labour, stones. The brick is, in fact, the only material used in his works. The supporting walls are made either of sun dried bricks, made of mud and reinforced with straw (Adobe), or of local stones or fired bricks.

Figure 7. Some of his work at new Gourna village. Luxor, Egypt (authors)

Figure 8. Dar Alsalam Project, New Mexico, USA 1981. The Vaults construction system (url-6).

2.1 Thermal properties of Adobe buildings

Adobe brick is considered to be one of the worst conductors of heat; this results from the significant decrease in its natural conductivity.

We found the following heat conduction results:
0.22 ca/min/cm2 for Thickness of bricks made of 20% Fine sand
0.32 ca/min/cm2 for Thickness of bricks made of 80% Coarse sand

The mud building is characterized by thermal insulation that loses heat at night and absorbs it during the day. The amount of heat lost outside the building is greater than the amount of heat that is radiated to inside the building.

So, the building gets cold during the day time and warm at night, which creates a natural air conditioning.

In Egypt, we resort to other treatments such as the construction of domes and vaults.

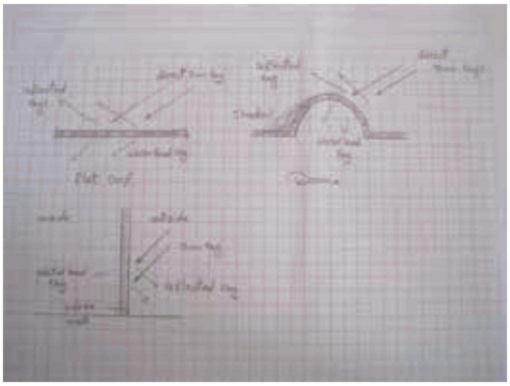

Figure 9. Thermal properties and the reflected and absorbed part of solar rays (Authors, sketch)

2.2 Components of Adobe bricks

In Egypt:

Soil + sand + straw + water = the mixture
3 : 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 10. Mixing process
Figure 11. Drying process for adobe bricks

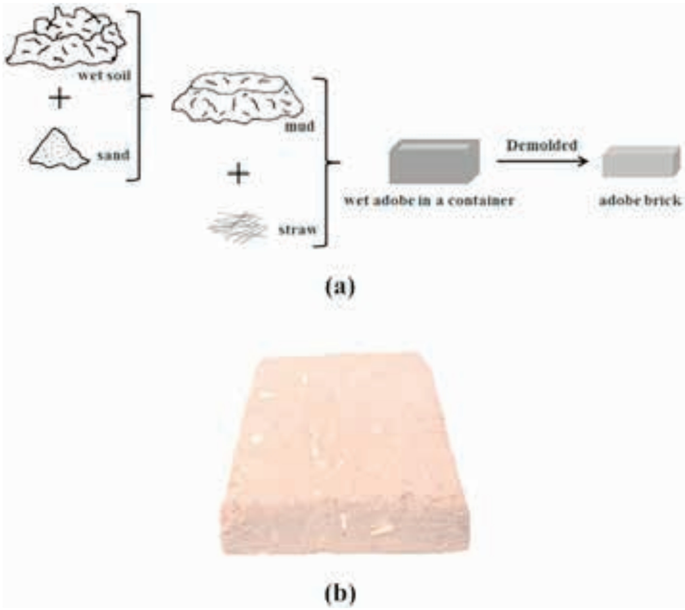

Figure 12. Steps of making the Adobe brick (authors)

2.3 The Straw: Rice and Palm fronds

Palm trees have been in existence since the dawn of human civilization, the earliest fossilized palms on record dating back nearly 80 million years to the Cretaceous period. They played an integral role as a resource that could be utilized not only for the fruits some of the trees provided but for a variety of different purposes. They were used as thatching to build roofs and walls for houses, the strong mid ribs used to make crates, fences, weapons and furniture and the smaller leaves used as a material for fashioning clothing, baskets, rope and cooking tools. Today, palm trees can be found growing around the world in a variety of different climates. The majority of species, however, thrives and can be found growing in warm tropical and sub-tropical climates.

Egypt is one of the famous and largest producers of palm trees, containing about 11.5 million palm trees. Each Palm tree produces about 12 palm fronds per year. And unfortunately, we are using a small amount of those palm fronds in some hand crafts and we let the largest amount go to waste, costing millions of Egyptian pounds every ear.

Recently, we have faced a real problem in rice planting and low water level in the River Nile, so we found that the palm frond will be a good replacement for rice straw.

We analyzed the palm frond to see the components as well as the Cellulose and Hemisylose, the two important items in fermentation process, to get a stronger brick.

3 RESULTS

All chemical and physical findings were obtained by using 3 replicates (samples), **received from the Engineer Rasha El-Borgi**, without any responsibility upon Faculty of Agriculture or Agriclinic Unit. Chemical and physical findings for date palm leaf samples are presented as follows:

Table 2. Chemical and physical findings for date palm leaves

Sample	%							
			Dissolving in					
	Moisture content	Extracted component	Cold water	Hot water	Cellulose	Hemicellulose	Lignin	Ash
1	7.82	28.86	18.13	23.49	38.72	32.94	28.34	10.82
2	7.80	30.30	19.26	24.55	39.96	34.60	25.44	10.70
3	7.38	27.61	18.85	23.96	35.47	35.93	28.60	10.80
Mean	7.67	28.92	18.75	24.00	38.05	34.49	27.46	10.77
SD	0.25	1.35	0.57	0.53	2.32	1.50	1.75	0.06

From the above mentioned results, the moisture content (%) of date palm leaves samples were measured according to American Standard Measurements (ASTM) in an oven on a dry-base for all chemical components, except cellulose and hemicellulose, which were determined according to Nikitin (1960) and Rosmarin and Simionescu (1973), respectively. All chemical components were analyzed as samples that passed from 40 mesh sieves but could not pass from 60 mesh sieves. Cellulose, hemicellulose and lignin contents were determined as samples free from the extracted component.

**mesh No= The number of pores per one inch length

According to rice straw components, we found that the content of Cellulose and Hemisylose, the two important items in fermentation process, is higher than rice straw.

In rice straw, we found:

Cellulose: 39.73% (+/- 1.01)
Hemicellulose: 25.77% (+/- 0.43)
Lignin: 13.43% (+/- 0.81)
Ash: 16.66% (+/- 0.33)

Figure 13-14-15. In the first and second Figures, the length of palm frond's fiber is shown and in the third figure, the cellulose percentage in palm frond (lab work, authors) is shown.

The Adobe brick strength testing


Figure 16. A sample made of 2(mud+sand) to 1 palm frond mixed by water (authors).
Figure 17. An original old sample from Qourna village Luxor, Egypt (authors).


Figure 18. Testing the brick durability and strength (authors).
Figure 19. The cracking level (authors).


Figure 20. The brick made of palm frond after reaching the max. pressure (authors).
Figure 21. The old brick made of rice straw after reaching the max. pressure (authors).

The same proportions of soil were mixed with palm fronds and water. Samples were left for fermentation process for different hours, ranging between 12, 17 and 24 hours. The shrinkage ratio in the bricks was not significant; it was between 0.1 and 0.3 cm in length and width.

Table 3. The samples strength testing results (authors)

Sample	Dimension (cm)	Weight/ Kg	Cracking Load
1	25* 11.5* 6	2.1	17/40
2	26* 12.2* 7.1	2.41	22/42
3	25.4* 11.9* 6.8	2.69	20/65

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Effects of Developing Technology on Earth Shelter's Architectural Design


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ABSTRACT

The use of earth shelters by human beings that started with the use of caves in the mountains and hills is now being reconstructed with the human efforts for returning to naturalness and nature, which seems to be an option of green architecture thanks to the effects of technological developments.

Thanks to the developments in nanotechnology, the development of steel structure systems, glass facade systems and advanced lighting solutions, smart facades and smart textiles, which can be integrated into any formal and fictional approach in earth shelter architecture design, earth shelter spaces can serve as functional, aesthetic, robust, sustainable, bioclimatic, and energy efficient spaces. These spaces can offer a comfortable space experience where people are associated with soil, water and their natural habitat. With the evolving technologies for intelligent buildings, energy efficient buildings, sustainable and ecological approaches (green buildings, passive spaces, awareness of recycling resources, certification systems like LEED, BREEM), nanotechnology materials, smart textiles, smart skin applications and increasing interdisciplinary studies, it is thought that the earth shelter's space experience will be increasingly attractive for space users thanks to increasing simultaneous technological feedbacks. The contribution of all these technologies to the underground spatial quality and the urban visual quality and quality of life thanks to the simultaneous development of virtual space experiences and virtual reality systems will be evaluated and examined in this paper.

In this context, Turkcell R&D Complex and some other buildings will be considered as samples and thanks to biomimicry, contributions of ancient civilizations and acquisition of the architectural collective information transferred from the past related to the earth shelter architecture will be examined.

Technological developments have been examined under subheadings such as the effects on space configuration in earth shelter architecture, roof and facade (building skin) design of earth shelters, space comfort, texture, color, material related effects and user oriented perceptual and awareness effects on earth shelter spaces.

Designing the earth shelters with these acquisitions from the past, along with contributions of simultaneous development process of technology and transferring these designs to next generations are important steps for space creators. It is the architect's primary responsibility to be able to meet the changing demands of the changing world (multifunctionalism, lightness, resilience) by providing simultaneous architectural solutions thanks to technological developments with the awareness that the building and the space are living and growing organisms.

Key Words: Sustainable Design, Earth shelters, Architectural Design, Developing Technologies, Green Architecture

1 INTRODUCTION

Earth-sheltered architecture, which is the ecological architectural solution of our era, is an architectural approach that is directly or indirectly affected by any kind of technological development, basically inspired by nature with biomimicry and more disciplines.. Developed countries determine their priority areas and are increasingly concentrating on this subject. All the prejudices about earth-sheltered architecture are clear when it is supported by innovative approaches. It is the architect's primary responsibility to be able to meet the changing demands of the changing world (multifunctionalism, lightness, resilience) by providing simultaneous architectural solutions thanks to technological developments with the awareness that the building and the space are living and growing organisms. This study focused on how earth shelters were positively affected from the developments in technology according to today's architectural design criteria.

1.1 Objective of the Study

It is aimed to investigate the effects of technological developments on earth-sheltered space design, space comfort and space perception today. It is aimed that the earth-sheltered spaces, which is a solution proposal against the climate change, are designed and widely used with technology and innovation support and contribute to urban values and high quality environment. Awareness raising and interdisciplinary studies are expected to increase in this regard.

1.2 Scope and Methodology

Within the scope of the study, the effects of developing technologies on the design of earth-sheltered spaces will be examined. Earth-sheltered structures were excluded from the study. The effects of the developing technology on the earth-sheltered spaces of the research will be examined in various subheadings:

- Effects on space configuration and space volume,
-Texture, color, material-related effects,
- Effects on Facade Design,
-The effects on space comfort,
-User-focused, perceptual effects,

As a study method, literature review was conducted first. Both books and web resources were searched with the anticipation that the technologies affecting the design of the space could also affect earth-sheltered spaces to a greater extent. In addition, recent publications and examples in the world are examined and the interactions and effects of earth-sheltered space design with technology are dealt with.

2 EARTH-SHELTERED ARCHITECTURE

Having been used since the early times of humanity, earth-sheltered spaces were simply the utilization of existing closed space for sheltering derived from obligation because of environmental conditions in the past. Used for ages and concealing property known by all livings, earth-sheltered spaces have become complex spaces which meet different needs, designed for different functions with space organizations and planned by multi disciplines partnership today. In this transformation process, earth shelters were built for different reasons according to region in which they were located. In time, the reasons leading people to utilize earth shelters varied and by the time cities have enlarged, the utilization of earth shelters has pervaded. (İncesakal, 2011)

Today, a new environmental awareness has emerged and criteria such as energy efficiency, ecology, sustainability, compatibility with historical environment and urban identity are included in today's architectural design criteria. (İncesakal, 2011)

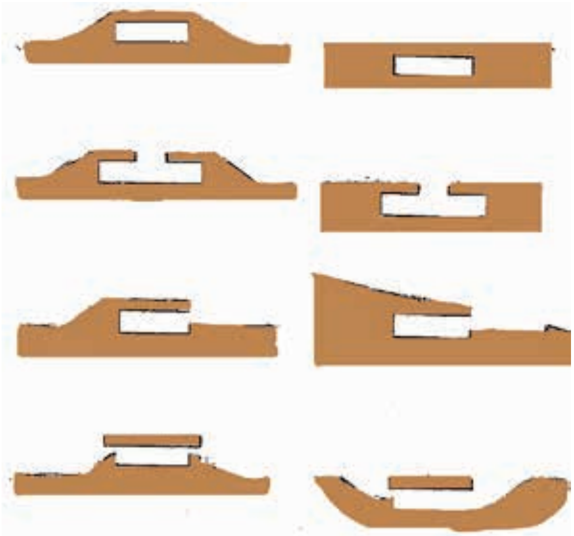

Figure 1. Left, earth sheltered building sections (on ground level);
Right, earth covered building sections (Under ground level) (Labs, 1975)

3 EFFECTS OF DEVELOPING TECHNOLOGY ON EARTH SHELTERED SPACE

3.1 Effects of Developing Technology on Earth Sheltered Space Configuration, Space Volume

Developing technologies have been a determinative factor in the design and form of earth-sheltered space. The effects of developing technologies on the form of earth-sheltered space are:

- Passing wider openings with steel structure system,
- Passing wider openings with advanced reinforced concrete flooring systems,
- Providing the possibility of designing higher and wider earth-sheltered spaces under the ground with cased drilled systems,
- Being able to obtain more robust structured spaces with round shaped designs in the ground, providing round shape capability of cased drilled systems, emergence of organic architecture trend,
- Works on the impact of round spaces on the user,
- Giving inspiration to the designer of biomimicry science,
- Reflection of the concept of "cyborg space (intelligent space)" to earth-sheltered architecture

Figure 2. Hobbitowa in Poland (URL [1])
An earth sheltered building designed and constructed with conventional building system

Figure 3. An earth sheltered building designed and constructed with the support of developing technologies (Christine Walsh, 2017)

According to a company based in Romania, it is also possible to build transparent domes on top of a stone wall, which is useful for gaining more usable height. They do require a foundation and cannot be moved easily once installed. Houses can withstand earthquakes up to 8.5 on the Richter scale and winds blowing up to 198 mph (320 km/h). The basic version must be hooked up to the grid, but they offer a variety of optional off-grid add-ons such as custom made triangular solar panels and solar hot water heaters. Magnetic blinds can also be installed to offer more privacy and shield the interior from the sun, while the domes can also be partly buried to create a thermally efficient earth-sheltered home. The prices for the domes start at $1060 per 10 sq ft (€1,000 per sq m).(Christine Walsh, 2017, (URL [2]))

Figure 4. Curvilinear spaces, long distance openings, steel structural system
Express rail link West Kowloon terminus by Aedas (URL [3])

The development of technology and the cased drilled systems enable deeper, higher and more robust spaces, which has been a groundbreaking factor in earth-sheltered architecture. Bored piling systems enable the design and construction of section and plans with circular shapes in earth sheltered buildings. The circular shape can fully meet the curvilinear moment with the vaults and curved walls, thus making widespread the earth sheltered buildings. In addition, studies that show user satisfaction for curvilinear spaces are increasing day by day. In these designs, the space is not cornered. So, the hygiene and comfort are at the highest level.

3.2. Effects of Developing Technology on Earth Sheltered Facade Design

- It is possible to design completely transparent facades with developing building technologies and facade systems and even the facade structures can be designed as glass.
- Designing smart facades, shell systems and kinetic facades,
-Ability to provide energy from the facade,
-Technological direction of our acquisition from ancient civilizations and local architects, mutual interaction of technology and acquisitions,

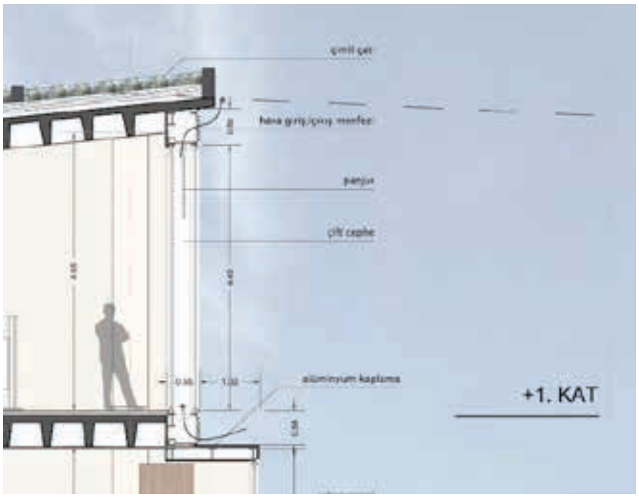

Figure 5. Turkcell R&D building, double facade detail (URL [4])

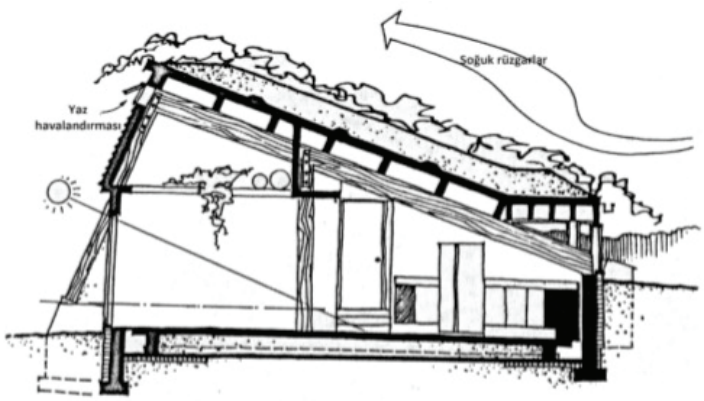

Figure 6. Solaria's Heating System with solar energy (Wells, 1998)

3.3. Effects of Developing Technology on Earth Sheltered Building Roof Design

- The introduction of the concept of the green roof,
- Green roof systems and people longing for nature,
- Contribution to ecology and habitat with green roof and vertical garden systems,
- Increased water consciousness and awareness with green building and water cycle systems,
- Contribution to urban sustainability, to the formation of bioclimatic urban spaces, to urban quality,

Malcolm Wells, the pioneer of the modern-day soil-covered structure, has argued that such structures are a green alternative to modern cities, which they call the asphalt society. After 11 years of architectural practice, he thought that there could be something in nature that would cause less harm to the asphalt and concrete, and he found the answer around him: Soil. The Solar Hemicycle, designed by Frank Lloyd Wright in 1943, also influenced Wells in 1959 and has been a guide in this point. He also stated that with the environmental awareness of the 1960s, he began to think that the surface of the earth was for living plants instead of dead buildings and asphalt (Wells, 2000).

Figure 7. Water recycling, bio-walls, and photovoltaic, wind turbines in an earth sheltered building (Janzen 2014, (URL [5])

3.4. Effects of Developing Technology on Earth Sheltered Space Comfort

-The ability to design bioclimatic spaces,
- Meeting comfort requirements such as in-house thermal comfort, ventilation with passive design,
- Enlightenment of earth-sheltered spaces by special light chimneys, light shelf systems,
- Increasing technological studies on the transport of light, projects related to the use of fiber optic cables in lighting technologies,

Figure 8. Nanyang Technical University, Singapore ((URL [6], 2008).

An internal main courtyard was created in the architectural design of the Art Faculty of the Nanyang Technical University in Singapore, and a microclimatic (wind, sun, etc.) controlled space was defined. Such space constructions are often required in educational settings and affect the building's energy efficiency.

The glass façade provides a high-performance building envelope that reduces solar gain and heat load while allowing the benefits of natural views and daylight into creative spaces. Glass walls provide a visual exchange between indoors and out, allowing students and teachers to experience the building, the surrounding landscape and the interior plaza as fluid spaces. (Kricenski, 2015, URL [6])

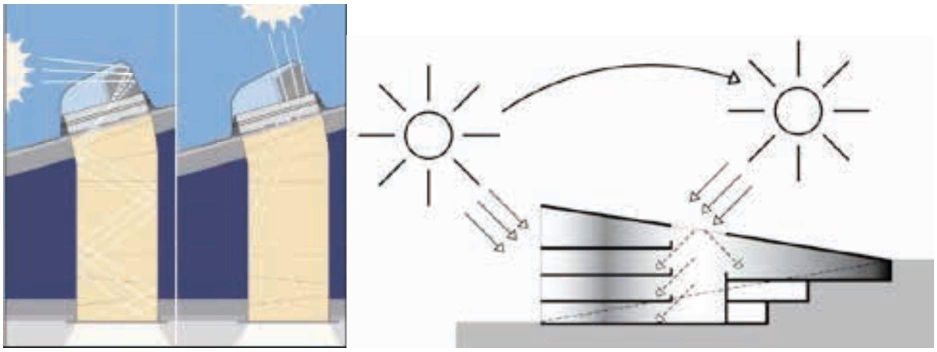

Figure 9. Left: Tubular skylights (URL [7]) Right: Natural lighting and glass facades in Turkcell R&D Building (URL [4])

Installing **tubular skylights** in your house will offer you several advantages. The most obvious one is that you will have more natural light due to the particular construction. The design of sun tunnel lights features a special sealed shaft, which takes care of controlling the heat and cold flow into the home, meaning that you will get higher energy efficiency. The construction controls UV rays and they are absorbed by the light pipe. Another great advantage is that this type of light comes with an affordable price tag which means your investment will pay off rather quickly, especially if you do not have to make any structural changes. (URL [7])

3.5. Texture, Color, Material Related Effects of Developing Technology on Earth Sheltered Architectural Design

-Effects of biomimetic design on the texture of the earth sheltered space
-Effect of surface and textures obtained by nanotechnology on earth sheltered space
-Increasing ecological consciousness, penetration of green areas into the structure and on it and its effects on earth sheltered spaces,
-Architectural trends and efforts related to nature and natural return, its interaction with technology
-Effects of smart textiles inventions and related studies on earth sheltered architecture
-Effects of self-cleaning paints on earth sheltered space comfort and aesthetic
-Achieving different textures and surfaces with three-dimensional models and laser cutting devices and their visual effects on space design.

3.6. User-Oriented Perceptual Effects of Developing Technology on Earth Sheltered Architectural Design

The technological developments of the 21st century offer the opportunity to experience and perceive the wider, higher, more spacious, enlightened, more colorful spaces and enriched experiences with different nanotechnology textures for space users. In addition, thanks to various 3D computer programs (Rhino, 3ds Max, Revit), modeling techniques that get better and better daily provide the expression of any model imaginable. Thanks to the visualization options in the design stage, perceptual experience of the earth sheltered space can be predicted before the construction. In addition, the developing virtual reality applications and virtual glasses are able to offer an unprejudiced, more pleasant and lively the earth sheltered space experience more.

4 CONCLUSION

Technology-oriented earth sheltered architecture shows that in the growing cities of the developing world, people can live ecological city life without being disconnected from nature and technology. Nowadays, earth sheltered buildings are mainly preferred as they are energy-efficient spaces, but they may also be preferred for their safety and protection from natural disasters advantages. Furthermore, because of the climate change scenarios in today's architectural agenda, earth sheltered architecture, which is an energy-efficient spatial solution proposal, will be the key alternative spaces of the future.

Earth sheltered spaces can be designed in small or large scales with various functions (housing, hotel, hospital, educational structure, etc.). Thanks to the developing technologies, it is possible to use all advantages and chances offered by above-ground buildings in earth sheltered buildings. It is also possible to expose the eco-conscious spaces by taking advantage of the soil such as radiation absorption, bioclimatic comfort, acoustic comfort and supporting them with technological developments. It is also possible to design eco-conscious spaces by taking advantage of the soil such as radiation absorption, biomass, bioclimatic comfort, acoustic comfort and supporting them with technological developments.

Scientific commissions have emerged in developed countries to demonstrate the strategic importance of earth sheltered buildings. Scientific organizations such as ITA, ITACUS, ACUUS, AITES and UCA, which carry out scientific studies internationally and organize conferences in different countries annually, support scientific studies to improve the design of earth sheltered spaces. (İncesakal,2011)

The earth sheltered spaces can only be designed as needed when they are supported with developing technologies and interdisciplinary studies. Although investment costs are higher than other structures, the cost of usage and operation will be reduced as it is supported by bioclimatic and passive designs. As smart textiles, nanotechnology materials and bioclimatic approaches diversify and increase, users' spatial requirements such as comfort and hygiene will be met because the biggest problem in earth sheltered buildings is mold and odor, which exist because of wrong air circulation designs. With the increase of Cyborg space approaches, earth sheltered spaces will meet people's technological needs as well. In this context, it is suggested to increase the interdisciplinary studies and to adopt spatial approaches that are focused on technological developments, which are suitable to the space demands of our modern technology and comfort oriented era. Nowadays, earth-sheltered architecture with developing technologies should be handled like high tech constructions. In addition, earth sheltered space design should be developed simultaneously with technological developments with the contributions of different disciplines. Simultaneous interdisciplinary studies should be conducted on this subject and all technologies should be provided to human beings even in the most challenging living conditions.

Some questions that can be investigated for next studies about earth sheltered architecture are listed below: (Kushner, 2015)
-Can new buildings learn the old numbers? (Subject no 58)
-Will your city of the future be like a living organism? (Subject no 62)
-Can architecture save us from the doom? (Subject no 68)
-Can an architectural sponge function? (Subject no 69)
-How many different ways can a roof serve a building? (Subject no 70)

5 ACKNOWLEDMENTS

This paper couldn't have been written without the contributions from and discussion with Bilge IŞIK and Mustafa İNCESAKAL, and Hasan Kalyoncu University Department of Architecture and Department of Interior Architecture and Environmental Design department's co-studies. Thanks for Medipol University and İstanbul Technical University for supporting with e.libraries and technical chances and anonymous revivers.

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6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Factors Leading to the Deterioration of Halfeti Houses and Recommendations for Preservation

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ABSTRACT

Halfeti is a residential area located between the cities of Şanlıurfa and Gaziantep, history of which coincides with that of Rum Kale (Greek Castle). It is located on a hillside facing the Euphrates River. In addition to serving as a residential area, the hill is also an archeological site. Most of the hill is covered with caves engraved in bedrock. Halfeti houses were built upon these caves. Halfeti houses, positioned according to the topography, differ from other residential areas in terms of not using the roof of adjacent low-elevation structure despite the terracing they create by lining up one behind the other. There are currently two main streets in Halfeti; access to houses is via stairs linked to these streets and built perpendicularly to the slope.

Halfeti houses show similar characteristics to Birecik and Gaziantep houses in terms of their facade, woodwork and stone ornamentation. Houses are generally two-storey with cave hollows in most of the bottom floors. The hollows in the bottom floor are used as functional areas such as barn, kitchen and storerooms. The top floor, on the other hand, is the living area. There are rooms, iwan and balcony on the top floor.

The main construction materials used in Halfeti houses are limestone and wood. Rubbles and irregular stone patterns are used for the bottom floor, while regularly-aligned stones are used for the top floor. Although Halfeti is not sufficiently rich in plants, the trees at the sides of the Euphrates River were utilized as both static material and aesthetics material in construction. The size of wood used as load-bearing element in Halfeti houses caused limitations in the size of houses.

The primary factor leading to the deterioration of Halfeti houses is the Birecik Dam built in 2000. Following the construction of the dam, a large part of the residential area sank beneath water, and the city texture, streets, neighbourhoods and buildings that constitute the city's silhouette such as mosques, baths, tombs and houses were exposed to the danger of disappearing. Severe cracks occurred in the walls of houses close to the river that survived the flood due to their deteriorated foundations. The disruption of social structure as a result of the construction of the dam led to forced migrations in the district, and thus the abandonment and ruin of traditional buildings.

The present study will provide information regarding the factors leading to the deterioration of traditional Halfeti houses and the materials and construction techniques, and will address the types of interventions for their preservation.

Key Words: Halfeti houses, Deterioration, Material, Construction technique, Preservation

1 INTRODUCTION

Halfeti, a district of Şanlıurfa province, is a settlement in the near vicinity, having a common history with Rumkale, which survived until today from the ancient times (YILMAZ 1999). Halfeti Houses that form a harmony with Euphrates (Fırat) River have been constructed in compliance with the topography with the regional stone construction material. Due to the dam constructed in 2000, a part of Halfeti and its surroundings has been impacted by the waters of this dam and deteriorations commenced in the historical fabric.

Documentation studies related to the structures that would be impacted by water in Halfeti and its surroundings were commenced by High Council of Immovable Cultural and Natural Assets in 1985 by the preservation of Ulu Mosque. In 1997, a corporate study was conducted to perform inventory survey in Halfeti by GAP Administration and Hacettepe University. Within the scope of this inventory survey, relieve drawings of Ulu Mosque, Kanneci and Bey Konağı, Çekem Mescid and cemetery in Halveti and Kaya Church in Savaşan Village were prepared. Information and documents obtained during inventory (preservation) study related to determined structures were gathered in the book named "Immovable Cultural Assets of Birecik, Halfeti, Suruç, Bozova Districts and Rumkale" and published in 1999 (Durukan 1999). The reviews related to "Urfa Province, Birecik and Halfeti Districts Traditional Rural Settlement in the year of 2010" were published as an article in 2011 and announced in the meeting of Results of 19th Research Studies (Akın 2001).

Although Ancient Halfeti settlement was announced as an Urban Sit Area in 2003, the deterioration started with the construction of the dam increasingly continues as a result of immigration from the district and uncontrolled tourism (Figure 1).

2 FACTORS THAT CAUSED DETERIORATION OF HALFETİ HOUSES

With each passing day, traditional Halfeti houses lose their authentic characteristics due to reasons such as dam construction, displacement, mandatory migration, desertion, changes originating from lifestyle changes, additions, partitions, measurement changes in construction material, structural problems, shanty settlement/repairs, uncontrolled tourism activities.

Figure 1. Deteriorations in traditional texture of Halfeti and Euphrates River

Various factors become effective as a result of natural events or economic situations for changes in the settlement areas during the historical process (wars, changes in trading routes etc.) (Tuncel 1977). The most important factors for the deterioration of traditional texture of Halfeti were the dam construction and changes in settlement areas (Boyraz 2016). Although Construction of Birecik Dam was included within the particular state investment projects, preservation of immovable cultural assets in the area of dam construction became of secondary importance. Despite the conducted inventory and documentation studies for the submerged structures left underwater since no holistic protection project could be developed in this area, many of the structures were submerged or deteriorations process was accelerated.

Figure 2. Deteriorations due to dam water **Figure 3.** Savaşan Village

Since the houses, gardens, fruitful agricultural lands have been submerged as a result of Birecik Dam most of the citizens who made a living by harvesting the fruits of fruit trees along the coast of Euphrates River had to migrate to cities like Gaziantep, Şanlıurfa, Birecik and Nizip in the near vicinity in order to find new job opportunities while others migrated to abroad and had to leave the district.

As a result of the dam construction, district governorate, municipality, and other public authorities of health and education etc. were moved to Karaotlak village in the South of the district that was selected as the new settlement area in 2001 (Boyraz 2016). As a result of this displacement, access to such services from Old Halfeti became harder and traditional houses were deserted and the will of moving to reinforced concrete houses, apartments in this new settlement area which are considered to be more comfortable came to the forefront. Many houses were demolished as a result of the road construction made on the coastal line in order to provide connection between the old and new settlement areas (Figures 4-5).

Figure 4. Deteriorations due to deserting as a result of displacement and migration
Figure 5. Material losses due to neglect and natural events

Deserted houses in Old Halfeti Settlement area due to dam construction, migration and displacement diminish due to neglect. Although the houses occupied in Halfeti by tenants or landlords are renovated according to the current needs, their authenticity disappears as a result of unconscious repair works. Since more space is required in the houses, and there are problems in access to basic requirements such as electricity, water, health, education; change of original occupants, the will to get settled in new settlement areas cause changes in the structures (Figure 6).

Figure 6. Deteriorations as a result of desertion
Figure 7. Deteriorations as a result of adding stories

Halfeti houses were built in three different styles when the number of storeys considered such as single storey, double-storey housing unit plus single storey outhouses. Interventions in the houses are generally reinforced concrete adding storeys, wooden pergolas, cantilevers and usage of flashing signs. Since parcel layout and topographical status of these houses do not permit lateral additions, new or additional space requirements can be met only by separating the rooms, changing vaulted or domed spaces into rooms by enclosing, creating new spaces in the backyard or terraces or by addition of storeys. Access to newly created spaces can be given across the room or from the vaulted or domed spaces. Walls have been constructed with briquette blocks within the rooms in order to meet kitchen, bath and toilet requirements (Figure 7).

Figure 8. Interventions on facade with unconscious repair works
Figure 9. Deteriorations by diminishing the gardens

In the Old Halfeti, which did not have a widespread area due to its topographical characteristics, there are main streets parallel to the valley and roads linked to them vertically (Bakırcı 2002). Typology of the facade has been changed as a result of interventions made in the houses that are separated by yards and garden walls, measurements of the windows and doors have been enlarged, narrowed or completely covered. Wide yard gates have been narrowed and become single doors. The proportions of door and windows in the newly added units are quite unlike the traditional proportions and look inconsistent with the general texture of the structure (Figure 8-9).

Masonry construction style of Halfeti houses includes limestone and wooden elements. Construction method is generally masonry in the region while usage of stone, mud-brick or collocation of stone and mud-brick as structural elements can be observed. Material fatigue and cave-in can be observed due to neglect and non-usage of the houses. After 1980s, the roofs of Halfeti houses made of soil changed into reinforced concrete. Since the reinforced concrete covers and any additions to the authentic structure could bring additional static load to the structure, structural problems such as collapse and cave-in may occur. (Figure 10-11).

Figure 10. Damages to the structures due to wrong material usage
Figure 11. Wall and floors losing their resistance due to reinforced concrete roof load

Humidity rate increased due to the climate change as a result of Birecik Dam and mossiness and weathering on the surfaces of stone facades of the houses and cutworm infestation and fungus covering events observed in wooden elements. Since the joints of the stones in supporting walls emptied or filled with cement based mortar led to the bonding characteristics of stone walls, loss of resistance in time may cause collapse.

One of the most important reasons of diminished historical texture in Halfeti has been the shanty settlement. Since the district has a coastal line, touristic facilities are required to be built. Accommodation and boarding facilities are either built without permit or in line with the temporary policies. Such structures deteriorate the silhouette of the traditional texture.

Figure 12. Reinforced concrete structures that deteriorate the silhouette of Old Halfeti Settlement
Figure 13. Deterioration due to incorrect repair and restorations

The plan type of the houses, functions of which changed in order to serve to tourism sector, is being altered by unconscious repair and restorations. Interventions in garden, room, vaulted or domed spaces and terraces of the houses, which are generally transformed into boutique hotels, deteriorate the authenticity of the structures. Reinforced concrete tea gardens and commercial areas built through reformation of traditional houses develop in contradiction with the historical texture (Figure 12-13).

3 ASSESSMENT AND CONCLUSION

The most important factors in the deterioration of Halfeti houses are dam construction and changes in social and physical texture as a result of displacement. Pontoon restaurants, great flashing signs aligned to the coastal line of the district, which has a high tourism potential (ÇİFTÇİ 2017) and meeting the car park requirements by damaging the historical structures, performing repair works that deteriorate the plan type of the houses, high rise structures risk the title of the city and diminish the traditional texture with each passing day. Unplanned structuring and disrespect to the nature in Halfeti result in irrecoverable interventions in the district.

Çekem Borough and Savaşan Village are the most tourist attracting places of Halfeti and its surroundings with respect to historical and natural aspects (Gül 2002). A preservation and development planning should be conducted through a site management in order to cover these settlement areas. Planning decisions from a single decision-making authority and implementation thereof will enable the controlled protection of the area. In order to prevent further deterioration of Halfeti houses, to provide sustainability of the historical texture integrity and in order to guide any future restorations, a Settlement Plan for Protection purposes should be prepared. Protection and preservation experts should be employed in the Municipality. Old Halfeti became one of the popular areas for tourism investment and activities with its natural, historical and cultural features. Tourism planning should cover this region and public awareness should be raised in the district.

Intervention techniques for restoration implementations should be separately considered for each structure (Ahunbay, 2009). These can be summarized so that observations performed at Halfeti houses should guide restoration works of such houses. Materials and supporting system of the houses should be reinforced; the integrity of houses should be achieved by demolishing the added walls in the spaces. Old materials should be renewed with original and authentic materials and the painted and plastered stone surfaces which cause visual pollution should be cleared. Successful sanitary applications should be made to provide wet floors, heating, cooling systems, electrical and water installations correctly. All buildings should be reviewed to serve to tourism sector and to make contemporary additions without distrupting the authenticity of the structures.

The most characteristic factors that distinguish the houses, which are the major construction type of regional settlements, are usage of local materials and their application techniques. (Ergin Oruç Ş., 2015). Widespread use of reinforced concrete and the decreasing number of specialist workers who use local materials result in the deterioration of historical houses and texture. Stone and wood, which are local materials, should be used in the restoration of Halfeti houses and for new applications. Financial support and incentives should be provided in this region in order to operate the stone quarries in the regions and to bring up new stone craftsmen.

New structuring, maintenance, repair and restoration applications which affect the traditional texture in Halfeti should be conducted following the necessary permits from the Regional Committee of Şanlıurfa for Protection of Cultural Assets (ŞKVKBK) and Protection Implementation Supervisory Office within Şanlıurfa Metropolitan Municipality (KUDEB).

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

The Potential of Adobe Use in Modern Turkish Architecture with the agenda of Sustainability

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ABSTRACT

Earth as a natural building material may also be regarded as an important solution for sheltering requirements. The natural morphology of geographical regions and climatic conditions of the residential areas for architectural as well as less labor requirements and accessible acquisition are some of the reasons for choosing adobe material. The people who chose settled lifestyle rather than nomadic, produced rational, temporary and permanent solutions while they brought their culture, attitude, demands to the districts where they settled.

Adobe material is chosed for its adaptability to the different climatic conditions, its natural structure, less energy requirements during its production, sustainability, thermal isolation capability as well as the ability to reserve warm air in winters for a long time and its resistance to hot air in summers and keep interiors cool. Moreover, it is a breathing and damp proof material, which may also be used with other environment friendly building materials that supply comfort conditions for residents.

The increase of environmental problems and the risk it poses to human health triggered the development of sustainable architectural solutions aiming at protecting ecological system balances. In this sense, the designs of modern architectural buildings and environment friendly design solutions are recommended at building material level and dissemination of usage of adobe as a natural building material with clean energy production equipment will hopefully help to reduce carbon release.

In this study, along with the effect of increased sustainability concerns in the construction industry, prominent international rammed earth and adobe construction examples are examined. Under the light of these distinguished cases, an evaluation is made for similar material and construction methods in Turkey. The potential of spreading adobe and rammed earth construction combined with modern construction methods is quite significant. Thus, this paper aims to attract attention to promote this construction method for ecological village projects as well as independent architectural initiatives.

Key Words: Adobe, Architecture, Building Materials, Sustainability, Traditional Turkish Houses, Vernacular Traditional Construction Techniques

1 INTRODUCTION

The environmental, economic and social problems experienced today in urban areas are expected to cause much bigger problems for future human settlements. Some of the causes of these complications are considered as consumerism, climate change, increasing social inequality on a global scale, increasing human-nature disengagement and weakening social attachments. Meanwhile, various suggestions are being developed to create alternative sustainable living environments for solving these problems. One of these proposals is eco-village settlements. Eco-villages are examples of alternative living environments. The eco-village movement originated from the combination of traditional ideas of coexistence and environmentalist approaches that emerged in the 1960s and 1970s. The aims of ecocities, which are conscious communities that come together for a common and special purpose, can be defined as the creation of sustainable, nature-integrated, healthy communities and settlements that produce solutions to today's problems. Sustainable, peaceful and integrated communities are expected to change the unhealthy conditions of the 21st century cities. [3]

Concepts such as ecology and sustainability rapidly became effective all over the world during the 1990s. This ecological trend against consumerism has also created terms such as environmentally conscious design, green/ecological architecture, environmentally conscious architecture, energy-conscious architecture, climatic architecture. These concepts discussed different physical and social environments leading to the development of eco-village initiatives. The associations established for the development of these initiatives aim to create information networks where experiences are shared to support ecological settlements. Design and research studies are also backed-up by educational and cultural festivals. Examining traditional materials or contruction methods and reusing them with improvements based on modern technology can help evaluate a more sustainable construction. However, it is important to take into account that some of today's manufacturing methods are also a part of the problem. Hence, new ways of construction should be considered for a deep-rooted solution. [1]

In this context, this paper examines traditional use of adobe and mud brick, traditional and promising new technologies of manufacture and discusses its potential to be used as a main building component for eco-villages.

2 ADOBE USAGE

Although traditional materials are gradually abandoned and the use of modern (contemporary) materials has become widespread, their impact on the environment and human health should not be ignored. Adobe, as a traditional material, is also an ecological building material that is environmentally sensitive with minimum energy needs from production stage to construction stage. Adobe is also a load-bearing material, obtained from clay soil and has a binding nature and is an economical material, which can be used as plaster material if necessary. Its usage is indispensable for the rural areas since the ancient days. It has a high value of heat insulation and does not require the establishment of any production facility. In every season, residents in a building of adobe have the most suitable living conditions. In this respect, it is economical because a thermal insulation material is not needed [11]
The adobe material is a preferred material for house construction and other needs. It is suitable for every type of building based on the conditions in our country. One or two-storey buildings are constructed with adobe material. The construction type, where adobe is to be applied, should have a square or rectangle structural system plan and it should be ensured that there are not too many indentations and protrusions. At least 50 cm of the walls of the load-bearing outer walls, 30 cm of the thickness of the load-bearing inner walls, non-partition walls not thinner than 15 cm are required. The transverse and longitudinal load-bearing walls should be continuous. It is desirable that the length of the load-bearing wall in a single span does not exceed 5 m. The location of the outer wall space should start from 100 cm in the 1st and 2nd degree seismic zones and from 150 cm

in 3rd and 4th degree seismic zones. Door and window width must not exceed 100 cm even if reinforced concrete is used. The partition of the wall of the lintels must be at least 50 cm. Filled spaces between gaps must be at least 60 cm. Large eaves are useful for protecting the walls from rain. If a flat roof is to be constructed, at least 40 cm of ceiling beams should be supported from the wall. Other rules regarding design and construction must comply with the adobe brick construction standards TS 2514 and 2515 [4] [7] [9] [11].

On the other hand, advantages and disadvantages of adobe material are as follows:

• The adobe containing structures keeps moisture in the interior by absorbing the inside air due to the pore structure of the adobe paste.
• Adhesive keeps the heat and moisture balance due to its heat retention feature. It provides a more viable, clean and healthy bioclimatic comfort within the building.
• The soil, which is one of the best energy-storing materials after water, forms the walls surrounding the building as building material, and collects the energy of heating. After the heating is turned off, it gives the heat for a long time to keep the temperature stable. It offers protection against undesired hot or cold weather.
• Production cost is low and no facility is required for production.
• No mechanical energy is required during production and use. For example, to produce $1m^3$ concrete, energy such as 300 - 500 kWh is needed. 1% of this energy is enough to produce mud brick. The researches have shown that for the power production of 1 kWh, the atmosphere transfers an average of 5.5 g $SO2$ and 2.5 g $NO2$.
• Adhesive does not damage the environment when it completes its production and material life. Demolition is a recyclable material that does not require much energy compared to other building materials.
• If the soil removed during the foundation excavation is used in mud brick production, it will not be costly to transport, thus providing additional savings to the construction economy. Also the basic excavation is also evaluated.
• The mudbrick is an economic material.

In addition to the positive aspects of adobe construction, there are also some inadequate features.

• Low pressure resistance,
• Too much sensitivity to water,
[5] [8]

2.1 Traditional and New Methods for Adobe Usage

Adobe is the first building material used for its flexibility. Just like supplying this building material shaping it is also easy. For these reasons, throughout the history of mankind, in comparison to stone and wood, adobe has been used as a building material to a greater extent. Soil and muddy mixtures have been used as building materials in a very wide range of applications in the past times such as inhabitants in the Mehrgarh region in South Asia. They lived in mud-brick houses built in this region between 7000 and 3300 BC. This material was also used in the Neolithic period in the Kingdom of Minos, and in the archeological work done in this area, the sun dried mudbrick residues used during the Neolithic Age were found. The Mesopotamian people also used mud bricks in their own constructions. The adobe was also used in pre-Roman Egypt, and the use of adobe was widespread in the period of Roman government [1]. Particularly in the 1950s and later in recent years, due to the higher awareness on environment / nature conservation, which has been rapidly concentrated around the world, the interest in earth architecture is revived again. In this context, new technologies emerge to increase the durability of the soil architect. [10]

In new adobe based methods, after pressing earth blocks, the slurry mixture is sprayed directly to form blocks for a wall construction. Soil buildings may be an option for the construction of new homes in developing countries. Soil-based construction techniques have been widely used in the past as mud bricks and mud-sticks. As construction technology has improved, more and more improved materials have replaced it. Bricks and briquettes, which are sold today on the commercial market, are being used. The cost of such commodities cannot be affored by a large population of people living in many countries.

Earthen buildings are a viable option in rural areas and disaster areas, where relatively little workmanship and resources are available and almost all of the materials needed are locally available. The vast majority of refugee families around the world are using these traditional methods to meet their own needs in residential areas. Many refugees use traditional construction techniques that have developed over the years in their own settlement areas to build functional homes, which have the conditions of their original surroundings. These techniques are generally based on construction materials which are cheap, easy to locate in the area and have long lifecycles. The currently used shelter techniques have a common goal: to provide shelter. However, in many cases, it is not the best option for the environment or for those who will live in it. Some have high costs and others are inefficient in terms of the environment. [12]6

It is necessary to understand how to compare the soil building techniques with the sustainability principles of other systems and to evaluate whether there is a better alternative to sustainable temporary architecture. [1] [2]

2.1.1 Masonry Blocks
In regions where mud quality is appropriate enough, it is possible to cut out mud blocks and use them such as masonry or brick blocks. In regions where the soil is not tacky enough, a layer made of soil (humus) and grass is used to keep the form of the blocks and bind them together [1] [2]

2.1.2 Adobe in Mold and Skeletal Structure
In such cases, the clay mixture contains an excessive amount of straw or wood chips. This mixture is shaped in a wooden mold and then both sides are covered (clothed). There is a need for such a skeletal structure and some frame work should be done during construction. The wet mixture is then filled in between the temporary molds. These walls are not load-bearing walls and are used to fill in wooden construction or pre-built blocks. [1] [2]

2.1.3 Adobe and Wood Sticks Application Method
This method is a very old and common method of dwelling construction. The construction starts with a wire netting made of brackets. This wire is plastered into the net, the gap is filled by pressing in places, and in case of other cracks, they are also filled. The roof is supported by the materials such as wood, bamboo or wooden sticks. The roof is made by forming a basket like mesh with straw and wood sticks. Surfaces can be removed by rustic plaster, or thin plaster is applied to them. The undisputed distinction of this type of construction is that it can also be applied in seismic zones. The main drawback is heavy rain, but the skeleton consisting of reed or split can easily be plastered with mud again. [1] [2]

2.1.4 Pre-Filled Adobe In Plastic Bags
It is based on construction of earth-filled bags as well as shelters / shields made by soldiers with this application. Polypropylene woven nets (or tubes) are filled with organic / natural materials such as hemp or sack cloth or other natural fiber textile materials (sacks). After the foundation is placed, each coat is knee-topped as if the beads are lined up, and the barbed wire is pulled at the top. The weight of these stuffed nuts ensures that the barbed wire is buried in the bottom row and the seams are tied together. Super adobe concept is presented today by Architect Nader Khalili. Pipe-shaped sand bag type and material filled with earth are used. To connect the earth pipes to each other, the barbed wire such as velcro is used. After placing the soil filled pipes in areas, the soil is used as plaster to cover and make them balanced. [1] [2]

2.1.5. Adobe and 3D Printing Method

3D printing is now used in many areas. At present, the Italian social business world WASP develops a full-size printer to print biologically-architectural homes. The project brings together the latest technology of mankind with the oldest construction material that is mud.

In many parts of the world, financial inadequacy is a growing problem. Mud is a widely available raw material that can be found easily. Hence, construction work is an activity that requires effort and overwork for this purpose. WASP firm intends to produce a 3D printer that can be portable and easy to install by two people on the road. More importantly, this printer is capable of constructing a 3 meter high building in 2 hours. At the moment, they are testing their project with a small-scale Delta WASP 3D printer. Both models require that the soil be sieved into powder, mixed with water with the addition of locally available fibers (wool or Indian wool). The printer, fed with the prepared material, sprays one coat at a time, depending on the design of the object (building). [1] [2]

3 ECO VILLAGES AND SUSTAINABLE DESIGN PRINCIPLES

Eco-villages are sustainable settlements with their ecological, economic, social and cultural life. For this purpose, it is aimed to protect the environment and the traditional way of living by using new design practices compatible with the existing texture, the environment and the traditional life style. Although the quality of life in industrialized countries has reached the highest level in the 1970s, global ecological footprint analysis reports indicate that human life is not sustainable over the world due to its use of natural resources above renewable borders. The adverse effects of ecological balancing, which have been increased by the depletion of natural resources, in human life, have brought about the creation of a sustainable common life. [7]

It is emphasized that eco villages are residential settlements that can be used to repair societal damage and to allow mankind to live within the limits that the world can afford. Eco villages are village establishments that provide an effective opportunity for sustainability of environmental values and provide tourism in rural and natural life in economic, social and environmental areas within the scope of sustainability. It is important for eco villagers to protect the nature, the environment, the village life and cultural heritage, the social equality and the equal sharing of the prosperity of the country. [8] [6]

4 WIDESPREAD CONSTRUCTION OF ECO VILLAGES WITH ADOBE MATERIAL

According to the principles of sustainable design, it is necessary to understand certain inputs for the widespread construction in order to increase in the number of eco-villages with adobe; concious eco-village planning, concious material users, climatic conditions, understanding traditional adobe usage and techniques, new techniques, education about eco-villages, considering ecological sources and above all inputs to sustainable design principles. These terms will be explained below in more detail. Figure 8 shows the obstacles and supporting solutions to overcome eco-village design and construction problems.

Eco-villages are required to be settled on the designated land that is determined according to sustainable design principles. The eco-villages, which have the function of tourism, for example, in terms of physical environmental conditions, social communication, economical reasons, need to be planned before setting the roads, landscapes and other built environment requirements. Thus, feasibility studies for the planned settlement will also help to protect sustainable resources by preventing the environmental touch in the present area.

Annual precipitation rate varies by geographical regions in Turkey, Therefore, other parameters such as type of soil, waterlogging capacity of the soil, average precipitation, annual solar angle of incidence are linked to climatic conditions and geographical regions. Unfourtunately, exposure of the muddy material to heavy rainfall is a disadvantage. For this reason, adobe structures are constructed often in central Anatolia, Aegean and Eastern Anatolia regions. So, eco-villages need to be evaluated both in terms of building material (adobe) and climatic conditions in terms of the physical environment and economic impacts on the users.

Moreover, the sources that will be used by eco village people in terms of carbon release, use of agricultural land, demand for forest products, use of pastures and livestock, structured area, fishing area are the terms to be considered for ecological footprints. It is necessary to reduce the CO2, CO, SO2 released into the air due to the lack of clean energy because the location of the land to be settled, the existence of structures to produce harmful waste will affect clean water sources as a threat to health of eco-village people. Thus, an outside environment without control will cause people living in eco villages to lose air quality, water quality, loss of activities such as agriculture and animal husbandry.

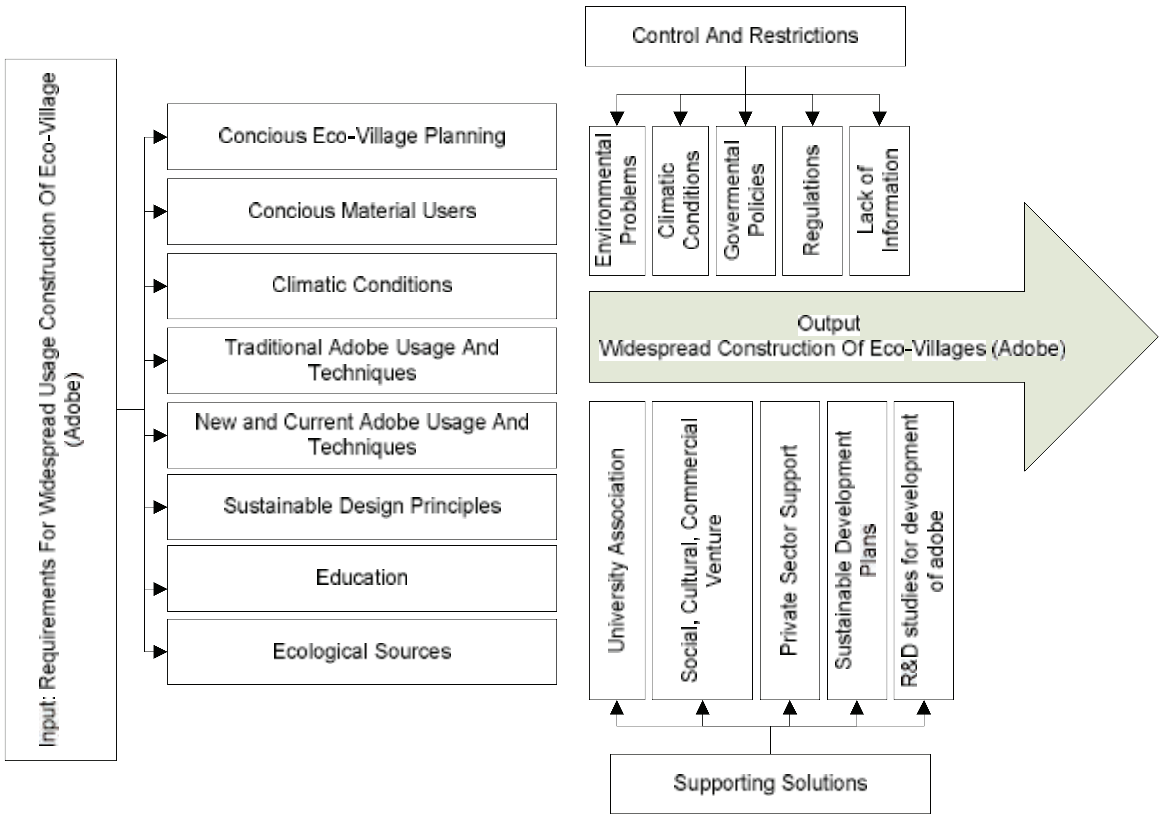

Figure 1. Solutions for Widespread Eco-Village Construction

One of the important inputs for adobe usage is the traditional construction methods that require molding, mixing, labor, education and ability. Besides, there are new techniques such as the 3D printers in construction to reduce errors, labor, loss of time, long-term costs and it can be used more efficiently by more educated workers. Another new preferred method is to construct by the plastic bags that are full of mud, which also reduces loss of time and labor.

For a sustainable eco village, it is necessary to develop an integrated approach to the components of the ecosystem and to develop local strategies, tools and methods to protect and develop ecological values. Providing collective trainings about soil structure, environmental conditions, earthquake and sustainable design principles of the villages will increase conscious usage of adobe and other materials. Eco-village team will be able to achieve desired results in a short time by reducing the errors and omissions. Unconscious use of adobe in Anatolia houses, especially in villages, unfortunately, causes damages, deaths in buildings, during earthquakes. In order to increase the life span of the buildings, special details are required for the design. Moreover, project stakeholders should better include construction technology experts, environmental consultants, architects, engineers. Accordingly, the preparation and presentation of this training content should be carried out by experts who worked in eco village projects before and those whom local people with knowledge about the village. So, this will provide a common language for villagers and other project stakeholders.

Lastly, the failure of the government to provide a budget for eco-villages and lack of awareness on the part of local governments on sustainability principles and processes creates drawbacks It is evident in the construction industry that the development of adobe is required but unfourtunately, R&D studies on the subject are not conducted at a sufficient level.

5 CONCLUSION

In the built environment, sustainability starts with researching sustainable materials and mastering design principles of sustainable architecture. Act of designing starts with a problem and projects are developed to solve that particular problem. Building materials are the flesh and bone of construction projects that construct a reality out of them. While designing a project, sustainability should be considered from the scratch. Otherwise, an increase in our ecological footprint, the depletion of natural resources, and being affected physically, emotionally and economically by these negative factors are inevitable.

On the other hand, eco-village concept enables a controlled approach to the natural environment by designing a sustainable project and creating an economic improvement adgenda for a region. Starting such a project with a consistent and educated team, researching the climate and ecology of the region and doing a target-specific feasibility study beforehand are some of the main characteristics of eco-village planning. Additionally, educating all project stakeholders will also minimize the losses and mistakes during the process. Moreover, net project inputs stated in the previous chapters of this research are set to help create and improve a natural, sustainable environment in line with the aims of eco-villages.

Although the considered inputs look constructive, there are many direct and indirect barriers obstructing the project to reach its aim. Although the environmental problems and climatic conditions are uncontrollable but avoidable situations, political decisions, regulations, budgetery cuts are controllable variables but set a major barrier for the needed workforce, equipment, and technology for the development of eco-villages. While this is the scenary of the Turkish context, international cases show a different motivation with R&D efforts supported by universities and private funds that seek for new construction techniques and improvement for the stability and robustness of adobe material.

Eco-villages can fulfill their mission by creating a sustainable environment, reducing the ecological footprint and creating a regional improvement by social, physical and economical development.

As a conclusion, this paper evaluates the potential of the adobe as a sustainable construction material and its propective use for designing eco-villages with inputs like sustainable design, R&D for improving the material. Overcoming the barriers in the process of implementing adobe as a sustainable materal may also help eco-villages to boost both in Turkey and abroad.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Comparison of Adobe and Container Structures via LCA

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ABSTRACT

According to recent reports, 40% of the world's energy consumption and 33% of the related global greenhouse gas emissions result from the building industry. With the increasing environmental awareness, much attention has been given to the energy consumption and greenhouse gas emissions in building structure types and materials. The selection of material and structure is not only related to the strength and durability. The energy consumption and environmental effects should also be taken into consideration. The objective of the present study is to make a comparison between adobe and container structure types by means of energy consumption and CO_2 emission via Life Cycle Assessment. For this purpose, Life Cycle Assessment methods are used to investigate and evaluate the environmental impacts of a building structure system over its entire lifespan. The gross areas and some technical properties of selected structures are similar to each other. Life Cycle Energy and Life Cycle CO_2 Assessment methods are two common methods that offer life-cycle energy and life-cycle CO_2 emission assessments, respectively. The lifecycle models focused on building construction, operation and demolition phases. The prediction of lifespan is too difficult. On the other hand, the adobe and container structure types are generally used as temporary shelters. The life spans of the container and adobe structures have been accepted as 25 years. The findings showed that the embodied energy and CO_2 emission values of traditional adobe structures are found as nearly advantageous as the container structures. The embodied energy value of adobe structure is 18% higher than container structures. However CO_2 emission value is 45% lower than container structures. The traditional adobe structures should be considered as an alternative and effective solution for environmental and energy policies in the long term.

Key Words: Adobe, Container Life Cycle Energy Assessment CO_2 Assessment

1 INTRODUCTION

Construction materials and structures play a significant role in consumption of energy and CO_2 emissions. Earth as mud-bricks (adobe) and containers have been used as construction structures in the building industry. Container type structures (CS) have a common usage area in construction industry [1,2]. At the same time, Adobe type structures (AS) are still a popular construction type in rural areas and developing countries.

As is generally known, unbaked, sun-dried mud bricks are mixed with water. Generally, mud mortars and earth roofs have been preferred for adobe buildings as for facade and roof systems, respectively. It has high durable and thermal properties. On the other side, CS is a typical kind of modular structure, generally known as factory-built. Fast construction time, cost effectiveness and structural integrity are superior features of CS.

The environmental and energy benefits of different type of constructions are very important in Life Cycle Assessment (LCA) studies. LCA is the investigation and evaluation of environmental impacts of a given product, system or service, over its entire life cycle. It quantifies resource use and environmental emissions associated with the system evaluated [4,5].

Besides LCA, life cycle energy analysis (LCEA) is used to assess the environmental impact of buildings. It is a simplified version of LCA which focuses only on the evaluation of energy inputs for different phases of the life cycle. In addition to LCEA, Life Cycle Carbon Emissions Assessment (LCCO$_2$A) is used for evaluating the CO_2 emissions as an output over the whole life cycle of a building. The approach considers all the carbon-equivalent emission output from a building over different phases of its life cycle [1,2].

Many researchers have emphasized the importance of LCA to understand the environmental impacts associated with buildings [1,2,6,7,8].

This study presents a LCEA and LCCO$_2$A of AS and CS types. The assessment includes construction, use and demolition phases. The carbon dioxide emissions intensity and primary energy requirements per square meter of the AS and CS are compared with each other. The results of the study will give an opportunity to select a construction type in terms of low energy and CO_2 emissions released from cradle to the grave.

2 METHODOLOGY

Life cycle stages of LCA are given in Fig. 1. It is obvious that LCEA focuses on energy inputs to a system, however, LCCO$_2$A motivates on the CO_2 equivalent emissions released from a system.

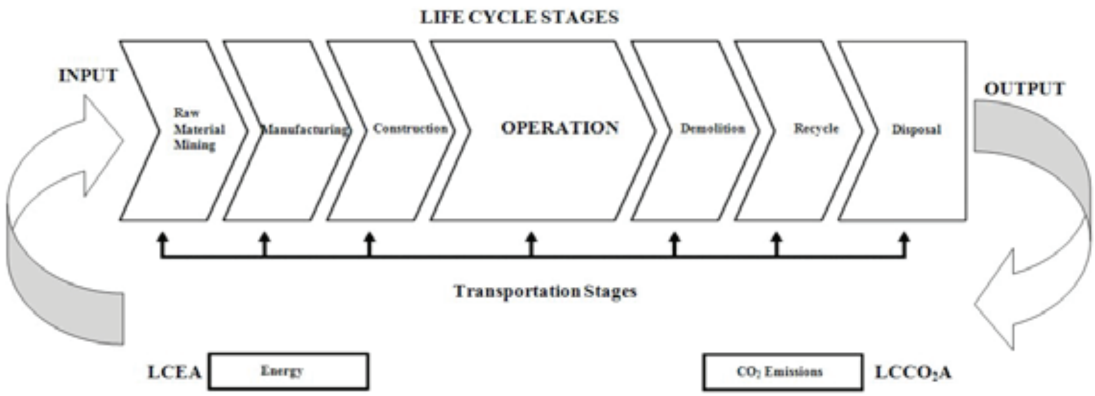


Figure 1. Life cycle stages of LCEA & LCCO$_2$A [1]

The LCA analysis compares AS and CS types of constructions. Figure 2 and 3 show floor plans of the AS and CS.

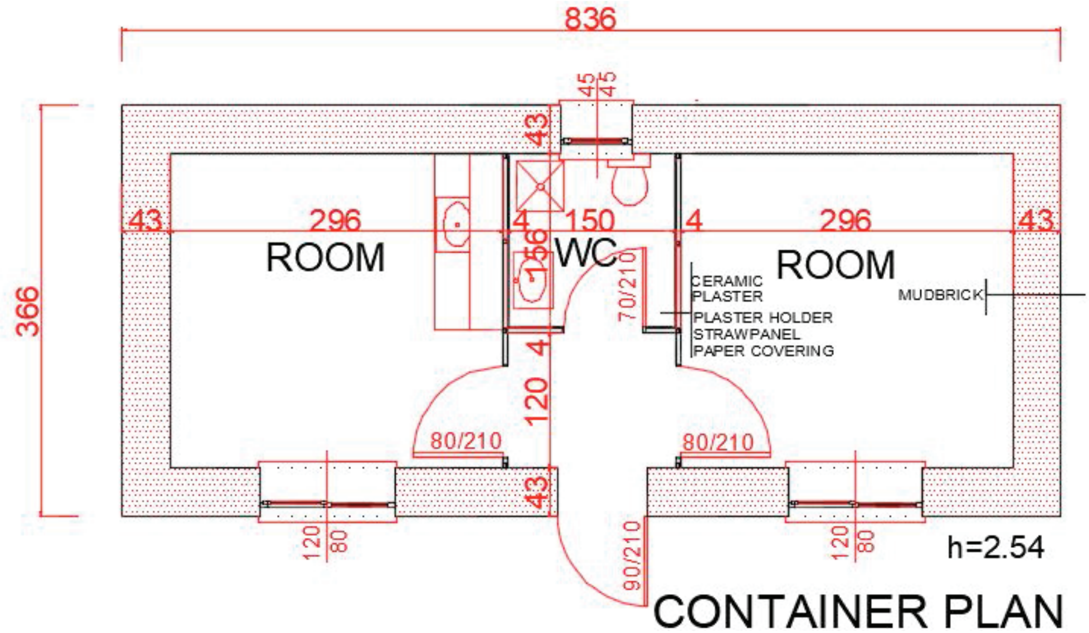


Figure 2. Floor plan view of AS

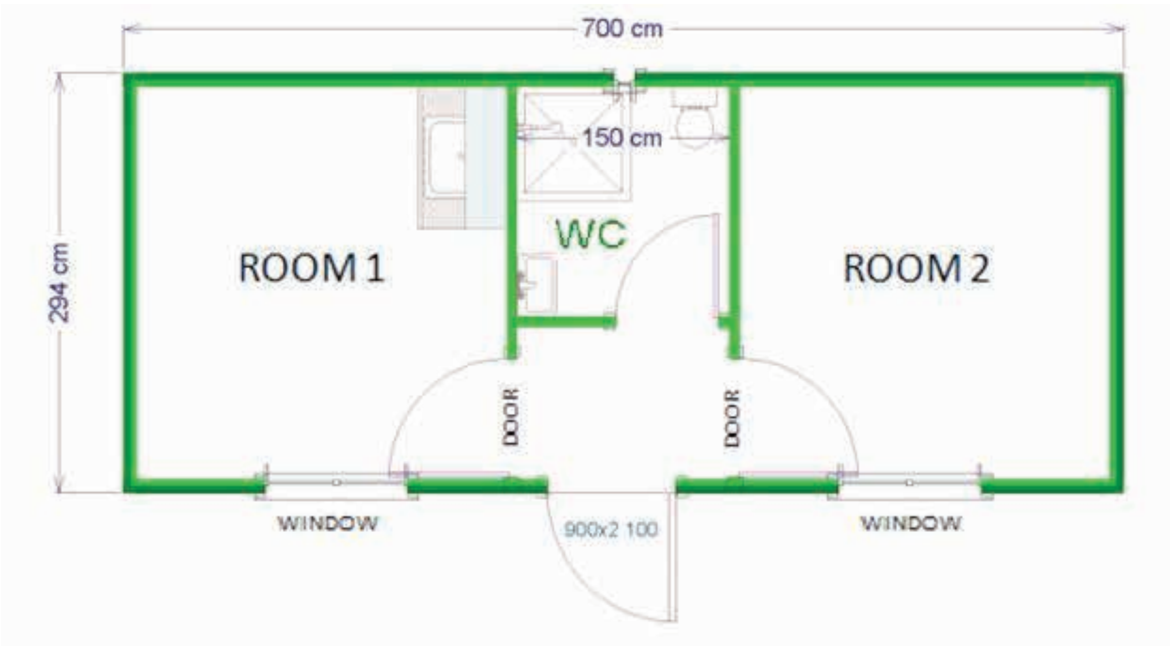


Figure 3. Floor plan view of CS

Demolition phase has been ignored in LCA analyses. Inventory of Carbon and Energy (ICE) Version 2.0 [3] is used for the calculation of primary energy requirements and GHG emissions.

2.1 Construction Phase

This phase includes embodied energy (EE) and CO_2 emissions of building materials used in construction of the AS and CS.

2.2 Use Phase

Use phase consists of the operational energy use. Because of limited data and information about the operational energy usage, the necessary data have been taken from the literature [1,2].

3 RESULTS AND DISCUSSION

3.1 Construction Phase

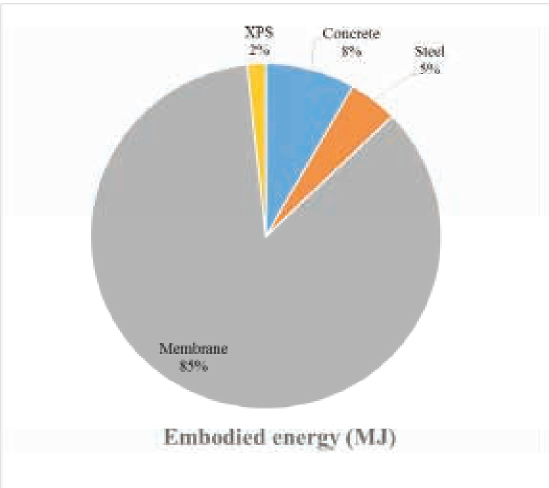
The life-cycle inventories for both of the AS and CS types are shown in Table1 and Table 2. The life cycle EE and CO_2 amounts of each raw material used during construction phase for AS and CS are presented in Fig.4 and Fig.5, respectively. The life cycle EE and CO_2 emissions percentages of each section of AS and CS are presented in Fig. 6 and Fig. 7, respectively.

Table 1. EE, CO_2 and construction material quantities of each section of AS.

Sections	*Materials*	*Amount (kg)*	*EE (MJ/kg)*	*CO_2 (kg CO_2/kg)*	*Total EE (MJ)*	*Total CO_2 (kgCO_2)*
Foundation	Concrete	11712	0.78	0.113	9135	1324
	Lean Concrete	4532	0.58	0.0755	2629	342
	Crushed Rock Blockage	5562	0.083	0.0052	462	29
Structure	Steel Profiles	298	21.6	1.86	6437	554
Floor	Floor Ceramic	10	12	0.78	120	7.8
	Linoleum Floor Coverings	36	25	1.21	900	44
Walls	Mudbrick	30945	0	0	0	0
	Plasterboard	54	6.75	0.39	365	21
	Wall Ceramic	59	12	0.78	708	46
	Plaster holder	49	1.8	0.13	88	6.4
	Straw Panel	65	0.24	0.01	16	0.65
Roof	Membrane	909	134	4.2	121806	3818
	Crushed Rock	5508	0.083	0.0052	457	29
	Straw Panel	110	0.24	0.01	26.4	1.1
	Extruded Polystyrene (XPS) Foamboard	28	88.6	3.29	2440	91
Other	Timber Doors	140	3.5	0.178	490	25
	Timber Window frame	31	47.4	2.42	1470	75
	Total	60048			147549	6414

Table 2. EE, CO_2 and construction material quantities of each section of CS.

Sections	*Materials*	*Amount (kg)*	*EE (MJ/kg)*	*CO2 (kg CO_2/kg)*	*Total EE (MJ)*	*Total CO_2 ($kgCO_2$)*
Foundation	Concrete	10080	0.78	0.113	7862.4	1139
	Mesh Reinforcement	630	28.5	2.03	17955	1279
Structure	Steel Profiles	1135	21.6	1.86	24516	2111.1
Floor	Precast Concrete Panel	443	2.33	0.242	1032.19	107.2
	PVC Flooring	20	68.6	3.19	1372	63.8
Walls	Plasterboard	70	6.75	0.39	472.5	27.3
Roof	Oriented Strand Board	600	15	0.99	9000	594
	Steel Profiles	115	21.6	1.86	2484	213.9
	Glass Wool	25	28	1.35	700	33.75
Façade	Plasterboard	280	6.75	0.39	1890	109.2
Other	PVC Doors	50	77.2	3.1	3860	155
	Steel Doors	125	21.6	1.86	2700	232.5
	PVC Windows	115	77.2	3.1	8878	356.5
	Total	13688			82722	6422.2



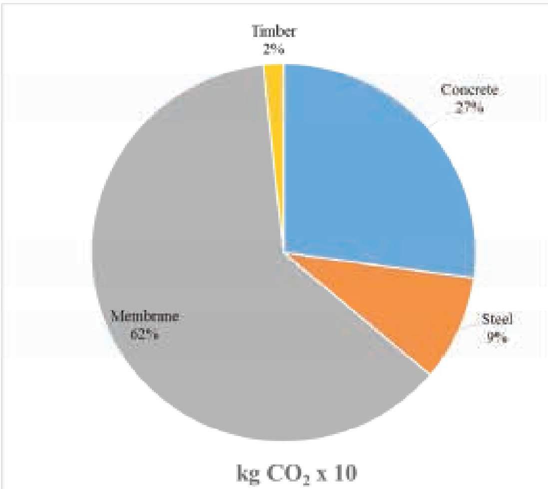


Figure 4. Life cycle EE and CO_2 amounts of some important raw materials used during construction phase for AS

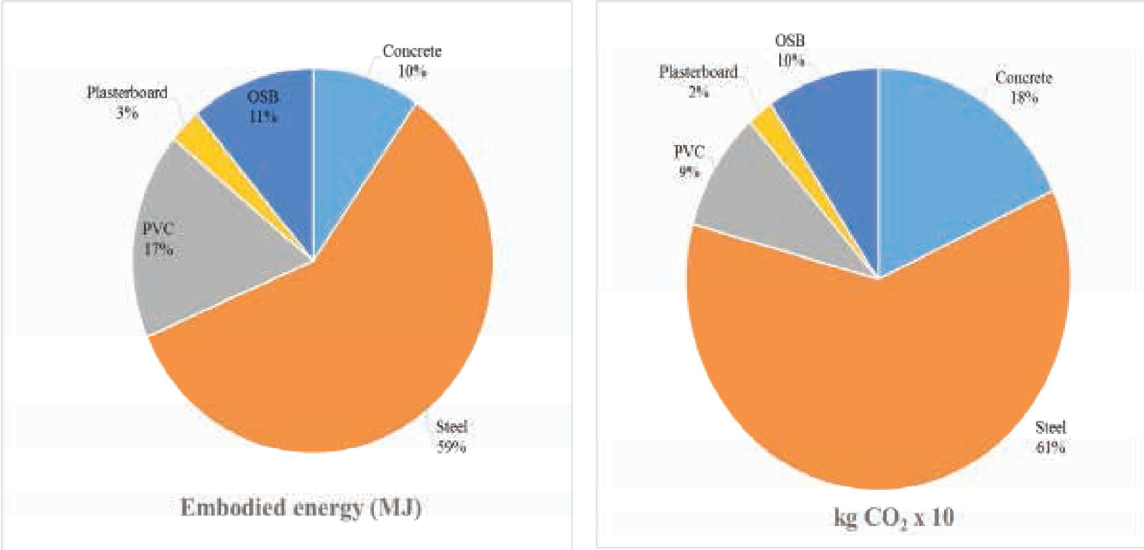


Figure 5. Life cycle EE and CO_2 amounts of some important raw materials used during construction phase for CS

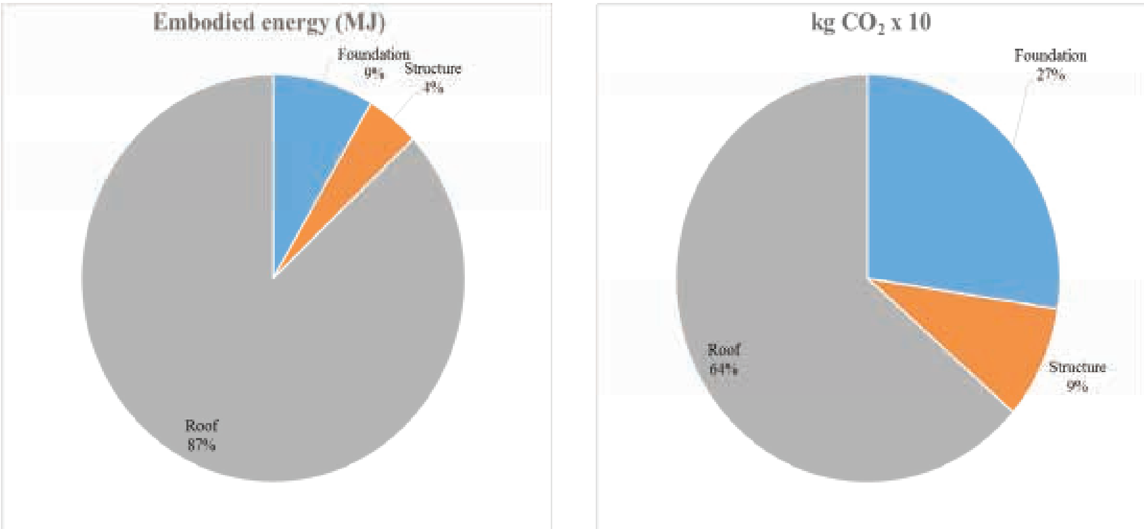


Figure 6 Life cycle EE and CO_2 emission percentages of each section of AS

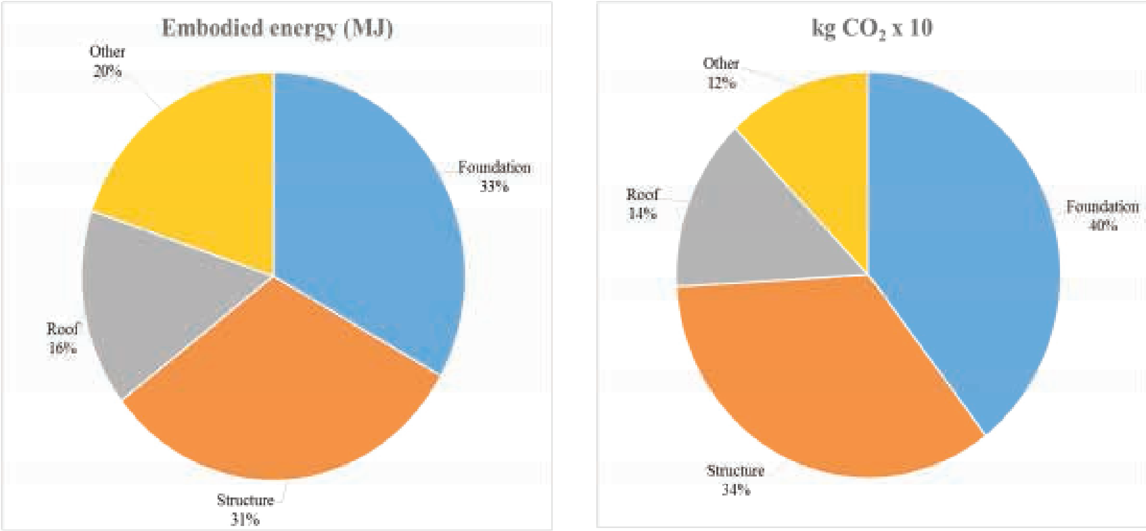


Figure 7 Life cycle EE and CO_2 emission percentages of each section of CS

3.2 Use Phase
The life cycle energy requirement and CO_2 emissions of the use phase for AS and CS are presented in Table 3.

Table 3. The life cycle energy requirement and CO_2 emissions during the use phase for AS and CS

Energy	*AS (GJ/m²)*	*CS (kWh/m²)*
Electrical energy consumption	13.2	12.2
Lignite coal consumption	43.9	36.9
Total	57.1	49,1
Emissions	AS (kg CO_2/m^2-year)	CS (kg CO_2/m^2-year)
Emissions from electrical energy	70	64.6
Emissions from lignite coal	481.7	404.9
Total	551.7	469.5

4 CONCLUSIONS

LCEA and LCCO_2A of AS and CS are presented. The construction and operation phases were considered in assessments.

The roof represents the largest EE requirement and CO_2 emissions when considering the construction phase for AS (87-64%). The foundation represented 9–33% and 27–40% of energy and CO_2 burdens, respectively; the structure accounted for 4–31% and 9-31%, for AS and CS, respectively and other (PVC and steel doors and windows) contributed 20% and 12% only for CS.

The findings showed that the embodied energy and CO_2 emission values of traditional adobe structures are found as advantageous as the container structures. The embodied energy value of adobe structure is 18% higher than container structures. However, CO_2 emission value is 45% lower than container structures. Use phase energy value of AS is also 14% higher than CS.

The traditional adobe structures should be considered as an alternative and effective solution especially for environmental and energy policies in the long term.

Further studies are needed for different climatic and socioeconomic perspectives, including demolition phase.

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6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

Survey and Analysis of Various Domes in the Structure of Traditional Iranian Buildings

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ABSTRACT

One of the most important structural parts in traditional Iranian buildings that has an impact on the formation of architecture as well as the landscape is the section of the coatings, in particular the domes. Traditional Iranian domes are among the most prominent examples of traditional buildings in Iran. It has been around for thousands of years and many have survived for many centuries. Dome practices, recognizing its types, examining structural performance, drawing styles, stylistics, executive methods and related issues are covered. Domes have always been a concern of Iranian architects. The purpose of this paper is to study and analyze the types of domes in traditional Iranian buildings for the sake of their appearance and construction technique. After introducing the history of the construction of the dome in Iran, this paper examines its position in Iranian architecture and defines the terms of the word dome. After describing the types of domes, the constituent parts and their technique, they are analyzed in the structure of traditional Iranian buildings. In this regard, the paper is also trying to use the resources of the library and the historical descriptive method to find the results related to the subject.

Key Words: Dome, Islamic architecture, Iranian Buildings, Tradional Iranian domes

1 INTRODUCTION

The Islamic architecture of Iran is rich in valuable treasures, which always seeks to create a sense of desirability and spirituality. In addition to the impact on users, certain areas are also featured as indicators of identity. One of the most prominent examples of these values is the dome. Iranians from the past considered and used this element in buildings as an intermediary for separation from the earth and connection to the sky. They are pioneers who have presented innovative ways in the structure and development of this element on the base of the quadrangle. In buildings such as mosques and tombstones, they have been used as an elemental identity (Mahdavinejad and his colleague, 1391)

In traditional Iranian culture, the shape of sephere always has a profound meaning in relation to the heavens. The landed dome is a worldly manifestation of the ideal heaven. The construction of the dome in Iran dates back to the third millennium BC. Since then, Iran has created various types of structures with the best shape of the dome, using traditional methods. Since dome construction method in Iran has always been applied by using the exact mathematical order in the formulation and construction of correct methods, many still exist (Hejazi and Mirghaderi, 1382).

Although the dome in the traditional Iranian buildings has an inescapable connection with other elements that give meaning to the function and form of Iranian architecture, they contain mysteries, on their own. Independently, researchers have been discussing various issues and especially in recent years, the trend of these studies has grown.

The Iranian buildings' domes have different categories such as appearance and differentiation from domes constructed in other countries, shape, structural systems, and the process that has been carried out for many centuries, structural strength and stability. The theoretical foundations are related to the glory and beauty of origin.

2 HISTORY OF THE CONSTRUCTION OF DOMES IN IRAN

From pre-historic to contemporary, humans have made dome buildings and residences by using materials available at the site. Dome cover in Iran has a long history. The lack of solid and stretched wood, which is in fact the main element of the flat cover, has led to the validity of the coil and dome cover, and especially in the wider openings.

Although it is unclear when the first dome was built, scattered samples of the dome-shaped structures were discovered. Recent discoveries in the ancient site of the Chaghamsh Hill (6800-3000 BC), located in the Dezful plain, show the use of mud bricks and adobe structures in the construction of the dome (Ghodar, 1358).

The oldest curve shapes are seen in underlying casing chogazenbil in the second millennium. With a long interruption during the Hakhamanesh period, a high and flat coverage appears to be at the peak of power and efficiency. But it was not possible thereafter due to the lack of economic conditions during this period, it was difficult to bring the cedar wood from Jebel Amel and Teak to Gandarah. And in the forests and plains of this land, there is not enough wood to be covered, so the use of curve designation and dome will find its place as a structural and climatic phenomenon in Iranian architecture (http.en.wikipedia.org/wiki/Dome, 1393).

Sassanid Persian architecture is likely to inherit Mesopotamian domes. The ruins of the Ardeshir Babacan Palace and the castle daughter (Firuzabad) in Fars province, built by Ardeshir I (240-224), show the use of the dome by the Sasanid Empire. During the Sassanid period, the construction of domes are becoming more and more evolving, and from now on, to this day, the coverage of a dome in terms of construction is used as a general pattern and instruction. Dome construction method, either during the Sassanid or in the Islamic period, is used based on the exact mathematical order in the formulation, construction and application of the method. Correctly done, in all types, the domes are well adopted without any need of foroccasions and the body and mold resist all compression forces and throwing pillars. Although from the early Islamic era till the present, various developments have taken place, the construction dome method in Iran has always followed its specific cultural and special performance. It is worth mentioning that this characteristic, whether in the form of the run (not having the template), always distinguishes it from other domes in the east.

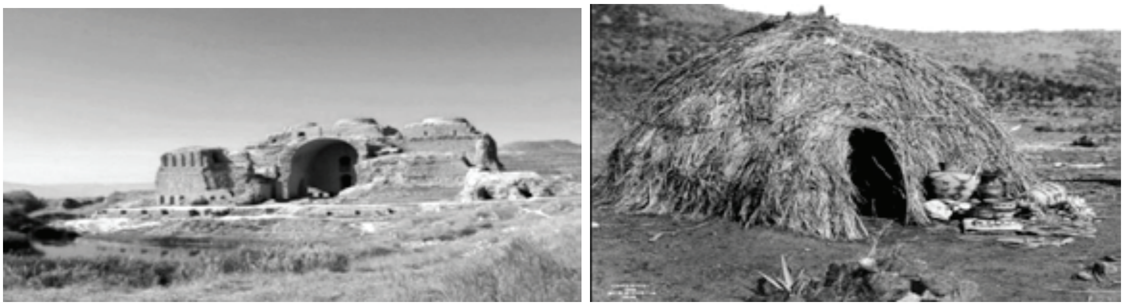

Figure 1&2. Example of the original dome (right) Ardeshir Babakan Palace, the Sassanid Dome (left), (15)

3 DOME POSITION IN IRANIAN ARCHITECTURE

The Iranian dome, apart from the special meaning that has been accorded to it by the architects, has always reigned in Iran.

The Iranian dome has a deep link with our soul, a sense of whether you can watch it from the outside or dipped in the sky from the inside of the dome. In Iranian culture and architecture, the dome form has always had a special place and the dome can be considered as one of the representatives of the Iranian-Islamic architecture.

Examples of these domes are visible at the Chogha Zanbil Ziggurat and the Saragong Palace. But over time, a lot of changes were made to these forms, which resulted in the significant development of Iranian architecture in the construction of such a building. There are two main reasons for using the dome form in Iranian architecture. (Ashrafi, 1392).

1. Special position of the spherical shape in Iranian culture. 2. Materials available to the architect

The dome form has always had a special meaning, these symbolic meanings are common in some cultures.

The square or rectangular building - called Bashan – is the symbol of the earth and the domain of the dome is the symbol of heaven.

This interpretation can be seen in other cultures. For example, in the Buddhist culture, one can find some kinds of beliefs. Stupa Buddhists and domes constructed under the center of the Byzatine churches also partly show this meaning. In Islamic culture, in addition to the meaning mentioned, the Mogharnas arc is considered as a mediator between the earth and the sky.

In Iranian architecture, they built a dome without using the mold. But at the same time, the order that governs it is so precise that it exhibits the best resistance against all kinds of seismic and thrusting forces. The highlights of the dome-shaped construction form are the static nature of these building.

Domes, which, by definition, have a rotational geometric shape, are bilateral in curvature, transfer forces of weight and other forces, essentially with the mechanism of membrane forces to the support. The geometric shape of the dome possesses this property, which usually produces the low tensile stress in these forms. Therefore, it is possible to construct domes with building materials (flowers, bricks, and stones) that can not tolerate bending forces.

From the point of view of the evolution of the building forms, the dome forms have the ability and superiority to the framing forms and even the vaulted construction forms. Another advantage of the arched arch and dome is that the wind passes away from the convex surface with less ease and less erosion and degradation (the same).

4 DEFINITION OF THE DOME

4.1 Geometric definition of dome

In the geometric definition, the dome is the geometric location of points that arise from a distinct revolutionary time around a vertical axis. But in the architecture language, the dome is a cover that is built on a circular background.

4.2 Applied definition of dome

It is a semi-spherical or concave overhead dome that is usually located above the circular planes, or square and multicolored circles, with the help of circular earrings.

5 DOME TYPES BASED ON THE APPEARANCE

In a territory such as Rome, the shape of the hemisphere was chosen for the dome because the thrust curve did not match its curve. They had to make the edges more stable in order to prevent the drainage of the barrier. If the Iranian architects preferring the semicircle did not know the proper cover, they would choose shapes such as egg, Chinese peach and oval, which would be driven by the membrane itself. This choice made it possible to dip the thickness of the dome in its origin and purge by only one-sixth of the span (which, however, went up taller to reach the stigma).

1) Onion dome, 2) Mogharnas dome, 3) Dome Elliptical, (4) Dome of the Parade, (5) Multi-Dome Dome, (6) Dome of the Yacht, (7) Dumb of Daisies, (8) Dumbbells

6 DOME TYPES OF TRADITIONAL IRANIAN BUILDINGS

According to the classification of Professor Pirnia, the dome is divided into two main groups in terms of form (Pirnia 1365).

Figure 3, 4&5. Right to left Onion dome, Mogharnas dome and Yawn dome (15,17)

6.1 Nar Dome

It is the most common type of dome in Iran. The form of this dome is spherical and is the main roof covering of the most important mosques in Iran, such as Juma Mosque, Imam Mosque, and Ahle Vardikhan Mosque in Isfahan, Jame Mosque in Yazd and Agha Bozorg Mosque and school in Kashan. The dome of these mosques is made up of two shells, namely two domes on each other.
The loader is in the domes of two shells, the common underlying crust, and the crustal shell for posing as well as dealing with atmospheric agents.

One of the reasons for the two domes is the size of the city since large and long domes signify the importance of the building. These domes should be adapted to the scale of the city and be seen from different parts of the city. Preferably, therefore, a high dome is built. But because the scale of the hall below the dome is not very heterogeneous and does not look like a vertical tunnel, the lower crust runs at a lower altitude.

Because of the thickness of the lower dome, which is the loader, it is closer to the tip of the dome, so that the weight of the dome is reduced. For this reason, it bridges onto the dome (like the dome of the glaciers), and to cover this roughness, the second dome is struck. But the dome of the two shells is better in terms of reducing the heat exchange between the inside and outside of the building. Relatively warm air, stagnant between the two, prevents the exchange of heat, but it should be noted that there is no room for confinement in the building, because due to the humidity of the air and the condensation of moisture at night or in cold weather, and turning it into water, it damages the materials from inside this space. Therefore, the air between the two shells must always be ventilated (Qobadian, 1389, 137.)

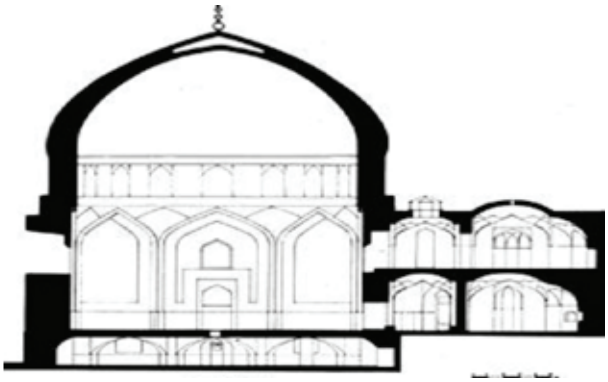


Figure 6&7. The dome of the Sheikh Lotf Mosul, an example of the Nar Dome (two continuous shells) Source (Ganjnameh and writers)

Types of Nar Domes:
A. Curved domes: From the full time of a revolver, it grows sharply around the vertical marble axis.
B - Lacquered domes: From the discontinuous time, a wafer rises around the vertical axis of the snake.

6.2 Dome rack Dome of the rock
Dome rack is pyramidal or cone on a cylindrical base or prism often placed. The most famous of these is the Qaboos dome in a city of the same name in Mazandaran province that is tomb of Shams al-Ma'ali Qaboos bin Voshmgir Al Ziar. It is considered the best example of the 4th century AH. It is also used as a monument for the sultans and Seljuk rulers (Pirnia, 1365).

There are so many cases of Rack dome in the Caspian Sea. It may be claimed that they are located more on this coast than the other parts of Iran because the climate is better.
Nan Dome is located in this area because it is faster and better than the dome NAR passes away from the building and has a lot of resemblance to the steep roofs of the locals. On this side, this type of dome is enclosed with wood truss and covering tile, pottery or boards.

If you are building a brick dome:

The dome is run by two shells, and it is often proportional to the scale below, and also more robust in terms of instruments (Qobadian, 2010, 140-139).

Types of rack domes:
a) Ocherine dome (stairs): The ocherine dome is similar to a dome of a conical rack, but a staircase exists on it. This dome is called the dome of the stairs (in English, the dome of pineapple). This kind of dome was used only for the direction. In terms of spatial structure, geometric relationships within and between the dome are divided into two types of ocherine. The domes of which there are dignitaries and those whose rules are multi-religious (Sa'idian et al., 2011.). The most famous of these domes is the tomb of Daniel Nabiin Shush. Other buildings with a dome of the Orechin are the tomb of Imam Sarband and the tomb of Jacob Lith in Dezful, Imamzadeh Abdullah in Shushtar, Imam Zadeh Jafar in Borujerd, Imamzadeh Mir Mohammad in Kharg Island, Tomb of Sayyed Salehiddin Mohammad in Abdanan (Iylam Province) and also Dome of Zubayd Sultan and Tahrir Sheikh Omar Sohrevardi.

b) Chestock (cone) A dome that is a complete cone, that is, the volume formed from the full time of a uniform equilateral triangle around its constituent angle. The more precise definition is the geometric location of the lines that connect the circle's circumference to a point above the circular plate, located on the vertical axis of the snake, on the center of the circle, such as the desire of the Radkan Quchan (Raisey Nefchi and free, 6.)

c) Pyramid: The domes of the Imamzadeh of Aboululu Kashan and Dome of Hajj Abdul Samad Monastery in Natanz are some examples.
d) Sarvak: Rack domes come from some of the archways like Chafad Sarvak. The domes of Shah Ligham, Ali ibn Hamza and Ali al-Din Hussein in Shiraz are some examples.
e) Rack and Narcissus Combination: That is, they have docked the dome on Nar. Most of these domes are up to a certain height of the shafts, but then the line is the straight line (the same) instead of the grave.

7 TYPES OF ROTARY DOMES IN TERMS OF THE ARC OF THE BASE

All the vaults, arches and domes are divided into two categories: "prostrate" and "dirty". In all sorts of forms, the arch is curved but the graceful shapes of the summit are pinnacle. The same is true of the rotating dome cover, which dates from the era of different types of daisies around their vertical axis. On this basis, Sagre is a period of time, a sharp knife, a dome, and if the basis of the arched arch,the dome is lame (Reyes Nafchi and Azad, 2010)

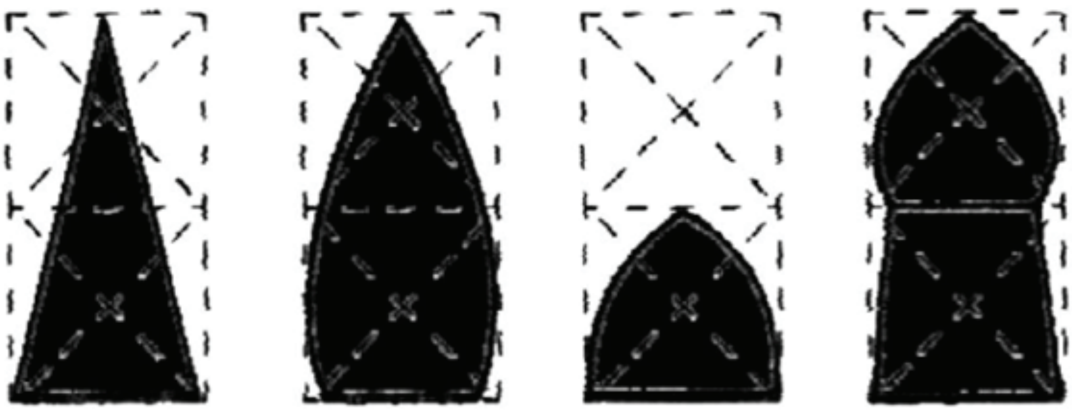

Figure 8. Comparison of the dome height of the nar dome and the rock dome in the nar dome used grave to reach the height of the long. (Source: Reyes Nafchi and Azad, 6138)

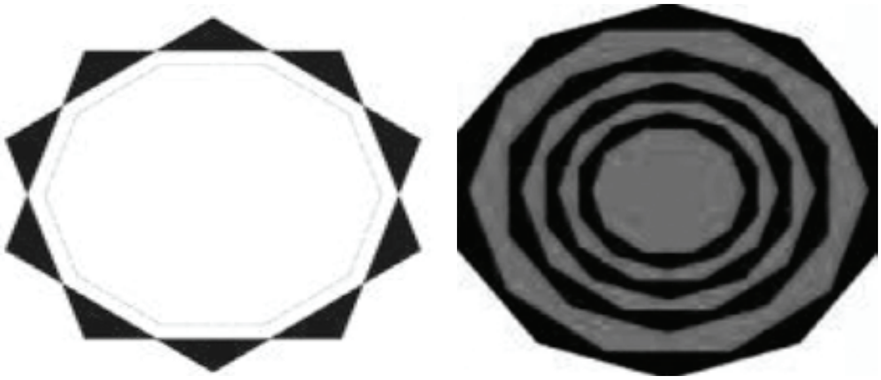

Figure 9&10: Dome plan with dummy base (right) and dome plan with a multiplying rule (Source: Saeidian 2011)

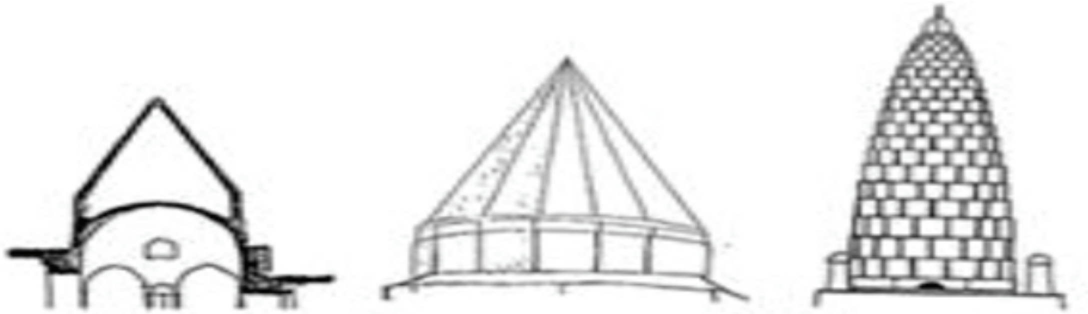

Figure 11. Three major types of rack domes in Iran (steppe, pyramid and cone) (Source: Zermanshid)

8 COMPONENTS OF THE DOME BUILDING

The dome consists of three parts:

1-Dome of the house = Dome field
2-Benshn = The body is the part that appears on the background of the color of the cube, rising up to one or both sides. (In pre-Islamic domes, all four sides led to open openings).

Chipper= accumulated
In Iranian architecture, we rarely get to the bottom of the round color, and usually the end section of Beshen is in the form of a square and sometimes a rectangle. After chipping out, it turns into a circle, then the dome is mounted on it, so the chipping stage in the dome is worthy of attention because it is possible to have a rounded field that allows the final execution of the dome to be covered. Usually, in maps that are dome-shaped, the field is considered as a square so that it can simply be converted to 8, 16, 32, and finally, the circle is created (http:/www.persianpersia.com)

9 CONCLUSION

According to the studies conducted, it can be concluded that in the construction of traditional Iranian buildings, design criteria, resistance, hardness and stability were not considered but the masterful unity of science was applied. Both the structural and architectural features of the building ensured the full function of the building, reminding that the structure and architecture were the same.

According to the studies, it can be concluded that large buildings are constructed today without the need for central columns by using the materials and everyday technology.

The PHD dissertation will focus on the issue of how to use the modern structural system (called cable structures) in brackets and domes.

In this paper, the design of openings and covering roofs in ancient times was studied, but in the PHD dissertation, cable system used for covering roofs and openings in the modern world will be examined.

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The Role of Materials in Sustainable Architecture from an Environmental Point of View

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ABSTRACT

In recent years, the increase in construction rate has led to the production of various forms of waste spread across the cities, contributing to environmental pollution. Modern buildings, especially in the cities, are constructed of new materials. The level of energy that is used for production of such materials is relatively high. To reduce the environmental risks associated with construction materials, we need to analyze the energy consumed throughout the entire life cycle of such materials, starting from the time they are extracted from the nature to the time they return to the nature. In this research, we have analyzed the environmental challenges that can possibly surface due to improper use of new/modern construction materials. Moreover, we have evaluated the advantages of using local construction materials from an environmental perspective and have proposed using local materials in construction projects as a safe, useful, and low cost solution. The processes for producing both local and modern construction materials, from extraction from nature to their return to nature, and their impact on environmental pollution have been studied and compared. Each stage in the life cycle of materials is described in this framework. By analysis and comparing local and new/modern materials, the benefits of local construction materials as a better choice are discussed. Some of these benefits are: no damage to nature during the extraction process, lowest impact on air pollution, low consumption of energy during the production process, saving on transportation energy, reducing energy consumption during the operation, reducing costs, and most importantly, fast return to nature and no degradation to the environment. However, the use of local materials has its own requirements and conditions.
Keywords: Local materials, Sustainable architecture, Life cycle, Environment.

1 INTRODUCTION

Increasing building construction in cities is coupled with the destruction of not-so-old buildings. Buildings are often made with non-local and new materials such as pottery brick, plaque, gypsum, cement, steel and glass. These kinds of materials are transformed into waste after destruction, which results in environmental pollution in cities. In the future, industrial and chemical materials such as aluminum, plastic materials, bitumen and combined materials such as asbestos and Iranites (used in new construction) will be added to these wastes. Overuse and improper use of new materials has caused irreparable environmental damage. Given the advent of industrial materials, such damages will be more and more harmful. The energy used to supply new materials is very high. High consumption of energy in the building sector and many environmental challenges make it essential to review the construction process in the country. Effective and critical decisions are usually taken during the design process of the building construction. At the design stage, decisions are made that will affect the environment and nature until the end of the lifecycle of the building and even years after its destruction (Zhou, Yin, Hu, 2009). Selection of materials is one of the architects' decisions in the design process and if not properly done, the recovery will be difficult. However, a lot of factors are involved in selecting the desired materials when designing buildings. Here are some questions: What is more harmful to the environment and what factors contribute to this choice? What is the difference between local and new construction in this regard? Various environmental factors have been analyzed in a variety of studies. However, there is no framework that includes all these factors. In some cases, these frameworks emphasize on a specific problem. In this research, understanding the environmental impacts of every building material is analyzed, taking into account the entire life cycle of that material.

1.1 Purpose

The purpose of this paper is to examine ways to minimize the consumption of fossil fuels with the aim of - Maintaining environmental safety and energy storage, Creating buildings to meet the needs of society and solve human problems, Visual and functional coordination with the climate of the region, Creating comfort in the building, Increasing the average life of the building, Reusing or recycling building components and Improving the quality of the structure.

1.2 Methods

The research method is based on literature review and field studies. The literature review includes studying papers in the field of rural and urban life and statistical resources. In the field study method, to study the characteristics of housing in rural and urban context considering the diversity of Iranian ecosystems in terms of the extent and location of their spatial dispersion as well as the persistence of choices in different regions in determining these areas, the main framework of the cluster sampling method has been used. In selecting some patterns, the local features of the area are considered so that the region is compatible with the climatic conditions and achievements of the architecture.

2 SUSTAINABLE ARCHITECTURE

The focus of all discussions related to the sustainability has been the future of the environment and the protection of the global environment. The most important definition of sustainable development is related to the Rio Summit which states: An agenda that addresses the current human needs without compromising the needs of future generations as well as the attention to environment and tomorrow's generations. The principles of sustainable development in relation to environmental sustainability include the consideration of the use of renewable resources, the use of less non-renewable and polluting energy, the provision of basic human and social needs, and the creation of a healthy environment for future generations environmental attention and pollution reduction (Beranvand,1390).
The expression of sustainable development in the field of built environment is called sustainable architecture. What has been considered in this article is a sustainable architecture approach to environmental issues: although it is difficult to isolate this from other economic, cultural and social aspects. According to Richard Rogers, sustainable design aims to meet future needs without destroying the remaining natural resources for the next generation. In the case of buildings, sustainable design refers to resource efficiency, minimum energy flexibility and long service life. According to Jong-jin Kim, three principles for saving natural resources include life-cycle design and human design of sustainable architecture topics.

3 LOCAL MATERIALS

Local materials consist of existing or available materials in a village or city or materials imported to a village or town from a short distance (Veise, Khodabandeh, Hakkakifard, Tahmasebi, 2009). The term "boomavard" means the materials belonging to their own area and place according to Professor Pirnia. He considers one of the principles of Iranian architecture as its perfection and considers the use of "boomavard" materials as self-constituting examples (Pirnia 2008). In this article, the term local materials emphasizes on "the boom" of the materials and the use of local technology in the production and extraction of such materials.

4 ATTRIBUTES OF SUSTAINABLE MATERIALS

In the context of sustainable architecture, the characteristics of suitable building materials are considered as the consumption of energy and the amount of contamination that it minimizes (Zimmermann, Althaus, Haas, 2005: Calkins,2008) does not endanger the nature of its production (Wever, 1997), its primary sources are renewable (Wever, 1997), consumes less primary resources and water and energy (Calkins,2008: Akrami,2004).

Characteristics also include minimized need for raw materials extraction (Kim,2003), durability and high strength to increase the life span of the building (Godfaurd, Janssen, Hendriks, 2005; Isik, 2008), preventing poisoning and carcinogenization, preventing noise, producing fewer wastse (Zhou, Yin, 2009; San-jose, Losada, Cuadrado, 2009, calkins, 2008), low cost (Veise, Khodabandeh, Hakkakifard and Tahmasebi, 2009), forming in the production and in the process of recycling (Howarth, Hadfield, 2006; Gabriella, Janssen, Hendriks, 2002), the right selection of materials according to the area to reduce energy consumption during the exploitation of the building (Morel, Mesbah, Oggero, Lyons,2007; Zimmermann, Althaus, Haas, 2005), restoration to nature, and possibility to return irrigation water to nature (Powel, Craighill, 2001), possibility to reuse (Calkins, 2008; Yagi, Halada, 2001: Wever,1997) short transport distance (Veise, Khodabandeh, Hakkakifard and Tahmasebi, 2009) (Calkins,2006), repair at the time of operation (Yagi, Halada,2001), availability of manufacturing technology and no need for advanced machinery (Veise, Khodabandeh, Hakkakifard and Tahmasebi, 2009). The above factors, which can be interpreted as a reduction of resource consumption and reduction of waste production, should be considered throughout the life cycle of materials (Gabriella, Janssen, Hendriks, 2002; yagi, Halada, 2001).

5 TYPES OF PRODUCTION

Production can be classified as mass production (centralized) and local production (decentralized).
Local production: Materials such as brick and adobe can be produced locally[9]. This kind of production of materials is called local production. But nowadays, ceramic bricks are manufactured in a factory in a centralized manner.

Regional production: Cement is a type of material that has a long and complex production process but can be produced in any region of the country. This type of production of materials[10] is called regional production and is classified as Type II.

National production: Metals are produced with a long and complex process [11]; this kind of material production is called the national and is classified as Type III.

The nature and type of manufactured materials affects the consumption of energy in production, energy in the transportation of raw materials and energy in the transportation of the product.

6 LIFE CYCLES OF MATERIALS

To understand every material and its environmental impact, we must consider the entire life cycle of materials (Gabriella, Janssen, Hendriks, 2002; yagi, Halada, 2001). In Figure 1, this cycle involves extraction, processing (production), transport, warehousing, utilization (in the building), exploitation, demolition and return to nature. This chart is the result of a combination of several graphs from studies conducted by other researchers. What is important in terms of sustainable architecture in this cycle is the energy consumption and pollution that comes to the human environment (Zimmermann, Althaus, Haas, 2005).

Reducing energy consumption, reducing water consumption and other resources are the main goals of sustainable architecture (Akrami,2004). It is therefore necessary to examine the environmental hazards of materials throughout their life cycle. It is important to avoid causing poisoning and carcinogens3, preventing noise and waste at every stage (Zhou, Yin, 2009; San-jose, Losada, Cuadrado, 2009).

The issue of reducing energy consumption and consequently, reducing costs is not just about the initial stages but is also considered throughout the life cycle of materials and even in waste management. In Figure 1, nature and the environment are located at the center of the cycle. All building materials (or their raw materials) are extracted from nature and then they pass the production steps and are carried to the construction site. After construction and at the time of exploitation, the properties of materials can be effective in reducing environmental hazards. After the end of the lifecycle of the building, the fate of the materials depend on whether they are used again or returned to the production cycle or returned to nature. In each stage of the life cycle of materials, there are certain points that should be considered.

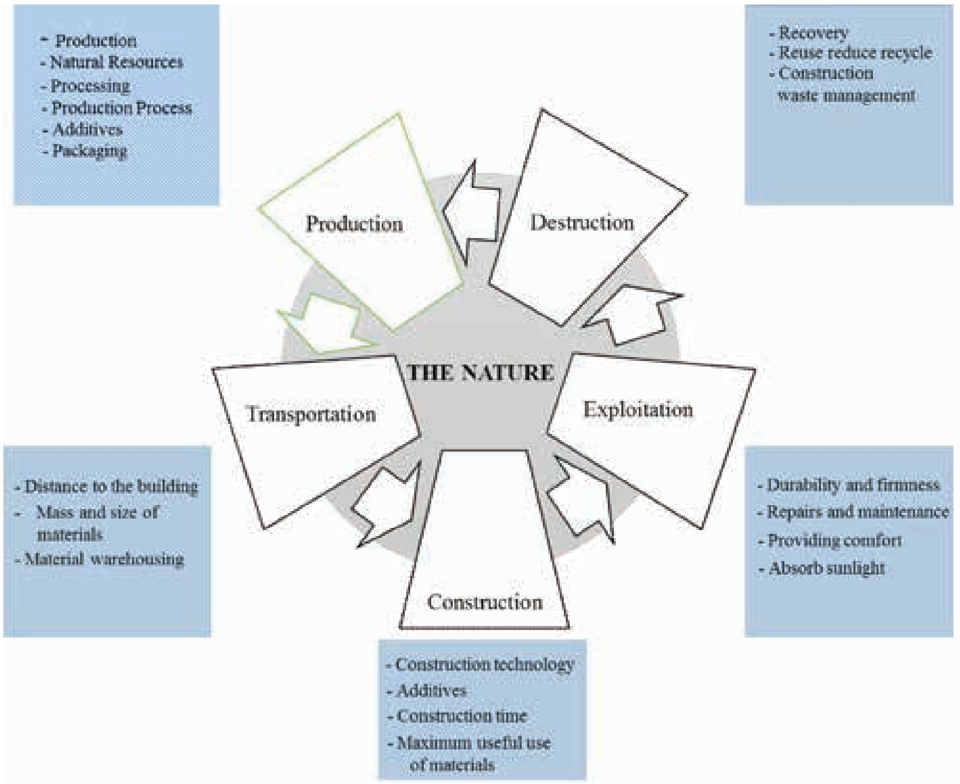

Figure 1. Material Life Cycle (Source: Research Finding)

7 PRODUCTION

The production of materials has a process that is remarkable. The process of producing all the materials is not the same. This process may be long or very short, but all materials are extracted from nature. The extraction of some materials such as wood is renewable. The extraction of some materials such as iron is long and complex. These types of materials are usually not reversible or their return to nature is very long. Some materials are available but some others have to be extracted. Soil is one of the available materials. Soil is extracted (4) directly from nature and returned to nature very quickly. Materials like lime and gypsum are extracted from mine. These mines are not readily available. Some other materials are not pure in nature and should be produced in a complex process such as cement and steel. The extraction of renewable materials (soil) has the least pollution and degradation for nature and the environment.

7.1 Production Stages

Extraction of materials is associated with contamination and energy consumption. Irregular extraction destroys nature and its destruction is irreparable. Under such conditions, nature (environment) is at risk of being destroyed (Wever,1997). For example, rock mining destroys the mountain. To produce cement or metals, much of the nature and environment are degraded quickly. For example, the "givchal" mine explosions destroyed the environment in the "Alamkuh" and "Takhte soleyman" regions and caused the "Sardabrud" river to flood and other unexpected events (selahvarzi,2006). The primary sources of materials must be renewable (Wever, 1997). In other words, the exploitation of resources should be done in a way to be possible to renew it. For example, the uncontrolled exploitation of forests for the production of wood causes their rapid destruction6. If the exploitation is carried out in a principled way and with the study, the forests will have the possibility of re-fertilization. With planning, management and investment, you can build the wood needed for construction7. The production of wood is useful and productive for the environment. Some materials such as wood and soil are consumed naturally and do not need to be processed. The production of some materials is associated with a great deal of energy and pollution. For example, stones can be used naturally (as used in native architecture) and if necessary with a slight deformation (such as rocks of rubble and carcasses). On the other hand, slate is used to produce a high amount of energy. In addition, degradation and pollution of air and environment are accompanied by noise8. High energy consumption, including water, electricity and fossil fuels is necessary to prevent it. So, the greater the use of raw materials, the lower the consumption of resources will be (Kim,2003).

In the production of many processed materials, chemical additives may be added. These materials (such as plastic materials) are often toxic and have many environmental hazards (Calkins,2008).

Since the durability of the materials affects the life cycle of the building and have an environmental value, the quality of production and the quality of the manufactured materials are considered. (Godfaurd, Janssen, Hendriks, 2005). The selection of materials of better-quality is considered an environmental strategy. Therefore, during the production, efforts should be made to optimize the product and its quality. Of course, high-quality materials also multiply costs.

7.2 Primary Transportation Costs

Local materials such as soil, local stone (rubble and ballast) and wood are the least expensive for local materials. But materials that require complex and long processing such as cement and iron impose a high cost of transportation. In order to supply cement, raw materials should be shipped to the factory with high energy costs, and then cement produced should be shipped to the building. For the production of steel, iron ore must first be explored and extracted in different parts of the country. And then the iron ore should be shipped to the factory from a place of several hundred kilometers with high energy consumption. Then, through very complicated processes, it will convert extra energy with a long and polluting process into steel to be transported and used for consumption again, with energy consumption throughout the country. Transportation of materials such as iron and steel requires energy consumption[12]. Also the use of iron and steel requires energy[13]. Therefore, materials such as steel have a very long process of extraction and consumption, and they consume a lot of energy in this process and are equally polluting and costly (Howarth, Hadfield, 2006). Regional materials consume less energy although they may not have a national difference in terms of pollution. The cement factory contamination around its surrounding destroys farms, forests and pastures. No living creatures in the pollution area of the cement factory are immune[14]. But in contrast to local materials, local materials have the least energy consumption both in production and in transport and also have the least pollution in production, thus producing a low level of pollution in the production cycle to consumption

8 CONCLUSION

In this research, the problem of material selection has been investigated. All factors to be considered in selecting sustainable materials should be according to the description and analysis of the life cycle of materials. By recognizing effective environmental factors and studying each of the influential factors, it has been determined that the use of local materials in each building area reduces the environmental hazards of construction. The privileges of using local materials are categorized as follows:

-The source of local materials is renewable.

-The use of local materials is often done in raw form or by simple processing, so they do not consume much energy in the production process.

-It does not require advanced technology and plant construction to produce this material.

-In the transportation stage, due to the short distance of transportation, there is less energy consumption and less contamination.

-In the construction phase, its manufacturing technology is simple and available and does not require advanced machines.

- In terms of noise and pollution and waste at the time of construction, it is at the lowest level.

-In the course of exploitation, they are in compliance with the climate of the site and they have a significant role in reducing the cooling and heating energy consumption.

-Provides repairs during operation.

-At the time of building demolition, local materials are returned to nature or used in other applications and do not produce waste or are very brief.

Therefore, using local materials compared with new methods of construction, less damage to the environment entails a more stable construction. The use of new materials and imitation from other countries without the knowledge and application of its technology will cause excessive consumption of energy and pollution. Although the use of these materials due to high resistance is inevitable, it should be done in a smaller volume and in a way that is most effective. The use of these destructive materials should not be in the form of fillers, but should be exploited at the very least. In this case, the production of abundant waste in the degradation stage, which leads to the destruction of the environment, is reduced. Therefore, a general review of consumer goods should be made and as far as possible be used for materials with safe environmental factors. In this regard, local materials can be the best options. Of course, we have to try to reuse these materials and fix their shortcomings.

9 ACKNOWLEDGMENTS

This paper is part of the Academic research, I thank the professor *Bilge Isik* very much because without her guidance it was very difficult to finish this dissertation. from Mr. kamran dehgan because of the many reliefs and aids that made it a lot easier for me.

10 REFERENCES

[1] fiberglass, plexiglas,polyethylene,etc.which returns to nature for hundreds of years.
[2] Life cycle assessment.
[3] Consuming chemical and combined materials (Iranites and asbestos) causes cancer damage to consumers.
[4] Extraction here means direct harvesting.
[5] alamkuh and takhtesoleyman are part of the national natural works that are part of the four ecosystems,and the givchal stone mine one of the most expensive granite deposits in Iran is located near this area.
[6] The forest must also be naturally harvested and exploited to stay stable,so if the exploitation of the forest is done correctly,and if any other tree is cut the other seedlings are planted,the forest remains intact and sufficient wood to consume. In the past when the villagers and natives used the forest, they did not damage the forest.because the villagers knew how to harvest the trees of the forest. However since the forestry and environmental organization has been the forest protection officer the peasants' hands have been shrinking from the forest and the factories have cut and destroyed the forests. So far over half a century of land reform, about 80 million hectares of Iranian forests have disappeared.
[7] In the past, the villagers plant all kinds of trees,including the poplar tree and built their houses with wood today the villagers turned their attention and became consumers of iron and cement.
[8] Stone cutting factories pollute all of their surroundings with round stone from the cutting of stone and are breath-taking disease.the sound of stone cutting devices creates dust and eliminates the effluent of the farms.
[9] The bricks have been produced locally from Iran for a long time and today it is also being produced and can be developed.
[10] Cement is produced locally in Iran but many regions of Iran still lack the cement factory.
[11] In each country there are usually one or two steel mills.in Iran,the most important metal and steel factories in Isfahan Steel and Ahwaz Steel but unfortunately in recent years other provinces have been trying to create a house of steel in a fierce competition.
[12] Loading and unloading of iron and steel requires lift and crane and these devices consume a lot of energy.
[13] To use iron,it should be cut and used to connect to each other,they must be welded together.to carry them to height should be used car and tower crane which means a lot of energy.
[14] For example,Abyek Cement Factory more than 50 years old has been compromised for the health of the people of the region due to the excessive pollution produced by the region. The permissible dust and dust levels are 150 mg per cubic meter which is equivalent to 500 mg per cubic meter and more than three times the limit for the production of abeyek cement factory which is more than three times the limit and alarming.
[15] The production of various metals not only pollute the environment but also pollute the workers inside the factory so manufacturers must pay for the safety of their employees and workers.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
6th International Conference
Hasan Kalyoncu University, Turkey, 1-2 June 2018

The Use of Traditional Houses in the Diyarbakır Suriçi (Walled City) Region in Tourism, as Boutique Hotels

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ABSTRACT

Within the scope of urban transformation, renovation of Diyarbakır Suriçi region, which enjoys historical and cultural values, which go back to 7500 BC, is aimed for the rectification of damages it suffered in time due to natural events and people. Within the scope of the renovation efforts, it is planned to restore historical and cultural structures located in the region in a manner faithful to their original state, and therefore, to create a center of commerce and tourism. The relevant urban transformation project is fairly important, both in order for these structures to be handed down to future generations, and for the local community to obtain financial income. Within the scope of the present study, it has been aimed to perform the restoration and restitution efforts of traditional houses located in the Suriçi region, and to use these houses in tourism, in the concept of boutique hotels.

Keywods: Diyarbakır, Tourism, Re-functioning, Boutique hotel

1 INTRODUCTION

Diyarbakır Suriçi region enjoys historical and cultural values, which go back to 7500 BC. Within the scope of urban transformation, the renovation of the region is aimed for the rectification of damages it suffered in time due to natural events and people. Within the scope of the renovation efforts, it is planned to restore historical and cultural structures located in the region in a manner faithful to their original state. Within the scope of these efforts, which are important both in order for these structures to be handed down to future generations, and for the local community to obtain financial scope, it has been aimed to perform the restoration efforts of traditional houses located in the region, and to use these houses in tourism, in the concept of boutique hotels.

Within the scope of re-functioning of Diyarbakır Suriçi region's traditional houses as boutique hotels, in the first section, urban morphology of Diyarbakır, which has a huge wealth, in terms of cultural and religious structures, will be explained. In the subsequent sections, the definitions of tourist and tourism, concepts of tourism accommodation and hotel management, information on traditional Turkish house, with an example of the subject, will be explained. And in the final section, conclusion and suggestions will be presented regarding the re-functioning of traditional houses within the urban transformation to be carried out in Diyarbakır Suriçi region, and their use in the tourism industry as boutique hotels.

Written, visual and web sources will be researched and suggestions will be shared for the effort carried out in order for the traditional houses of the Diyarbakır Suriçi region to be re-functioned, and used in tourism as boutique hotels.

2 URBAN MORPHOLOGY OF DİYARBAKIR

2.1 History

The first known name of Diyarbakır is "Amidi", according to Assyrian sources. During the Roman and Byzantine eras, it was known as "Amid", "Omid", "Emid", and "Amide"; and after the settlement of Arabs and Turks to the region, it was known as "Kara Amid" (Black Amid). Under the reign of Arabs, it was known as "Diyar-ı Bekr", a name derived from the Bekr tribe. The Republic of Turkey finalized its name as "Diyarbakır" with the law issued on December 10, 1937 and under no. 7789 (1). The map of Diyarbakır Suriçi region is given in Figure 1.

Figure 1. Diyarbakır Suriçi Map (1)

While it is known that Diyarbakır's history goes back to 3500 BC, excavations made at Çayönü archeological site has shown that its history goes back to earlier times, to 7500 BC. In consequences of excavations conducted, it was learned that people, who were living a nomad life in the beginning, later started to live in villages, laying the foundations of current city life. During the relevant era, which is known as Neolithic period, many trails were blazed, with agriculture-based way of life, nutrition, economy, cultural and social relations. It has an important place in the world history (2, 3). A current aerial photo of the Suriçi region is provided in Figure 2.

The district of Sur is among the four central districts of Diyarbakır. The district was established within the boundaries of the Metropolitan Municipality of Diyarbakır, with the law enacted under no. 5747 in the year 2008 (3). The district is established at the area hosting the oldest settlement of Diyarbakır. The district takes its name from the Diyarbakır walls surrounding the city center. It is founded along Tigris River, on an alteration of 660 meters, over the extinct lavas of Karaca Mountain (4).

Figure 2. Diyarbakır Suriçi Aerial View (2)

The district has been the center of various civilizations and cultures throughout history; therefore, historical artifacts from these civilizations are still encountered in the district. Around 30 civilizations ruled in the district, such as Hurrians, the Mitanni, Hittites, Assyrians, Meds, Persians, Alexander the Great, Romans, Byzantines, Arabs, the Seljuk, Ottomans. These civilizations ensured the district's enrichment in historical and cultural terms. Each civilization reigning at the district, mixed the cultures and traditions of previous civilizations with their own cultures and traditions, and handed over the same to future generations in a richer manner (3). It ensured that the district remained a center in historical and cultural terms up to the present day, and that the history and culture were protected. Current City Guide of Diyarbakσ Suriçi is provided in Figure 3.

Figure 3. Diyarbakσ Suriçi City Guide (3)

2.2 Climate

Continental climate is seen in Diyarbakσ (5). At Diyarbakσ, where temperature is very high during the months of summer, winters are experienced warmer, when compared with the Eastern Anatolian Region, since South Eastern Taurus Mountains block the strong winds from the north. The annual precipitation average is 496 millimeters, 2% of which falls during the summer (6). The highest temperature was measured on July 29, 1946, with 48,4 degrees Celsius, while the lowest temperature was measured on January 11, 1933 with -25,7 degree Celsius (7).

2.3 Population

Diyarbakσ□s population is 1.570.943, according to TÜεK (Turkish Statistical Institute) data announced in 2011 (8). According to 2015 general census data, the population of Sur district was announced to be 117.698 (9). Children constitute 53% of the total population (10). It reveals that the city has a young population. Diyarbakσ is the 2nd most crowded city of the South East, in terms of population, after Gaziantep (8).

2.4 Economy

The economy is based on livestock, forestry, mining, industry and particularly, agriculture.

Agriculture: Total agricultural area, where plantation is carried around, is around 650.000 hectares per year. Vegetables, fruits, and particularly grains are cultivated. The main agricultural products cultivated are barley, wheat, rice, legumes, cotton, sesame, tomato, cucumber, bean, zucchini, pepper, eggplant, grape, mulberry, almond, pomegranate, and pear. Also, Diyarbakσ is famous with its watermelon. 10% of the watermelons produced in Turkey are grown in Diyarbakσ. Diyarbakσ watermelon is huge and very delicious (11).

Livestock: Efficiency currently obtained from livestock is low in Diyarbakσ. Cattle, lamb, goat, mule, and monkey are grown. Also, horse breeding is continually on the rise (11).

Forestry: The forest area of Diyarbakσ constitutes around 500.000 hectares. Most of it consists of shrubbery. Since forestry efficiency is low, afforestation activities are ongoing (11).

Mining: The richest oil fields of Turkey are found in the Diyarbakσ □Siirt boundary. Half of the oil drilled annually is drilled in Diyarbakσ, reaching two and a half million tons. The first oil-well in Diyarbakσ was first operated in the year 1961 by Shell. Since 1974, TPAO maintains its activities at the region (11).

Industry: Activity is going on in the industries of copper working, iron working, weaving and jewelry, and particularly construction, which displayed a huge growth during the recent years. Many factories are operated, belonging to private sector, and particularly to the state (11).

2.5 Transportation
Transportation in Diyarbakır is provided through road, air, railroad, and sea. Interprovincial access is provided via Elazığ – Mardin, Siirt – Bitlis – Şanlıurfa highways, Istanbul – Kurtalan railway and Diyarbakır-Ankara – Istanbul flights. Also, passenger, timber and cargo transfers are carried out through open boats known as "kelek", between the coasts of the Tigris River. There has been a huge increase in the number of vehicles during the recent years (11).

2.6 Accommodation
Boutique hotels, converted from the restoration of historical caravanserais and mansions, public-operated guesthouses, and particularly 4-star and 5-star hotels are used by domestic and foreign tourists.

3 CONCEPT OF TOURIST

Tourists are people, who leave their place of residence for at most one year, and spend money, which they do not earn at their destination, at the places they travel to (12).

3.1 What is Tourism?
Relations with regard to purchase of goods and services needed during travels made by people due to reasons such as vacation, fun, sports, health, etc. away from their usual place of residence, are known as tourism (12).

3.2 Historical Development of Tourism in the World and in Turkey
Today tourism is among the most important industries connecting regions, countries and continents to each other with economic and socio-cultural ties. Nations make various investments, such as human resources, superstructure, and infrastructure, to increase their share from the relevant industry, which grows each passing day. They also display efforts to use these investments in a sustainable manner for many long years, without damaging natural resources they have, and to offer the same to the use of tourists. With this mentality, the tourism industry is developed and renovated each passing day.

3.2.1. Historical Development of Tourism in the World
Since location changes made by people during the early ages are now evaluated as tourism, tourism is an industry, which has existed since early ages. The industry has changed a lot since the early ages due to changes in people's living conditions, wealth level, and business work hours, and also developments in communications and technology, and ease of access. The first modern tourism movement of the world started upon the discovery of compass. Compass enabled overseas journeys and new discoveries. With new technological developments, in addition to compass, the number of travels increased. The relevant increase in the travels also increased relations between societies, and lead to the birth of Renaissance movements in the 14^{th} century. The latter development ensured that travels are made in the world for the purpose of culture and arts. Tours, which last one to three years, known as "Grand Tours", were organized in Europe by some authors to increase knowledge and good manners. These tours have been accepted as first tours made in the world, in the modern sense (13, 14, 15).
In time, international tourism movements increased, through the development in industry and technology, discovery of locomotive, increase in people's wealth levels, particularly after World War II. Travel freedoms between nations, increase in nations' income levels, easier access through development of air transportation, and popularization of package tours changed tourism and the mentality of vacation. People's ability to allocate time for travel with the increase in their free time,

access ease thanks to the development of technology, travel and communication works, increase in income levels after all the family members started to work, and the increased retirement periods have led to an increase in vacations and travels (16, 17, 18).

Social, political and technological developments experienced in the twentieth century enabled tourism to become a large industry, which also involves the middle class (14). "Alternative tourism" movement started in the 1970's, in line with the wishes of the customers, due to the effect of the oil crisis experienced globally. In the relevant tourism movement, options were offered to customers with regard to wish, demand, and price. Customers of the alternative tourism movement consist of tourists, who were bored of mass tourism, are respectful to environment, nature, and historical and touristic values of civilizations, and who intend to visit, and get acquainted with the same and to socialize. Chernobyl accident, which occurred in the second half of 1980's, terrorism incidents, and financial problems experienced negatively affected tourism (19).

Today, with the increase in free time and income level, the presence of cheap, fast and various means of access, the existence of various means of accommodations, the increase of quality in service, tourism policies renewed upon the emergence of people's desire to improve them have made tourism activities easy, cheap and joyful. According to researches conducted, it was revealed that tourism contributed to people's language skill developments, the increase of their cultural and educational levels, nations' pride in their historical and cultural values and world peace (15).

According to World Tourism and Travel Council, around 12% of the employment opportunities created in the world result from the international tourism movement, and economic income and job opportunities created by the tourism industry have an important place. It is contemplated that international tourism will create additional job opportunities for around 11 million persons until 2016 (19).

Tourism industry is among the three most revenue generating industries in the world, after petro-chemistry and automotive industries. According to the 2008 data of the World Tourism Organization, the number of persons, which were around 25 millions in the year 1950, 439 millions in the year 1990, 687 millions in the year 2000, and 903 millions in the year 2007, will reach one and a half billion until the year 2020 (20).

3.2.2. Historical Development of Tourism in Turkey

With its geographical position, and as a settlement hosting the shortest paths, Anatolia connected many civilizations to each other in the past. Many historical artifacts, which still stand, were inherited from these civilizations. These historical values are used today by Turkey for the purpose of tourism. With regard to tourism, the most revenue-generating industry of our age, Turkey intends to increase its tourism incomes by supporting the historical, cultural and geographical richness it has with investments towards new superstructure-infrastructure, personnel, etc.

Tourism movement in Turkey first started with travels made by civilizations living in Anatolia during the first age in order to meet their needs, and it increasingly went on during subsequent periods for commercial, religious, health-related purposes etc. In other words, tourism movement in Turkey goes way back. Turkey has become an Open Air Museum with its historical, cultural, and geographical heritage. The first mass tourism in Turkey gained importance with Ephesus travels of Alexander the Great. These visits are accepted as the pioneer of Turkey's first mass tourism.

Modern tourism movement in Turkey started through commercial travels of foreign traders since the nation had large lands before the proclamation of Republic, during the Ottoman Period. The first modern tourism movement in the Ottoman Empire started with a fair held in the year 1863, titled Sergi-i Umumi-i Osmani (Ottoman Public Fair). During the same period, tours abroad were held by some tourist groups, whose starting point was Istanbul. Balkan War, Independence War and the fall of the Ottoman Empire caused the Turkish tourism to be negatively affected. After the proclamation of the republic, developments in railroads and journeys organized by Orient Express to Istanbul, helped the tourism industry to develop. “Otel d’Angleteer”, which opened its doors in 1841, “Peri Palas”, and “Büyük Londra”, which opened its doors in the year 1892, all in Istanbul, are among the first hotels. With the wish and support of Atatürk, “Türkiye Seyyadin Cemiyeti”, which is today’s “Türkiye Turing ve Otomobil Kurumu” (Turkey Touring and Automobile Institution) was established on September 29, 1923. In the year 1950, “Turkish National Youth Organization” was established. The latter became the first substantial travel agency of Turkey. In the same year, “Tourism Credit Fund” was first initiated by Türkiye Emlak Kredi Bank (1920).

Due to political problems experienced in the world between 1923 and 1950, the development of tourism in Turkey was interrupted, just like it was the case in other countries. The first planned period in Turkish tourism industry started in 1961, with the opening of “Ankara Hotel Management and Tourism Vocational High-Schools”. As of 1980, the number of these schools had increased to 7. In 1963, “The Ministry of Tourism Promotion” was established in Turkey. In the year 1968, 281 travel agencies were established, and in 1972, “Turkish Travel Agencies Union (TÜRSAB)” was established. Tourism Incentive Law, which was enacted in 1980, ensured the development of tourism in Turkey (19, 20). In the year 1984, the number of tourists visiting Turkey passed 2 million. While political and economic crises experienced in Turkey, both in the past and present, have affected tourism, tourism has always been an improving industry. The number of tourists visiting Turkey in the year 2011 was 31,445,076. In the same year, the countries visited by most Turkish tourists were Germany, Russia and England (21).
Turkey displayed a big development in the field of tourism within the last decade, and it is among the top 10 nations generating the highest income from tourism. Turkey acts as a bridge between Europe and Asia. The relevant advantage ensures that Turkey has an important market in terms of tourism (15).

4 LODGING AND HOTEL MANAGEMENT IN THE TOURISM SECTOR

Concepts of Lodging businesses, hotel, and boutique hotel will be described, followed by the research on their historical progression.

4.1 Lodging and Hotel Businesses

Lodging businesses are hotels, motels, hostels, camping sites and lodging houses. A majority of lodging businesses is comprised of hotels with stars.

4.1.1. Lodging Businesses

Lodging Businesses are the foundation of the tourism sector. Since early days, lodging businesses have been providing services at the tourism sector in various forms such as caravansarys, inns, guesthouses, ribats, motels, hotels, hostels, and holiday inns. Activities conducted by these businesses have changed through time along with technological advancements, and increase in education and income levels of people. Today, a majority of lodging businesses provide food and beverage services in addition to overnight stay and accommodation (13). Hotels that provide services within the lodging business first appeared in the United States in 1700s. In our country, lodging businesses have first appeared as caravansarys during the Seljuk period and has taken its modern shape in the 19th century in Istanbul (15, 20). “Peri Palas” and “Büyük Londra Oteli” opened in Istanbul in 1892 were the first modern hotels (20, 22). Nowadays, lodging businesses offer entertainment services in addition to overnight stay, bedding, food and beverages, and vacation services in order to increase their profitability (15).

4.1.2. Hotel Businesses

The most important example of lodging business is hotels because hotels are lodging businesses which are used more frequently compared to motels, hostels, guesthouses and holiday inns.

According to the Regulation on Investments and Enterprises of the Tourism Promotion Law No. 2634 which was published on 13.08.1983, hotels are divided into two categories.

"Hotel businesses are facilities with the main function of satisfying overnight stay needs of customers in addition to providing auxiliary and complementary units for food & beverages and entertainment needs and they are divided into two groups as hotels and lodging businesses" (23, 24, 25).

a) Non-Touristic Lodging Businesses
These are lodging businesses which are classified by local authorities and lack a "Touristic Operation License."

b) Touristic Lodging Businesses
These are lodging businesses which are classified by the Ministry of Culture and Tourism and have a "Touristic Operation License." Lodging businesses are divided into six different groups. These are:
- Hotels (1 star, 2 stars, 3 stars, 4 stars and 5 stars)
- Motels, holiday inns (4 stars and 5 stars)
- Apart hotels
- Guesthouses
- Hostels
- Camping sites.

4.2. Boutique Hotel Businesses
Boutique hotels offer high quality and comfortable lodging to hotel customers in order to make them feel like themselves. Customers enter into close interaction with the personnel and managers. Tourists lodged in boutique hotels address their shopping, entertainment, transportation and similar needs outside the hotel. Thus, they interact with people outside the hotel. As in the rest of the world, boutique hotels add variety to our country's tourism sector.

It would be best if we understand the word boutique before we get into the concept of boutique hotels. This will allow us to better understand the concept of boutique hotels. The French word "boutique" means "fashionable small shop", "a small shop within a large shopping mall", and "small enterprise offering goods and services with premium features." Oxford dictionary defines the word boutique as "a shop that sells fashionable clothing" (15). The Chambers Dictionary defines boutique or boutique hotel as "a small shop or hotel with an individual style and a sincere atmosphere." Based on these definitions, the term boutique in "boutique" hotels is being used as a literary term. The word boutique is emphasized as "small size" and "unique, different, personal services." Thus, we would define boutique hotels as profit oriented urban or rural hotels with a small market share in terms of customer mass and with its own structural features, architectural design, unique presentation, services and decoration, and high quality service concept (15, 26, 27).
Boutique hotels operate as businesses within historical buildings with unique striking and colorful designs and calm and romantic settings to provide luxury services in urban and rural environments. Serving based on this theme, boutique hotels have become increasingly more established businesses in the world and in our country. In our country, small hotels run by family members are called boutique hotels, even though they differ from boutique hotels.
Boutique hotels offer:

- Comfortable rooms with features defined for 5-star hotel rooms,
- A lounge, a breakfast hall, and a lounge suitable for its size,
- Furnishing and decoration, including furniture and materials with modern, reproducible or antique features,
- An a la carte restaurant,
- An administration room,
- 24/7 room service,
- General air conditioning system,

- Daily newspaper service to the rooms for at least one newspaper selected by the customer
- Laundry and dry cleaning services,
- Parking lot services.

Boutique hotel customers are usually those with high income. These customers spend money for food and beverages, transportation, entertainment and similar needs, thereby contributing to the tourism sector and the national economy. Therefore, boutique hotel businesses develop daily to provide services to both local and foreign tourists.

4.2.1. History of Boutique Hotels
Boutique hotels were designed and opened in 1981 by Anouska Hempel in London (26, 27, 28). International communication and advancements in tourism has resulted in boutique hotels opening up in all parts of the world. Warm and sincere atmosphere, location, physical structure of boutique hotels, along with special services provided to customers, strengthen their position in the lodging sector each day.

4.2.2. Boutique Hotels in Turkey
With its historical and cultural legacy, geographical beauty and natural resources, Turkey has a vast tourism potential. Demand for boutique hotels with high quality infrastructure and services increase every day. The tourism industry increase foreign currency income of the country, thereby having a positive impact on national economy. Boutique hotels contribute to variety in tourism in our country and are among the most important examples in the lodging sector. Today, there are 500 boutique hotels in Turkey and this number increases each day (15).
The first boutique hotel in our country was opened in 1980s, although they have started to appear in regions with high tourism potential such as Cappadocia, Çeşme, Amasya, Safranbolu, and Istanbul in 2000s. The first boutique hotel in our country was Yeşil Ev, which opened in 1984 in Istanbul. This was followed by boutique hotels opened after restoration of the Soğukçeşme Street in 1986 (30). With the increase in sea and sun tourism after 1980s, the number of boutique hotels in sports, cultural and historical areas has started to increase (29).

5 DEFINITION OF THE TRADITIONAL TURKISH HOUSE

The type of house called Traditional Turkish House is houses built on regions with dense Turkish populations during the Ottoman Empire period. They are usually two or three store frame houses that reflect Turkish customs and culture and their construction halted at the end of the 19th century. There are a couple of definitions for the Traditional Turkish House. These are:

“The Traditional Turkish House is known and identified as a type of housing which has a shape and plan that reflects lifestyle and customs of the Traditional Turkish Family and has met the needs of Turkish people for centuries” (30).
“The Turkish House is a type of house which has been created in Rumeli and Anatolia regions within the Ottoman Empire and has lasted for 500 years while distinguishing itself with its unique features” (31).

If we are to come up with a definition based on the definitions above, Turks have merged their culture with local cultures when they arrived in Anatolia to create a type of house.

5.1. Creation of the Traditional Turkish House
This type of house that reflect the Turkish culture was formed by various factors such as Turkish traditions and social life, religious beliefs, geographical location of Anatolia, climate data, materials present, and socio-economic status of its inhabitants.

5.1.1. Turkish Traditions and Social Life

Large family, which has been a Turkish tradition for a long time, is comprised of the father, the mother, sons, wives, and grandchildren, unmarried uncles in the family, aunts, grandmothers and grandfathers. This crowd that makes up a large family requires a multitude of locations. They had locations independent from each other for family members, store cupboards, water closets, and locations in which weaving looms for rug and carpet weaving. Turkish women would spend their days at home due to the fact that they would be busy with weaving and animal husbandry and the fact that production based work and social activities outside family life would occur indoors (32).

5.1.2. Religious

Privacy was paramount in Turkish family life, which led to men and women living in separate sections. Sections in which women lived were called “harem” whereas sections in which men lived were called “selamlık.” In addition, the privacy issue would also influence garden walls of houses. Garden walls were built high due to social norms, which led to isolated lives. Muslim Turks would adopt the philosophy of “thriftiness” as required by traditions and religious beliefs when building houses and they emphasized on durability of houses. However, this was not the case for religious structures which were built based on the construction philosophy of sturdier and more durable materials. In addition, non-Muslim population has occupied and still occupies the Suriçi region (33).

5.1.3. Materials

In Traditional Turkish Houses, materials found in the area would be the main material of the house. Materials frequently used in Turkish houses were stone, puddled clay and wood.

5.1.4. Geographical Location and Climate

Anatolia has a multitude of climates, which has resulted in Turkish Houses in each climate region showing certain varieties based on the climate in which they are located.

5.1.5. Socio-Economic Status

Turks needed working areas, storage rooms and spaces in which people were involved in handicrafts, whereas basement sections of houses would be reserved for areas required for animal husbandry in regions where people were involved in animal husbandry. This has played an important role in shaping the Traditional Turkish House.

5.2. Types of Plan for Traditional Turkish Houses

The plan for the Traditional Turkish House is formed by arranging around the sofa. Rooms show very little variation in terms of size, shape and features; however, sofas show all sorts of variations. Thus, the type of plan used in the Traditional Turkish House is defined by the sofa. Traditional houses located in Diyarbakır Suriçi have 5 different types of plans. These are L type, I type, U type, inner courtyard, and outer courtyard plan types. Figure 4 shows types of plans for the Traditional Diyarbakır House.

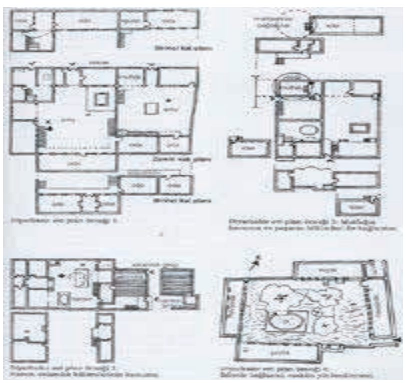

Figure 4. Types of Plan for Traditional Turkish Houses (4)

5.3. Constructional Components of the Traditional Turkish House

Formation of the Traditional Turkish House was shaped by culture, tradition and lifestyle of the traditional Turkish family.

5.3.1. Floors

The Traditional Turkish House originally has a single floor although it may have multiple floors due to several reasons. Traditional Turkish Houses have a single floor in rural areas; however, they have multiple floors in urban areas due to lack of space. In these houses, the basement floor would be used as entrance courtyards (patio), job shops (hut), cellars (storehouse), stables, and haylofts. The top floor, also known as the main (living) floor, would be located at the top floor in order to benefit from the scenery, the sun and fresh air in a more efficient manner. Houses with three floors would have a winter floor with a lower floor between the basement and the main (living) floor which would be easier to warm during winter. Traditional Turkish Houses with landing stairs usually have a landing platform used to access the winter floor. Traditional Diyarbakır houses do not have winter floors.

5.3.2. Rooms

In Traditional Turkish Houses, a room has multiple functions. A room is a place in which all activities related to daily life such as resting, sitting, food preparation, eating, sleeping and warming take place. Therefore, furnishings inside rooms are adjacent to each other, which create an empty space in the middle of the room which can be used to carry out any kind of activity inside the room. Rooms are usually square or rectangular. Rooms that are independent from each other can be defined as the Home of a small family. All rooms are designed to be suitable for carrying out various activities such as sitting, sleeping, eating, and bathing at the same time (34). Figure 5 shows an example of a room from a Traditional Diyarbakır House.

Figure 5. View of a Traditional Diyarbakır House Room (5)

One or two walls of rooms are covered with racks and cupboards along with a bathing cubicle and a closet. Facades of the room facing the street have windows. Windows have low elevation in order for the room to benefit more from the sunlight and improve visual comfort for those living inside the room. However, windows also have shutters in order ensure privacy inside the room. Couches are located in front of the walls except for the front of cupboards inside the room. Couches were used for sitting. Beds stored in cupboards would be laid upon couches for sleeping. Floors of rooms would be covered with materials such as wood, soil or bricks, so they would be covered with carpets, rugs, mats and similar elements. Rooms would be constructed in a width that would allow people sitting face to face to see each other's movements easily and at a length that would allow them to hear each other. This distance is 3-5 meters. Racks, windows, doors and similar elements inside the room where shaped in accordance with human ergonomics. Plan types differ based on the number of rooms. Certain types of plans would require fewer rooms, whereas others increase this number to a certain amount. Rooms would be named corner room, middle room, side room etc. based on their location inside the house (33).

5.3.3. Eyvans

In traditional Diyarbakơ houses, an eyvan is a semi-open location with walls on three sides and a large arch or a couple of small arches on the fourth side. Eyvans are covered with poplar beamed housetops or cross vaults. Access to eyvans is provided by stairs located in the courtyard. In addition to being the living space of family members, courtyards were used for events such as weddings, engagements, or circumcisions (35). Figure 6 shows an example of an eyvan from a Traditional Diyarbakơ House.

Figure 6. Photograph of a Traditional Diyarbakơ House Eyvan (6)

5.3.4. Courtyards

People in Diyarbakơ spend their days in courtyards due to hot and dry weather. Courtyards are crucial for privacy of the household and removal of dust. Rooms, eyvans, bathing cubicles, water closets, kitchens and storerooms in traditional Diyarbakơ houses are accessed through the courtyard. Courtyards have a door that open to outside. Courtyards are decorated with pools, trees and flowers, depending on how wealthy their owners are. Family members spend their time in courtyards during summer (36). Figure 7 shows an example of a courtyard from a Traditional Diyarbakơ House.

Figure 7. View of a Traditional Diyarbakơ House Courtyard (7)

5.3.5. Service Areas

In traditional Diyarbakơ houses, the kitchen opens to an opening via an arch. Certain kitchens are covered with a wooden cage to be separated from the courtyard. A cellar that is used to store supplies is located behind kitchens. Kitchens did not have plumbing; people would carry water from the outside. Food was cooked on stones placed on the floor, whereas kitchenware would be stored in alcoves. Kitchens were usually located on the northern part of houses in order to use winter sun more effectively (37).

5.3.6. Wet Areas

In traditional Diyarbakơ houses, the process of bathing would be carried out in rooms in which a major part of life would be spent. People used to bath in large closets on the walls of rooms and sections on room floors. Water would be carried from the outside for the bathing process. In addition, special bathhouses were built inside houses for bathing. These baths have doors that open to the outside; house owners would leave this door open after they have had their baths in order to have the neighbors use the bath.

Toilets are connected to the courtyard, in a location close to exterior walls of the house, which would shorten sewage distance. Water would be carried from the outside into toilets as they did not have plumbing.

5.4. Materials used in Traditional Turkish Houses

Puddled clay was used as a filling material in Traditional Turkish Houses; meanwhile, wood was used for construction of the main supporting structures. “Puddled clay is a material which has been used since the early days of humankind. The main component of puddled clay, a material used in Mesopotamia and Nile valleys for thousands of years, is soil, although it would be reinforced with straw and reed and dried under the sun” (34). Puddled clay is a material that is still being used in structures due to the fact that it is healthy, it accumulates heat, it is resistant to fire, it provides sound proofing, access to raw material is easy, and it is cheap (33, 34).

Construction systems of traditional house architecture differ based on nature, climate, materials, and socio-cultural make-up. Thus, basalt extracted from Karacadağ, an inactive volcano in the region, was used in construction of traditional Diyarbakır Suriçi houses. Railings and cages on windows were made of iron as decoration. Terrace sets were used as roofs.

6 EXAMINATION OF THE DİYARBAKIR BÜYÜK KERVANSARAY HOTEL EXAMPLE

We will examine transformation of Deliller (Hüsrev Paşa) Caravansary, which is located in Suriçi region of Diyarbakır, into Büyük Kervansaray Hotel in the past years.

6.1. Historical

Deliller (Hüsrev Paşa) Caravansary was constructed by Vezirzade Hüsrev Paşa, the governor of Diyarbakır, in order to provide a resting place for delils (guides) who guide traders and pilgrims travelling to Hicaz, Iran, Syria and India over the Silk Road. Deliller (Hüsrev Paşa) Caravansary was called Deliller Caravansary due to the fact that delils that guide pilgrim candidates would rest in the caravansary. Deliller (Hüsrev Paşa) Caravansary was constructed as a social complex along with mosque and madrasah structures in front of Bezirgan Caravansary.

6.2. Architectural Features

Deliller (Hüsrev Paşa) Caravansary is comprised of 72 rooms, 17 stores, a stable with a capacity of 800 camels, a mosque and a madrasah. The caravansary is comprised of rooms, stores, and a stable shaped around a central courtyard. Black and white stones were used in construction of the structure. Black stones used in its construction were supplied from Kurtboğazı quarry, whereas white stones were transported from Urfa (38, 39). Figure 8 shows Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel.

Figure 8. View of Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel (8)

6.3. Conversion

Restoration works in the scope of transformation of Deliller (Hüsrev Paşa) Caravansary into Büyük Kervansaray Hotel was carried out based on expectations and needs of our time. Arrangement works were carried out in a manner that preserves physical features of the structure while making some additions based on needs of our time. These additions are elements that reflect architectural features of the region, although modern elements were used as well. People used to lie in divans or beds placed on the ground in the past, but now they lie in bedsteads placed inside the rooms. In addition, the rooms are equipped with a wardrobe, nightstand, dresser, TV, air conditioner and similar articles. Toilets and bathhouses built for common use where used for bathing and toilet in the past, whereas bathrooms were installed inside hotel rooms in order to meet changing lifestyle needs and provide comfort to customers. Bathrooms include a bathtub, lavatory, toilet bowl and other modern articles. Hotel management has given different names to hotel rooms such as Standard, Murat the 4th, Hasankeyf, Suite etc. based on the level of physical comfort they provide to the customers. The original bathhouse of the structure is still functional and open to hotel customers. Figure 9 shows a suite room from Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel.

Figure 9. View of a Suite Room from Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel (9)

Today, the hotel's courtyard is used as an open restaurant and a place for events such as weddings, engagements, and meetings. In addition, the courtyard and other locations inside the hotel are used for organizing events such as sira nights in order to introduce hotel customers with Diyarbakır culture and keep local cultures alive. Figure 10 shows the courtyard of Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel.

Figure 10. View of the Courtyard of Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel (10)

The kitchen has been equipped with modern technology in order to serve both hotel customers and outside customers at the hotel's restaurant. Sections of the caravansary, which were used as storeroom, stable etc., are now used as winery, restaurant, and indoor wedding ceremony hall. Figure 11 shows the winery of Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel.

Figure 11. View of the Winery of Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel (11)

During the restoration works which have reorganized the caravansary to meet today's needs, the empty area next to the caravansary was converted into a modern pool and a parking lot used by customers to park their cars. Aside for being an area in which customers staying at the hotel can engage in activities such as swimming, the poolside is also used as a location in which events such as meetings, weddings, engagements, and graduations can be held during the summer (39). Figure 12 shows the Hotel Pool of Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel.

Figure 12. View of the Hotel Pool of Deliller (Hüsrev Paşa) Caravansary - Büyük Kervansaray Hotel (12)

7. CONCLUSION AND SUGGESTION

An urban transformation project will be carried out in the Suriçi region of Diyarbakır, which has a history dating back to 7500 B.C., in order to repair damages caused by natural disasters of human activities. Subjects such as urban morphology of Diyarbakır, the concepts of tourist and tourism, lodging businesses, and Traditional Turkish Houses have been defined in the scope of the study involving converting traditional houses situated in the Suriçi region of Diyarbakır, which has a grand historical and cultural past, into boutique hotels in order to be used for tourism purposes. Works carried out during redesigning Deliller (Hüsrev Paşa) Caravansary situated in the Suriçi region of Diyarbakır as Büyük Kervansaray Hotel have been examined. As a result, restoration and refurbishment works in the scope of adaptive re-use of traditional houses as boutique hotels would ensure preservation of both physical features of these structures and the local culture via events and decorations with which historical and cultural aspects of the region are introduced. In addition, an additional venue from which local residents can generate income will be created.

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Examination of the Change of Traditional Houses in Diyarbakir Suriçi Region According to Spatial Relationship

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ABSTRACT

Diyarbakir Suriçi region is the earliest settlement of Anatolia where many civilizations and cultures coexist. The space setup of the traditional houses in Diyarbakσ Suriçi region reflects the culture, traditions and customs of local inhabitants. Diyarbakσ traditional houses are multi-room buildings for the entire family that combine mother, father, children, brides and grooms under the same roof, which form big family concept. Spaces are also created by considering climate conditions. Family members frequently commute between courtyard and iwan. Social, cultural, economic and technological changes in our society have taken place with the changing conditions of life. The patriarchal family structure has been transferred to the core family structure, consisting of mother, father and children. Changes have occurred in space relation of the traditional houses. The buildings that reflect the social, cultural and economic situation of the period they have been built have begun to lose their original state with the changes made by the new users. Within the scope of this study, suggestion has been made for the space setup of the traditional Diyarbakσ houses, the number of which is gradually decreasing, maintaining their cultural values.

Keywords: Suriçi Region, Traditional houses, Space, Family, Culture

1 INTRODUCTION

Diyarbakσ Suriçi region is located in Southeastern Anatolia region. Throughout history, it hosted many civilizations. There are many historic buildings and traditional houses in the region. Walls reflect the history and the past of the Diyarbakσ region. The walls ensured the integrity of the castle walls and the city. The venue setup reflects the culture, customs and traditions of the people living in the Diyarbakσ Suriçi region. Today, many historic buildings and traditional houses have been destroyed, demolished or undergone spatial changes according to the needs of the users. Continuous change of the socio-economic environment because of constant migration to the region has caused illegal constructions. Illegal construction is the main cause of the deterioration of the historic and cultural pattern. Applications made in the name of modernization have increased the destruction of the urban pattern.

The purpose of the examination of the change of the traditional houses in Diyarbakır Suriçi region according to the spatial relationship is to examine the historical development process of Diyarbakır Suriçi region. It also aims to scrutinize the effects of the social structure and traditions of the people living in Diyarbakır Suriçi region, their religious beliefs, climate and geographical position, and the socio-economic condition on the spatial formation of traditional houses in the Diyarbakır Suriçi region. It also aims to examine the social, cultural and economic changes of our society and to investigate the effects of this change on the physical structure of traditional houses.

The scope of this research is to examine the effects of social, cultural and economic characteristics of the people living in the traditional houses of the Diyarbakır Suriçi region on the formation of spaces in the buildings. Courtyard and balcony, which are open spaces, iwans, which are semi open spaces, rooms, which are indoor spaces, barns and pantries, which are service spaces, bathrooms, kitchens, toilets, which are wet spaces, are also scrutinized for their effects on spatial relationship. The paper also investigates the effects of new users on the changing social, cultural and economic effects of our society.

Within the scope of examining the transformation of the traditional houses of Diyarbakır Suriçi region according to the spatial relation, printed sources and internet resources related to the topics were referred. Internet resources and books were used for photographs of venues.

2 EXAMINATION OF DİYARBAKIR SURİÇİ REGION

2.1 History

Suriçi region is the earliest settlement in Diyarbakır. Sur district is located on the edge of Tigris River, 650 meters above sea level, established on the foothill of Karacadağ. Suriçi region hosted many civilizations. After Hurri-Mitannians around 3000 BC, Assyrians, Aramaics, Urartians, Scythians, Meds, Persians, Macedonians, Seleucids, Parthians, Great Tigran Administration, Romans, Sasanians, Byzantines, Umayyads, Abbasids, Sheikhs, Hamdanids, Marwanids, Seljuks, Inalids, Nisanoğulları, Artukids, Ayyubids, Mongols, Aq Qoyunlus, Safavids and Ottomans dominated Diyarbakır (1). Numerous historical monuments inherited from the civilizations that rule the province are still on the scene today.

During the time of Roman Emperor Constantine 2nd, the city was surrounded by walls. It is one of the four central districts of Diyarbakır. It is named after the Diyarbakır Walls (Sur), which surrounds the district center (2). Walls are the symbol of Diyarbakır. The walls break off the relation with the outside world and secured the safety of life and property. The walls are about 5.5 km long, 1400 m from the east to the west and 1040 m from the south to the north (2). As seen in Figure 1, the planar view of the walls resembles a turbot. There are four gates of the outer castle, which are used for entry in and exit out of the city. These are Dağ Kapı in the north, Mardin Kapı in the south, Urfa Kapı in the west and Yeni Kapı in the east. The height of the bastions is 10-12 meters and the width is 3-4 meters. There are inscriptions on the bartions. On the northeast corner of the outer fortress, there is an inner fortress surrounded by a separate wall (2). According to A. Gabriel, the inner fortress region is the first settlement area of the city.

Figure 1. Diyarbakır Suriçi road axes and entrance to the old city (1)

After the Republican era, there are great differences between the new city that was built outside the city walls and the old city that remained in the city walls and decay in the cultural pattern. Important historical buildings in the city are located in the Suriçi region.

2.2. Location

The Suriçi region is a total of 158 hectares as an urban protected area. The area has a population of 7100, with a total of 15 neighborhoods (3). All of the city's population lived in traditional houses in the Suriçi region until 1945. Due to security problems in the Southeastern Anatolia region, migration started from the countryside to the city (4). The intensive migration has caused changes in the socio-economic structure and the city pattern. As seen in Figure 2, the squatting has begun to increase, and it has flowed out of the city walls, causing an urban spawl. Infrastructure services are inadequate. Having been abandoned because of the failure to respond to the needs of our time, the traditional houses are faced with the culture of urban life. Suriçi Region has begun to lose its historical and cultural texture with new constructions built.

Figure 2. Diyarbakır Suriçi (2)

2.3. Formation

Social life has an immense impact on the formation of Traditional Houses. Suriçi region hosted many civilizations. Therefore, it has rich cultural assets. They are loyal to their customs and traditions. They have patriarchal family structure consisting of mother, father, children, brides and grooms. Because of this, they needed many rooms in traditional houses. Traditional houses have spacious courtyards and many rooms. Each room is considered as an independent unit. In the Ottoman period, men and women are separated and seen as two separate communities outside their family life. Women carried out production-oriented works and all kinds of social activities in the house and spent their lives at home (5). With the influence of Islam, an introverted experience in domestic life and a restricted environment from external relations were planned and the outer walls were raised to the first-floor level. In addition, living quarters where women and men spend time separately were created. These areas are called as "haremlik-for women" and "selamlık-for men". Both continental climate and tropical climate features are seen in terms of climate. Climate characteristics have also been influential in the planning of traditional houses. Summer and winter rooms are planned.

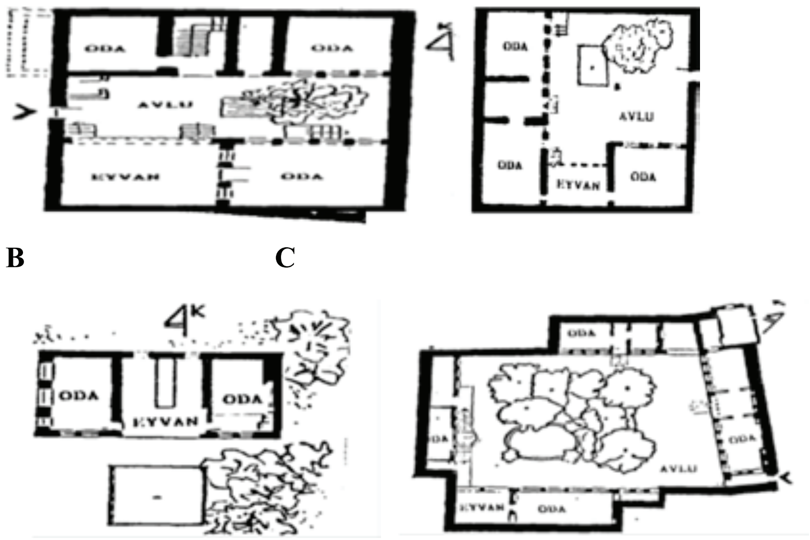
Basalt stone belonging to the region was used as material in the construction of traditional houses. Diyarbakσ houses were built from black basalt stone.
Muslims and non-Muslims lived together in the Suriçi region. Although their religious beliefs are different, there is no difference in the physical appearance of traditional houses. Today, the number of non-Muslims has decreased.

Today, with the transition from the patriarchal family structure to the core family structure, traditional houses are not being used. Economic and social problems have begun to emerge with the intense migration from rural to urban areas. People engaged in agriculture and animal husbandry had difficulties in finding work in urban life.

3 ARCHITECTURAL FEATURES OF DεYARBAKIR SURεÇε REGION

3.1 Plan Types

In Diyarbakσ Suriçi traditional houses, 5 types of plans are seen. As seen in Figure 3, these are U-type plan, L-type plan, I-type plan, inner courtyard plan and outer courtyard plan types (6). Generally, plan types are formed by arranging the places around the courtyard. Plan types reflect the lifestyle in Diyarbakσ. The layout for large families and the areas where women can deal with housework are considered in the plan chart. Service spaces and wet areas were shared by the household. The notion of privacy is in the forefront, as can be understood from the plan chart.



A

B C

D E

Figure 3. A-U type plan, B-L type plan, C-I type plan, D- inner courtyard plan E-outer courtyard plan(3).

3.2. Facade Features

The facade features will be examined as street facades and courtyard facades.

3.2.1 Street Facades

The elements forming the street façades are the courtyard walls, the street gates, the oriels that protrude from the upper floor, and the upper floor windows facing the street. As shown in Figure 4, the street corner is quite plain. The walls of the courtyard are higher with a sense of privacy forefront so as to prevent the inside being seen from the street. Houses were built adjacent. The oriels on the façade allow the expansion of the plan layout. There are examples of protruding to streets or courtyards. The walls of Diyarbakσ's oriels are mostly wooden carcasses to keep the attachment light (7). Because of the seasonal situation, the wooden joisting creates a room on the top by passing through the parcel opposite the narrow street and it is called "kabalt". As can be seen in Figure 5, the "kabalts" are formed in shady spots while wandering in the street during hot weather.



Figure 4. Street Facade(1) **Figure 5.** Kabalt(1)

3.2.2 Courtyard Facades

The courtyard facades have an ornate and rich architecture. In Diyarbakır houses, one needs to pass through a passage as it can be seen in Figure 6 to step in the courtyard. The courtyard facades have main areas such as iwans. There are different decorations and ornaments with arch spaces. In the windows, doors and iwans, there are decorated railings, moldings and inscriptions.

Figure 6. Passage(4)

3.2.3 Façade Elements

The courtyard doors are single-winged or double-winged. The width of the doors varies between 90-200 cm. Planned with privacy in mind, they are one floor high. As shown in Figure 7, there are ornamented knockers on the courtyard doors made of simple arcs. The room doors jambs are escalloped depressed arched doors. The room doors are 85-90 cm wide, which opens to courtyards or iwans. On the inner face, there is lintel. As you can see in Figure 8, the doors of the room are doweled, mirrored and double-winged.


Figure 7. Courtyard Gate(4) **Figure 8** Interior Door(5)

The window hollows are depressed arched and bonded with sliced arches. Horizontal and vertical window millworks are divided into two. It opens in two wings. Their width is between 90 and 100 cm. Top windows are used because of the seasonal features. They are shorter compared to the lower windows. They are depressed arched, with colored glass and made of plaster.

Iwans are semi-open spaces that provide passage between the courtyard and the rooms. There are 3 types. They are one, two or three sectioned with pointed arches. They are the places where the household spend their time in summer.

The bossages can be seen both on the outer façade as well as on the courtyard. The oriels were built to protrude to the streets to keep the rooms spacious. Thanks to the oriels, the upper floor is more spacious compared to ground floor. The oriels are the brightest and coolest part of the house. The cantilever located in front of iwans and rooms are called "gezemek". It occurs when stone plates are placed on stone consoles.

3.3. Materials

The material used in the construction of the traditional houses in the Diyarbakσ Suriçi region is basalt stone. The basalt stone is black colored. Yellowish white limestone is also used in the walls. Limestone is brought from the Ergani district. When limestone is not found, the front face of the basalt stone is whitened, and the same effect is tried to be created. The white colored decorations made of slaked lime are called "cas"(7). The floor is made of poplar wood used as beam.

3.4. Spatial Features

3.4.1 Open spaces

In traditional Diyarbakσ Houses, life passes in the courtyard due to climate conditions. The walls of the courtyard are elevated to maintain the privacy of family life. When entered from the outer door, one needs to pass through the passage and then step in the courtyard. As shown in Figure 9, the courtyard is in the center of the house. The courtyard-related units are wet spaces, semi-open, indoor spaces and stairs (7). They are in the form of open top rooms where one can sit in the morning and sleep at night in summer. Women pass their days in courtyard. At the same time, the courtyards are places where events such as invitation and mourning take place. The floor of the courtyards is made of basalt rocks, called female stones. Therefore, flowers are planted in flowerpots and placed in the garden. The pools are located in courtyards and iwans. They are square, rectangular, elliptical or circular shaped.

Figure 9. Outlook from courtyard (6)

The balconies were used for cooling off, as shown in Figure 10. There are few examples of balconies because courtyards and iwans are also used as balconies.

Figure 10. Balcony Outlook (1)

3.4.2 Semi-Open spaces
Iwan is the room where most of the time is spent in summer. It is closed from three sides and from top and one side opens to courtyard through arch. Iwans are located in the northern part and are not exposed to sunlight. As you can see in Figure 11, they are cool spaces combined with the courtyard. A pool is also available in iwans. Their height is 5.5-6.5 m. It is the place where activities such as sitting, sleeping, preparing food and guest welcoming are carried out.

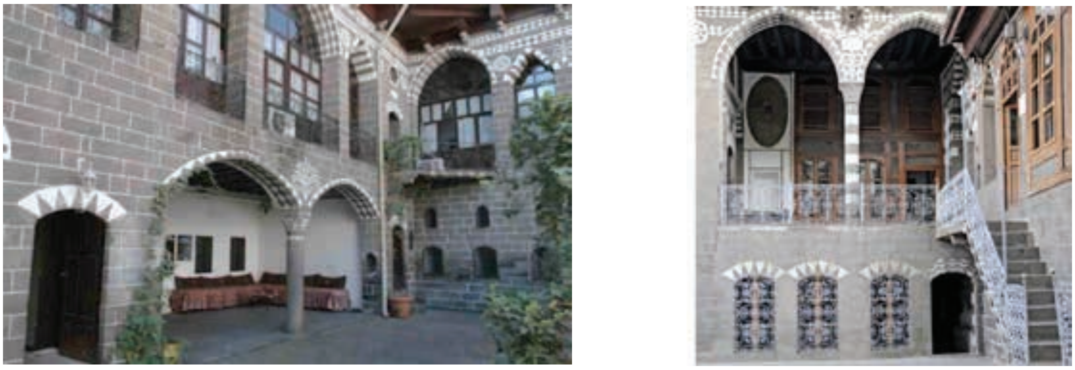


Figure 11. Outlook from iwan(6)

3.4.3 Indoor spaces
The needs such as sitting, sleeping, eating, working, resting are met in the closed rooms. Due to climate features, winter, summer and spring rooms are planned on the same building. Winter rooms are located on the ground floor. They are located in the south of the courtyard, with south-facing window openings. The size of the rooms is small for the sake of easy heating. Braziers are used to warm up (7). The floor of winter rooms is khorasan mortar. 40 cm cut basalt stone was used to provide insulation. Summer rooms face north and are not exposed to sunlight. Sunshine is provided the courtyard. While the temperature in the region is 45-50 degrees Celsius, it drops to 20-25 degrees Celsius in the summer rooms. The floor of the summer rooms is salt stone. The walls are made of porous basalt. As the temperature increases, household tend to sleep on housetops or in the courtyard. There is "serdap" on the basement floor to sit in the hot summer days. There is also small pool in serdap rooms.

There are rooms called "haremlik" and "selamlık". The room that connects these rooms is called 'Mabeyn' room. At the entrance of the rooms, there are lower berm sections where the shoes are removed. "In fact, the berm is a tool that prevents dust and dirt from being carried over by raising the ground level in succession as it reaches the living area [8]. Upper berm, the main floor of the room, is one step above the lower berm. As shown in Figure 12, no furniture was used in the rooms. The goods in the room are placed adjacent to the walls and the middle area is left empty. Couches for sitting on are placed at this section. People sit cross-legged on the couches.

The room for sitting during the day is arranged to allow sleeping at night. Beds and quilts are removed from the large cabinets for bedding at night and unfolded, and in the morning, they are placed back to the cabinets. As shown in Figure 13, a curtain was hung in front of the cabinet so that the items inside could not be seen (9). Some walls also have plaster-ornamented holes. The cabinets without door are built on the walls of the rooms, which are called "paca". When the food is served, ground cloth is spread over the floor, dough board or metal tray placed on it serves as dining table, and after dining is over, the floor table is placed in the cupboards.

Figure 12. Room Examples (5) **Figure 13.** Large cupboard for bedding (5)

3.4.4 Wet spaces and Service spaces

There is a kitchen in the harem section of the house. The food preparation is made in courtyard. In the winter months when the weather is cold, the preparation is done in the rooms. For reasons such as fire, privacy and ventilation, the kitchen is not connected into the house. The courtyard kitchen connection is made with arch. As shown in Figure 14, there are cookers in the kitchen. The food is cooked in the cookers. Meals are eaten in the courtyard, the iwan or the rooms. There are built-in cupboards with no lids on their walls (10). Food ingredients are stored in the pantry or wire cupboards. Foods are stored in large earthenware jars so that they will not spoil. The pantry is located in the basement. The basement floors cool and are illuminated and ventilated with the help of small windows. There is no water connection in the kitchen. Water is provided from wells located in the courtyard or from the water pumps shown in Figure 15. Water is drawn manually by a water pump. Excess is spilled over into the garden.

Figure 14. Kitchen view (5) **Figure 15.** Example of Water pump at the Courtyard(1)

Toilets are located in the ground floor's courtyard in the Diyarbakır Suriçi traditional houses. They are located close to the street as shown in Figure 16. The aim is to keep the sewage length short and keep it away from the well. Toilets are used with carrying water. Diyarbakır Traditional houses have very few baths. The baths shown in Figure 17 are seen mostly in the houses of rich.

Figure 16. Toilet view (1)

Figure 17. Bath(1)

4 CHANGE OF TRADITIONAL HOUSES IN DİYARBAKIR SURİÇİ REGION ACCORDING TO SPATIAL RELATIONSHIP

Social, cultural and technological changes have affected the change in the spatial relationship in the traditional houses in the Diyarbakır Suriçi region.

4.1 Examination of Social and Cultural Structure

Every person has various needs in order to survive. He/she has to meet his/her needs such as breathing, sleeping, eating, and sheltering to get protected from external factors. In the design process of traditional houses, the needs of the people are effective in creating the spaces. The space arranges the relation between the people (11). The plan feature of a dwelling is an indication of the social structure of that dwelling (12). Family structure, belief, social identity, culture, social status, educational status, local climate and geography are influential in the formation of the housing. Maslow refers to the socialization of people in their surroundings as the need after the sheltering and also includes privacy. The definition and level of privacy depend on the cultural background of the individual. Culture, environment and behavior take place in every detail of the traditional houses. Culture shapes the environment. And the environment conveys the culture to future generations. The need for sleeping, sitting, bathing and eating, which may vary from cultural point of view, also determines the functioning of the space. Changes in the lifestyles affect the changes in places.

4.1.1 Social and Cultural Change

People living in Diyarbakır Suriçi region are loyal to their traditions and customs. Traditional Diyarbakır Houses are multi-roomed structures suitable for patriarchal family structure. The formation of plan schemes of Traditional Houses is culture-driven. Furniture is resolved depending on the structure. Plans are created by considering climate conditions. They reflect patriarchal family structure. Every family carries out the activities of sleeping, resting, chatting and eating in the rooms. Privacy requirement is at the top level. The courtyard walls are built high. Men were mostly out of the house. The women passed their days in the courtyards. Women conducted neighborhood relations, socialization and housework. Education status has also influenced the socio-cultural situation. In families with a lower level of educational background, the number of children would also be high. People living in Diyarbakır Suriçi traditional houses are loyal to their traditions and customs. Events such as weddings, circumcision ceremonies, and deaths took place in courtyards.
Today the family structure has changed. Transition from the patriarchal family structure to the core family structure has taken place. The place of women in society and the level of education have changed. The younger generation that is more educated has fewer children. Traditional housing has begun failing to meet today's needs. The houses have been abandoned or started to be used by several families. This has caused differences and undesirable situations in the number of spaces.

4.1.2 Economic Shift

The people who have a different culture, economic situation, religious belief lived together. Class differences have led to different plans in traditional houses. Non-Muslims are usually engaged in jewelry. They built large houses as a reflection of their wealth. The higher the income of the father who is the breadwinner of the family, the better the level of life, jars and pantries will be. Individuals with different income groups have gathered in different neighborhoods. In the past, the breadwinners of the houses were engaged in such activities as ironsmithing, tinning, masonry, stonework, stoving, blacksmithing, carpentry and kerchiefing. The group that comes with migration works in daily works. In traditional Diyarbakır Suriçi houses, the lower income group is still preparing their winter food at home today. Nowadays, depending on the economic situation, some houses are using furniture in their living room and bedroom, while some houses are still using couches for laying beds to sleep on.

Today, one of the most important reasons for not paying attention to traditional houses is the economic situation. Migration of people with different socio-economic conditions from the country to the city is the most effective reason for the deterioration of the texture. The original owners of traditional houses have abandoned these houses or moved to contemporary houses by renting them to the lower income group. New users with low economic incomes have damaged houses because they are unaware that traditional houses are part of our culture. The houses lost their original textures with the changes made.

4.2. Examination of physical change

During the time, the concept of home is physically changing. Differences form in people's values and opinions, or differences between the concepts of society and family influence the change in the physical structure. The change in the needs of the users causes the transformation. Physical change occurs due to the differentiation of the perception. The physical change of houses is reflected in the way of behavior, the relation of the house with the street, the relation of the rooms with each other and their controllability (11). Due to the reasons arising from infrastructure inadequacies, aging and usage difficulties and the desire to live in new and modern buildings, owners living in the traditional houses is gradually declining or tenants do not attach due diligence to preserve the building while using them(13). The feeling of physical environment privacy was at the forefront in the planning.

4.2.1 Change according to Spatial Characteristics and Accessory Elements

With the change of the family structure, situations such as division, annexation, and removal have occurred in traditional houses. Removing or adding new spaces has affected spatial organization. In large houses, the divisions are formed by walls that are attached to the courtyards. The house has been converted to be used by several families. "Haremlik" and "selamlık" sections have been removed. Some families have continued their life in common courtyard without using any separation. Iwans, which are semi-open spaces, are closed. To keep the interior warm in winter, glass frames were added or walls were built. As shown in Figure 18, mezzanines were added by using ceiling heights. Plan types are disturbed. New additions were made with brick material. Color and usage technique differed from texture. Extra floors, the bathroom and toilet extension affected the load distribution of the buildings unfavorably. It caused cracks in the walls and courtyards. Faulty repairs were made on the surface and tried to be covered up.

Figure 18. Addition in the Courtyard (7)

The doors and windows, which are building elements, are enlarged or closed. New gateways connecting to the street were made.

With the transform of the family structure to a core family, large square meters have begun to be unnecessary. Houses have become available to more than one user. Room system, where many functions took place, has changed in the Diyarbakır Suriçi region traditional houses. Each room has a separate function now. The hall, the bedroom, the kitchen, the bathroom, etc. are formed. Changes have also occurred in spatial elements in the rooms. The couches used for sitting down have left their place in the hall to the seats and sofas, and to the tables, chairs and coffee tables. Bedrooms are being used instead of floor beds. Instead of floor tables, dining tables and chairs are being used in the dining rooms. The cabinets in each room have been removed. Bathing cubicles in the rooms are unnecessary now. Bathing culture has begun to take its place in the houses. The toilets on the courtyard are removed. Some houses have additional toilets. Kitchens located in the garden have taken their place inside the houses. As refrigerators, washing machines, televisions, and numerous other home appliances are not included in the traditional housing layout guidelines, the functional layouts of wet spaces such as kitchens and bathrooms lag behind contemporary expectations (14). Due to the new technological tools being used, electricity has started to be used in various fields.

5 CONCLUSION AND RECOMMENDATIONS

Diyarbakır Suriçi region hosted many civilizations and cultures. Non-Muslims and Muslims have lived together in the Diyarbakır Suriçi region. The venue setup of the traditional houses bears the traces of the culture, customs and traditions of the period that they were built.

Today, social, cultural, technological and economical occurrences in the Suriçi region vary according to the past. The decrease in the number of non-Muslim families and their abandonment of traditional houses and the settlement of the other people in modern houses has negatively affected the preservation and sustainability of the traditional way of life. Traditional houses have been rented by the people with low economic level coming from rural areas. Since the existing lifestyles in traditional houses are not compatible with the lifestyles of new users, the unconscious changes have begun in traditional houses. Consequently, this has accelerated the deterioration of the houses. The inadequacy of the education level and the lack of good economic conditions have caused the deterioration of the texture in traditional houses and building and its annexes. Continuous change in the socio-economic environment because of constant migration to the region has caused illegal constructions. Illegal construction is the main cause of the deterioration of the historic and cultural fabric.

Along with the changing life conditions, the family structure has transformed from the patriarchal family structure to the core family structure. With the transformation of the family structure, more than one family has begun to live together in the traditional houses. This situation has led to changes in the architectural characteristics of the houses. The formation of open spaces, semi-open spaces, indoor spaces, wet spaces and service spaces has changed. Changes in the spatial characteristics of the iwans and courtyards, the places where most of the day is spent, have been made. Each space has a separate function now. The spaces are customized as bedroom, living room, kitchen and bathroom. The place of women in society and the level of education have changed. "Haremlik" and "selamlık" sections have been removed.

It is a serious problem that the changes in traditional houses in the Diyarbakır Suriçi region are being made without observing our culture and identity. Applications made in the name of modernization have increased the destruction of the urban fabric. In the traditional houses, the space relation is being organized by considering the present technological, social, cultural and economic aspects. Within the scope of the urban transformation project, the Diyarbakır Suriçi region should be planned in relation to space in order to meet the current needs without losing the cultural characteristics of the inhabitants.

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Kerpic'18 – Back to Earthen Architecture: Industrialized, Injected, Rammed, Stabilized
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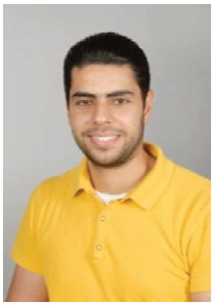
Palestine as Logistic Zone to Facilitate Trade at the New Silk Road by Using the New Technology of Prefabrication



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ABSTRACT

This paper deals with the new vision of developing Palestine as a logistic zone in the Middle East to facilitate the international trend at the new silk road by using the new technology of prefabrication to face the increasing population in the zone and rebuilt Gaza more efficiently with less energy.

Keywords: Middle East, Culture Silk Road, Logistic, New technology

1 PALESTINE AT SILK ROAD

Historically, Palestine was an important node on the ancient Silk Road. Beginning around 100 BC, the fabled Silk Road brought goods and travelers from China and the Central Asia, through the lands of Persia and Mesopotamia over to Palmyra in Syria. One branch of the road then turned south, crossing through Bethany, the biblical village on the outskirts of Jerusalem, as it headed west from Jerusalem to Yoppa (today's Jaffa) and the Mediterranean Sea. Today the town of Bethany is known as Abu Dis. It is still on the outskirts of Jerusalem. And the ancient road is still there. Dusty and pothole-filled, it winds through the center of the Palestinian town, with auto-parts yards and small dingy shops selling vegetables and furniture, lining both sides. The road then comes to an abrupt stop, blocked by the towering, graffiti-covered cement slabs of Israel's separation wall. Today, the Silk Road stops in Abu Dis.

When Israel first occupied the Palestinian territories in June 1967, Abu Dis was a small, crowded West Bank town outside of Jerusalem. After the war, Israel expanded the municipal borders, and soon expropriated and annexed huge swathes of West Bank Palestinian land into what quickly became known as the "Greater Jerusalem." The heavily populated Palestinian areas were excluded so Israel could insure a 70-30 percent Jewish majority in the city. Most of Abu Dis remained outside. The Palestinians had long insisted on their right to establish the capital of their future state in Israeli-occupied Arab East Jerusalem. **(1)**

Just like trade between Mesopotamia and the Indus valley was the key to the development of this civilization, the unification of Egypt must be associated with the trade contacts between the Nile delta and the route connecting Syria with Mesopotamia and Anatolia (map 3). In fact, the boom in this trade occurred simultaneously with the unification of the Egyptian State (3000 BC) within the framework of the wars of conquest between the three proto-kingdoms of Upper Egypt (Nagada, Hierakonpolis and Abydos) "for the control of the exchange routes for prestigious goods" (Campagno cited by Flammini 2005:15). Likewise, it is considered that the monopoly of this lucrative trade (copper in particular) undoubtedly contributed to the centralization of the State (Marfoe 1987;26).**(2)**

Figure 1. It show the Palestine in the early civilizations and their relations **(2)**

Although few details are known, during the Middle Empire (2050 - 1750 BC) a number of Egyptian settlements were established in the Syrian - Palestinian area and diplomatic contacts with representatives of peoples in Asia revealed the frequency and intensity of some pacific and principally commercial relations with Asia (González-Tablas 2010:245). In this way, a complex network of overland trade routes was gradually constructed and which, at the beginning of the second millennium BC, linked areas as different as Afghanistan, the vast plateaux of Iran, Mesopotamia, the plains of Syria and Anatolia (Larsen 1987:47). To this system, the maritime trading routes should be added, which, despite all the dangers involved, linked the Red Sea, the Persian Gulf, and the west coast of India (Carter 2001, 2003). The routes also crossed the Sahara desert, in a north - south direction and east to west, following the paths of the oases. Caravans transported gold from Ghana, Senegal and Mauritania to the north in exchange for essential salt (Sanz Roche 2001). In turn, communications were established between the great trading centers such as Timbuktu and Agadez with the Nile delta. Following the river course, gold from Nubia (present day Sudan) and other products from this contemporary Egyptian civilization also reached the Nile delta (Gonzalez-Tablas 2010:240-1). The pharaohs soon sent trading expeditions to the horn of Africa, where, in the land of Punt, they had access to the tropical products of sub-Saharan Africa. (Phillips 1997).2

Obligatory transit centres such as oases, mountain passes, caravan crossroads, or sheltered ports, gave rise to cities which started to make their livelihood from trade rather than what they produced. In this way, cities arose without an agricultural hinterland to support them, and therefore also depend on commerce for their subsistence, as illustrated by the exemplary case of Assur (Bauer 1998:160; Larsen 1987:53). In this way, a network of cities was created which, due to their capacity to control and exploit the routes passing through them, was to condition the rise and fall of empires for many centuries to come. The central area of the Near East, from the Zagros mountains to the Mediterranean and from the Persian Gulf to the Tauro mountains and, at times, extending as far as the Black Sea, appears to have formed a natural unit since few goods needed to be introduced from outside and there was a highly developed network of routes and exchanges within the region, undoubtedly connected to Egypt. This region had a number of centres which did not compete politically amongst themselves, although there were conflicts within each region (Mesopotamia in the south, Anatolia, Syria) but which did not affect the interregional trade, regulated by written treaties (Larsen 1987:53). In turn, the Egyptian empire gradually integrated the territory in Upper and Lower Egypt into a single commercial and economic network, which stretched towards the south and towards the west through the desert.

Neither did it abandon the control of the north-eastern trade, and to ensure its safety, by establishing military posts at strategic places such as Ugarit, Byblos, Gaza, Jerusalem etc. and with the presence of its fleet. For this reason, between the 16th and 14th centuries BC, the contact zone for these great centres (Mitanni, Egypt, Hattie), namely the Syrian - Palestinian corridor, became a "disputed periphery", being the place where the Near Eastern routes converged and the location of the ports for the exchange of goods with the Eastern Mediterranean (Gestoso 2006:16).

Despite the geo-political tension between the powers over the control of these routes, there was always a shared limit to this tension due to the need to maintain trade. For this same reason, in the majority of cases, the empires were content to set up a few garrisons to protect their interests and solely had recourse to physical control when the conflicts between the local powers endangered the route (Gestoso 2006:16). **(2)**

Figure 2. Trading circuits of 13th Century **(2)**, **Figure 3.** The map show the development of occupation **(3)**

1. 1. Strategic Location of Palestine
The State of Palestine[i] also known simply as Palestine, is a partially recognized state in the Middle East.[15][16] Its independence was declared on 15 November 1988 by the Palestine Liberation Organization (PLO) in Algiers as a government-in-exile. Most of the areas claimed by the State of Palestine have been occupied by Israel since 1967 in the aftermath of the Six-Day War.[8] The Palestinian Authority applied for United Nations (UN) membership in 2011[3] and in 2012 was granted a non-member observer state status (4).

Situated at a strategic point among Europe, Asia and Africa, and the birthplace of Judaism and Christianity,[1] the region has a long and tumultuous history as a crossroads for religion, culture, commerce, and politics. The Palestine region or parts of it have been controlled by numerous different peoples.

The region was among the earliest in the world to see human habitation, agricultural communities and civilization. During the Bronze Age, independent Canaanite city-states were established, and were influenced by the surrounding civilizations of ancient Egypt, Mesopotamia, Phoenicia, Minoan Crete, and Syria (5).

Figure 4. The map show the strategic location of Palestine in the world **(22)**

Palestine is an ancient country as much as the history of mankind can tell. Its East Mediterranean situation engendered this land's first touch with the old great civilizations of Egypt and the Mesopotamia. Palestine lies at the routes linking three continents. This unique position as a geographical bridge among Asia, Africa and Europe rendered it to be an open land to the cultural and religious winds of Egypt, Syria and Mesopotamia. It is worthwhile to mention in this regard that Palestine location at a vintage point among these three Arab countries has determined its Arab identity from ancient times (6).

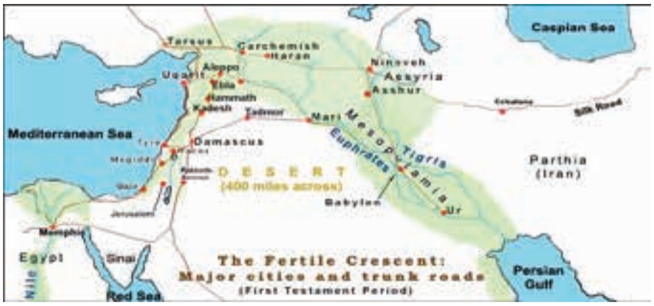

Figure 5. The map shows the strategic location of Palestine **(25)**

Its climate is arid. The southern half, the Negev, is desert, but in the north, there are several fertile areas. The principal water source is the Jordan River, which flows south through Lake Tiberias into the Dead Sea. **(7)**

1.2. Trade Routes of Palestine

The land of Canaan has been called the "sacred bridge," a strip of land that connects two worlds. In ancient times, it was the only way to travel between Egypt and Mesopotamia since a more direct route through the Arabian Desert was impractical if not impossible.

Figure 6. Trade Routes of Palestine **(8)**

The other major route, the King's Highway, was located to the east along the high fertile plain beyond the Dead Sea and the Jordan River. The two routes converged on Damascus, where the route splits toward Antioch to the north and towards Mesopotamia to the east.

A regional route worth noting, though of less importance for international commerce, is known as the Ridge Route, which traveled through the hills of Judea and Samaria, passing by the city of Jerusalem.

The impact these international trade routes had on the cultures and societies of ancient Canaan cannot be underestimated. The strategic importance of this land bridge for gaining and maintaining power and wealth in antiquity is reflected in the constant struggle that went on between regional and imperial powers to control the region for centuries. **(8)**

1.2.1. Ancient Caravan trade route of Palestine at Silk Road
In the 1st century BC, the Romans gained the control of Syria and Palestine - the natural terminus of the Silk Road, for goods could move west more easily from here by sea. Soon a special silk market was established in Rome. **(9)**

Like today, with its riches of oil and natural gas, ancient Arabia controlled the ancient Caravan Trade (transferring spices, frankincense, myrrh, gum, gold, textile and Ivory) from India, Yemen and East African Horn to Iraq, Egypt, the Mediterranean coast and Greece. The Caravan Road and the ancient Silk Road were the main trade routes for the ancient world (Both roads neither terminated at nor crossed Palestine/Jerusalem) **(10)**

Figure 7. Ancient Caravan trade route of Palestine at Silk Road **(10)**

The ancient Caravan Road cut across ancient Arabia, from North Yemen in the south to Petra and Egypt in the North. And it flourished from the 9th century BC to the 2nd century AD, when it began to lose its strategic value. Poor Arabian economic conditions and a growing direct naval route between India and the Mediterranean heralded the end of Caravan route. **(10)**

2 GAZA AS A LOGISTIC CENTRE IN PALESTINE

This was the port city that the Nabataeans used on the Mediterranean Sea until most of their trade was switched to Alexandria. The ancient harbor was situated in the north west of the old city in a place known as Blackhia (El-Mashtal.) The name of the sea harbor varied according to the various eras and rulers. It was called Athedyoun, meaning the white flower Costandia during the age of Constantine, Meyouma and then Teda in the Roman and the Byzantine period. **(23)**

Gaza is one of the oldest cities in the world. The city is strategically situated between two continents, Asia and Africa. This geographical location made the city acquire a strategic and extraordinary military status. Consequently, the city had been a battle field for most of the ancient and recent empires, the Pharaonic, the Assyrian, the Persian, the Greek, the Roman, the Crusades, and during the First World War. **(23)**

Gaza has an important strategic location between the continents of Asia and Africa. This important location made Gaza a vital entrance to the most important trade and military routes in the world. This route was known as "Via Mars - Sea Route" or "Horas Route". This route connects Palestine with Egypt on one side, and the Arabian Peninsula and Southeast Asia on the other; it also connects all of these areas with Europe through the Mediterranean. **(23)**

Figure 8. The map show the important of Gaza at Silk Road **(26)**

2.1. Logistics Centre/zone Definition
Definition of a Logistics Centre is the hub of a specific area where all the activities relating to transport, logistics and goods distribution both for national and international transit are carried out, on a commercial basis, by various operators. The operators may be either owners or tenants of the buildings or facilities (warehouses, distribution centers, storage areas, offices, truck services, etc.) built there. **(11)**

Figure 9. Dubai-based Centre Point Logistics Centre**(24)**

In order to encourage intermodal transport for goods handling, a Logistics Centre should preferably be served by a variety of transport methods (roads, rail, sea, inland waterways and air). **(11)**

1.2 The most important elements
The Logistics Centre concept is based on three important elements:
1. Territorial planning alongside infrastructure rationalization
2. Transport quality
3. Intermodality development

1.Territorial planning alongside infrastructure rationalization

The Logistics Centre is a specific area where all the activities relating to transport, logistics and goods distribution are carried out by various operators. **(11)**

2. Transport quality
The high service quality standard is certainly one of the most important elements in assuring an excellent level of competitiveness, particularly considering that nowadays competing means surviving the effects of globalization. **(11)**

3. Intermodality development
It offers very convenient transport and synergic solutions (rail/road/short-sea-shipping), using block shuttle trains on long-range journeys. **(11)**

2.2. Location
Location is a key factor for all the transport operators whose main activity is moving freight from one place to one another by using different modes of transport. **(11)**

2.3. Activities
It should be remembered that the activities referred to in this point are exclusively specific to the company managing the Logistics Centre. **(11)**

1. Defining infrastructure necessities these being:
- Road connections
- Rail connections
- Connections with ports

2. Defining the Logistics Centre layout based on:
- Customs infrastructures
- Postal/bank/insurance services
- Offices
- Intermodal terminals
- Warehouses **(11)**

3 LOGISTIC ZONE INCREASING THE POPULATION BY THE IMMIGRATION

The new logistic zone will increase the population in the country, by the immigration types, when the zone will create a high number of new jobs, so the human movement will start from outside and inside the country. So, in Gaza, we will need more construction movement because of the big population there. (by researcher)

Figure 10. Mena-Gatar -new logistic zone **(27)**

3.1 Immigration Definition

Immigration is the movement of people into a destination country to which they are not native or do not possess its citizenship in order to settle or reside there, especially as permanent residents or naturalized citizens, or to take-up employment as a migrant worker or temporarily as a foreign worker. (12)

3.2 Types of Migration

We live in a world shaped by human migration. Every day, people make a decision to leave their hometown or even their own country and move elsewhere to work, study, retire, or reunite with their families. Migration has changed the demographic composition of towns, cities, and nations.

3.2.1 Internal Migration

Moving to a new home within a state, country, or continent.

3.2.2 External Migration

Moving to a new home in a different state, country, or continent.

3.2.3 Long-term Migration

Examples of people in this category include:

1) Labor migrants (these can be either high-skilled or low-skilled workers who seek permanent employment elsewhere);

2) Professional, business or investor migrants (e.g., individuals in specific professions, or those who invest or establish businesses in a receiving country);

3) Forced migrants (e.g., political or religious refugees and asylum seekers).

3.2.4. Temporary Migration

Examples of people in this category include:

1) Labor migrants (e.g., seasonal migrants, laborers on temporary working visas, or commuter migrants);

2) Professional and business migrants (e.g., diplomats and other business migrants, religious migrants);

3) Student and scholar migrants (e.g., degree-seeking students, short-term students, and exchange scholars) **(13).**

That this classification scheme can be related either to international or internal flows of migrants.

4 INCREASING POPULATION NEED RAPID CONSTRUCTION AS PREFABRICATION

There are three options to meet this increasing demand. First is to use indigenous building materials, second is to search for the improvement on the conventional method of construction as well as the design standard and lastly, to utilize innovative technology. Innovative technology refers to the use of newly discovered construction materials or methodology such as prefabrication **(14).**

Figure 11. Increasing population need a speed in the building process **(15)**

4.1. Prefabrication Definition

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site, where the structure is to be located. The term is used to distinguish this process from the more conventional construction practice of transporting the basic materials to the construction site where all assembly is carried out. **(16)**

Figure 12. Assembly in the site **(17)**

4.2. Types of Prefabrication

We classified the prefabrication system based on conceptual dimension and practical dimension.

4.2.1. Prefabricated Construction Systems in conceptual dimension.

Prefabricated systems can be categorized as:

4.2.1.1 Open systems

By means of standardization of dimensions and details, the components produced by different companies in construction industry can be used together to design and construct the buildings. The components can be selected from the catalogues.

4.2.1.2 Mekano systems

The components are not interchangeable with the components of another system. The components are produced as the certain parts of a package and cannot be replaced.

4.2. 2. Prefabricated Construction Systems in practical dimension.

Prefabricated systems can be categorized as:

4.2.2.1 Skeleton systems

Prefabricated systems that comprise structural, load-bearing elements such as columns, beams, and slab elements. One of the dimensions of these elements is greater than the other dimensions.

4.2.2.2 Panel systems

Prefabricated systems that comprise structural, load-bearing elements such as walls and slab elements. Two dimensions of these elements are greater than the third one.

4.2. 2.3.Cellular systems

Prefabricated systems that comprise three-dimensional cellular units.

4.2.2.4.Combined systems

Prefabricated systems that use different types of elements stated above together. **(18)**

5 EXAMPLES OF NEW TECHNOLOGY OF PREFABRICATIONE

In this example of prefabrication, they used iron **Skeleton systems**. A developer in China built an entire 57-story mixed-use building brick by prefabricated brick at a rate of three full stories a day. The building took only 19 days to complete, according to Gizmodo located in Changsha, China**.**

Figure 13. It shows the height of the building in the construction period **(19)**

The building has 800 apartments and enough office space for 4,000 people. It was originally planned to be built up to a height of 220 stories, but it was cut down because of concern that it was too close to a nearby airport.

Figure 14. Assembly process in the site **(19)**

The prefab construction is also environmentally friendly, as large sections of the building were built off-site and taken to the building site to be stacked on top of each other. This significantly reduced the number of trips needed to transport the raw materials.

The building was also constructed with China's pollution problem in mind, using quadruple-thick glass and tight "99.9% sealed" construction. **(19)**

Figure 15. The entire design of the building **(19)**

A key element in the design of Sky City is the interior square and "sky street" that connects the building vertically. There are 19 of these 3 story high atria stacked on top of each other, and 3.6 km (2.23 miles) of ramp. The atria can be used for basketball, tennis, theaters or even vertical farms. **(20)**

Figure 16. The completion of the building **(19)**

The building is reportedly energy efficient, as it uses quadruple-paned glass that should reduce CO2 emissions by 12,000 tons. The astonishing speed is due to the modular blocks used and allows the developers to add up to three stories *per day*. **(21)**

It is called Mini Sky City. The man behind it is Zhang Yue, a Chinese entrepreneur with an Elon Musk-ian streak for launching revolutions. **(21)**

6 CONCLUSION

We have seen that Palestine was a very important region on the Silk Road, and still a very important region in the middle of the world, especially for connecting the three parts of the world, i.e. Asia, Europe, and Africa. So, that makes it a very important country to facilitate the new silk road. I have chosen the city of Gaza as the logistic zone to support the new Silk Road because Gaza has an important strategic location between the continents of Asia and Africa. This important location made Gaza a vital entrance to the most important trade and military routes in the world. This route was known as "Via Mars - Sea Route" or "Horas Route". This route connects Palestine with Egypt on one side, and the Arabian Peninsula and Southeast Asia on the other; it also connects all of these areas with Europe through the Mediterranean. Therefore, building a logistic zone in Gaza will increase the population in the city, through different types of immigration. To face the increasing population, we need to have a rapid construction to meet the increasing demand for houses and the building as well as the need of the logistic zone. So, the best choice for fast construction is the prefabrication. We have also seen in some examples the new technology of prefabrication and how fast it is and how environmentally friendly, more efficient and less energy consuming it is.

As we all know, Gaza needs to be built up because of the repeated attacks of Israeli occupier. So, by using the new technology of prefabrication, we will be able to build it at a lower cost and with more efficiency and less energy. The future Gaza will bring peace.

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The Protection of the Cultural Values of Sur Town; Unesco's Studies and Recommendations

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ABSTRACT

Turkey has hosted many cultures, languages and races for thousands of years and is an important country in the cultural sense. For this reason, it plays an important role in preserving the historical cultural heritage. Protecting our cultural values is not just about passing on to future generations, but also, and most importantly, nurturing new ideas for the future. "A nation that does not know its history is condemned to disappear" (Mustafa Kemal Ataturk). It is best explained in this saying why we should protect this heritage as it is.

Due to a number of events in the world, many of our values are in danger of extinction. One of those places that has been home to many cultures is Sur district in Diyarbakir, Turkey. Sur District attracts the interest of domestic and foreign tourists with its mosques, inns (ancient road houses), bridges and bazaars. It is also recognized as part of UNESCO's World Cultural Heritage. However, because of today's terrorist attacks, the region has fallen into ruin and people have begun to abandon their place of residence. It is included in the work agenda to reconstruct the buildings under the name of urban transformation and restoration of the buildings, which have not been completely ruined so that the city can be reinstated. Reports have been prepared and studies have been initiated in order to return to the former settlement of Sur District through the approval of UNESCO and return to where people live.
The paper will give information on UNESCO's work and recommendations on the reasons for migration of people living in that geography and on the protection of this cultural heritage.

Keywords: Protection, Urban Protection, Cultural Heritage, UNESCO, Forced Migration

1 INTRODUCTION

Turkey is a very important country that has hosted a great number of cultures, languages and races throughout the history. It has been a wonderful example for the history and multi cultures from coast to coast. One of those places that has been home to many cultures is Sur District in Diyarbakir, Turkey. Sur district attracts the interest of domestic and foreign tourists with its mosques, ancient road houses, bazaars, bridges and the walls (Sur) which is located nearby the Dicle River. It is also recognized as a part of UNESCO's World Cultural Heritage with its Hevsel Gardens.
However, because of terrorist attacs, the region has fallen into ruin and people have begun to abondon their place of residence. The recovery period of the region started with the partnership of Unesco and

governer's office. The project primarily focuses on recovering the entire region and to the extent possible, returning it back to its original state. This means building low profile buildings with 2 or 3 floors and using basalt stones for construction as the original building material.

1.1. The Importance of Research

We will have the opportunity to get acquinted with the characteristic and cultural features of the Sur district. Some proposals for UNESCO's project to be undertaken will also be shared.

1.2 Scope of the Study

We will understand through this research why the cultural haritage of Diyarbakir is very important for Turkey. The most important region is Sur district, and the research will help to get to know and understand its architectural identity throughout the history by evaluating and examining the region from an architest's perspective. We will learn the extent of damages suffered by the district resulting from the attacks and their effects on the UNESCO's project.

1.3 Method of Research

The focal point of this project, i.e. Sur district, has been researched in historical sources. First, the region will be introduced and then, we will elaborate cultural and historical heritages and get a general idea about these subjects. In this context, we will follow the course of study related to urban development process and finally, the settlement. In the final chapter, the project of Unesco concerning Sur district is explained. (Library research; Library of Istanbul University, Istanbul Chamber of Architects, books, journals, articles and documents available in the Turkish National Commission for UNESCO were examined).

2 DIYARBAKIR SUR CULTURAL VALUES

2.1. Considering Sur Region

Considering Sur Region, the main feature of the residential city started in the Late Roman Age. In the middle of the 4th century, Romans decided to make it the capital city of Roman Mesopotamia. This created opportunities for trade and lead to the building of the walls of Sur. The two main roads connect to four main gates and meet at the prime services intersect at the center. The city plan comprises of main lines of the Hellenistic Roman. In this period, the name of city Amida changes in the process of daymares only two roads have reached the opposite (Kursuncu, 2006:38-39) Sur district was founded in 2008 in the oldest settlement of Diyarbakir. Sur is located on the edge of the Dicle River, the elevation of the wall is 660 meters. It was built on lavas of the Karacadag. The name is derived from the city walls of Diyarbakir.

Sur district of Diyarbakir has hosted many civilizations and rich cultures through the history. It is possible to observe traces of almost all civilizations that dominated the region in their relevant periods. Today's archaeological excavations are found out in Sur region. The region has always been able to protect the position of being the capital of cultures.

2.2 Cultural and Historical Values of the District

-Walls of Diyarbakir:

Walls of Diyarbakir are one of the oldest and strongest walls of the world after The Great Wall of China. The dimensions of the wall are 5700 meters length and 10 - 12 meters height. The wall has 82 towers and each one has a thickness of 3-5 meters. Also, it has 4-way opening main gates. The priceless engravings and legends are another detail on the tower. When we look closely at the outskirts, four doors exist: Mountain Gate on the north, Mardin Gate on the south, New Gate on the east and Urfa Gate on the west. The outer wall was used for protection while the inner castle was used for defensive purposes. When and by whom the Diyarbakır Walls were built is still a mystery. The Hurrians are known to have lived in the region for the first time. A large number of motifs and relief figures can be seen at a closer look. When these are carefully examined, it is possible to argue about the cultural and historical specialties of many civilizations. It is possible to see many motifs from our past history from Roman (1st century BC), Byzantine (395-1453), Arab, Turkish-Islamic, Seljuk (1037-1157) and Ottoman (1299-1922) periods. This adds the stones found in the walls a historical identity as well as an architectural identity.

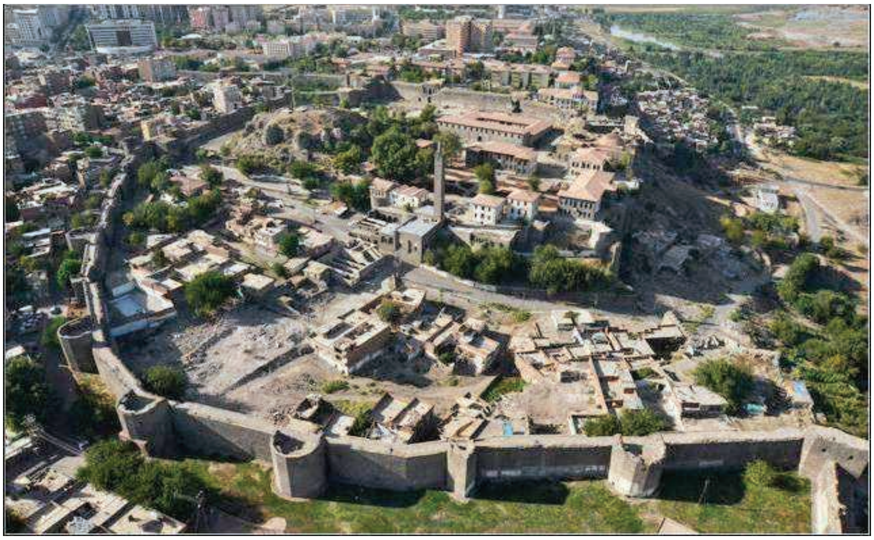

Figure 1. Diyarbakır Walls

-Ancient Road Houses and Caravansary:
Diyarbakir is located on the Historical Silk Road and it has a lot of caravanserai in the region. Delillet, Hasan Pasa, Ciftehan and Yeni Han are the most famous caravanserai and they are still operating as carpet and hand engraved silver accessories stores.

-Museums in Sur District:
Diyarbakir has hosted some famous people as well as cultures, civizilation. The renowned poet Cahit Sitki Taranci's and philisopher Ziya Gokalp's homes were converted to museums. The museums exhibit etnoghraphic objects related to region, photographs and personal belongings.

-Mansion in Sur District
The mansion of Iskerdepasa is the most important heritage in the region. The mansion is reflecting the charateristics of Diyarbakir mansions. The method of joining two blocks to each other was used on the construction. The mansion is also populer for its Harem section. It is currently under restoration to be used as a foundation museum.

-Sur District Villages;
Grand Mosque:
The Grand Mosque of Diyarbakır is one of the oldest and most significant mosques in Anatolia. Following the Muslim capture of Diyarbakır in 639, a church in the city was used partially as a mosque. According to an inscription in situ, Seljuk sultan Malikshah directed the local governor to rebuild the mosque in the year 1091/484 AH. The Diyarbakır Mosque consists of a rectangular courtyard, measuring 63 x 30 meters, bound on the east and west sides by a single-aisled portico, on the north by an agglomeration of buildings of later date, and on the south by a long and narrow prayer hall.

Figure 2. Diyarbakır Ulu Mosque

Nebi Mosque:
It is a single dome mosque covered with stones in terms of its architectural feature. The mosque faces some problems during the period from sunrise to moon. At present, the Shafii and medresses are completely open for visitors. The unique material of Diyarbakir, i.e. basalt stones, were used for the construction of the mosque. The dome was built with crown molding and covered with lead. The mosque is also known as Prophet's Mosque.

Figure 3. Diyarbakır Nebi Mosque

Hazrat Suleyman Mosque:
The famous Ottoman traveller-explorer Evliya Celebi said that this mosque was the first to be built after the conquest. The mosque is open for visitors. It was restored upon the orders of Silahdar Pasha Murtaza in the Ottoman Empire era.

Bedram Pasha Mosque:
The mosque is one of the projects carried out by Mimar Sinan ("Architect Sinan"). The mosque is an ashlar-masonry structure. It is situated on a large paved square at the center of which is an octagonal fountain covered by a pyramidal roof. The main facade (north side) of the mosque faces this square. The building itself consists of a prayer hall in the form of domed cube fronted by a double portico on its north side, which opens onto the aforementioned square. Alternating black and white rows of stone slabs (ablaq) were used to construct the pointed arches of the portico as well as the façade of the prayer hall. A minaret rises from a base adjoining the southwestern corner of the portico.

Figure 4. Behram Paşa Mosque

Ali Pasha Mosque:
It is another single dome mosque in the district. The mosque is one of the projects carried out by Mimar Sinan. Mimar Sinan used hexagonal blue colored china on the inner walls of the mosque.

-Schools in Sur District
Islamic education is considered as the general name of the madrasah education institutions. The Sur district is also known as the center of education.

a-Ali Pasha Madrasa: The madrasa is considered among the works of Mimar Sinan. It is not open for visitors. It was restored and is still in good condition. There are iwan rooms in front of the courtyard on the east and the west sides. It has come to an angle from a half-octagonal site located to the south of the courtyard.

b-Husreviye Madrasa: The structure is accessible through the madrasah portal on the north. The building is made of black rows on white cut stones. Diyarbakir's unique cutting stone was also used for construction. Portacious arches revolve in the middle of courtyard. There is no porch for direct access to the south.

c-Mesudiye Madrasa: The most important feature of this madrasa is that it is located in the same complex with the Grand Mosque. This madrasa was built as a double story cut stone structure. It is understood to be the fiqh madrasa for the four Sunni sects in the book of the Medresen[2]. It is a unique madrasa in Anatolia.

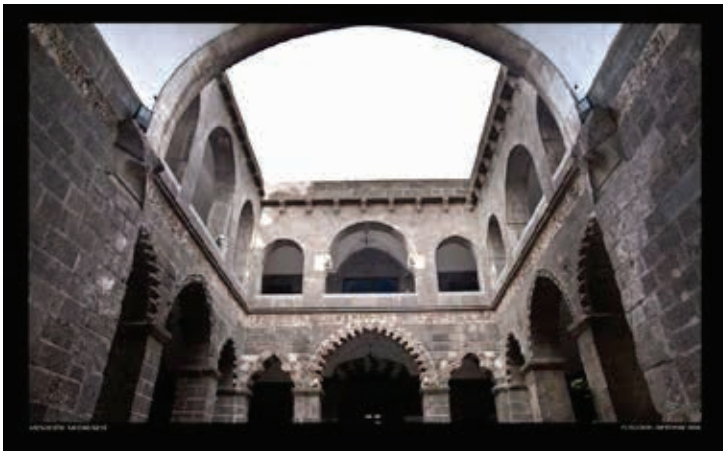

Figure 5. Mesudiye Madrasa

2.3. Urban Development in Sur District of Diyarbakir

Sur District is one of the oldest settlements in Diyarbakir region that has been the center of many cultures for centuries. The urbanism started in Diyarbakir in the periods of Hittite and Hurrians. Archaeological excavations proved that Ergani-Cayonu area had settlement around 7000 BC [3]. The castle and walls of Diyarbakir are the icons of Diyarbakir region and its historical texture starts with these components. The outdoor museum is the most popular stop of the tourists. It had maintained its structure for years. It was restored with new additions. It has never lost its original identity with those new additions

Figure 6. Sur District of Diyarbakir Satellite Image

The process of urban regeneration in Sur district continued until the 19th century. Outdoor renovation on the wall started after the Ottoman Reform Era ("Tanzimat") [4]. Sur district is the core element of the identity of Diyarbakir and it has been a cultural center.

Examples of the heritages:

1- It has hosted many cultures and civizilations.
2- The integrity of the city is protected by the castle walls surrounding the city.
3- It is one of the main centers of many important commercial roads such as Silk Road.
4- It can be listed as it has been an urban site district.

Sur District began loosing its importance after trade developed. A big portion of the population migrated from Sur district. Other people who had worked in agriculture moved to Sur district. Meanwhile, the population in suburban area increased. This migration increased the problem of accommodation and people started to build shanty houses and thus, destroyed the historical places. People came up with a solution, which was building traditional Diyarbakir courtyard houses. Also, additional floors were added to existing buildings or old buildings were knocked down and new buildings were built.

2.4. Sur Province of Diyarbakir

The main feature of the residential city started in the Late Roman Age. In the middle of the 4th century, Romans decided to make it the capital city of Roman Mesopotamia. This created opportunities for trade. It also has started to building the eastern wall in AC 330. The two main roads connect to four main gates and meet at the prime services intersect at the center. The city plan comprises of main lines of the Hellenistic Roman.

The city expanded in terms of systematic and plans. The productivity of agriculture increased and then new districts were created for crowded populations. Immigrants who came to the region and settled randomly created a disordered city plan. This resulted in greater problems for the future such as uncontrolled city plan and pushing into a deadlock. Sur district was caught without preperation.

Economically disadvantaged people built single floor or multi-floor buildings and created a shanty neighborhood. Two criteria are used as basis for developing the city. These are authentic and unauthentic structures. The Dicle Valley is located on the east, the airport is located on the southwest, military reserve is located on the north. These locations are the reasons why the city developed so disorderly. The city looked like ink desolving in the water disorderly from the eyes of a bird. The north side of the city developed orderly whereas the south and east sides did not.

3 UNESCO'S STUDIES IN THE REGION CONCERNING CULTURAL HERITAGE

3.1.What is the importance of Sur District for UNESCO?

UNESCO was established on November 4th, 1946 as a specialized agency of the United Nations. After World War II, in November 1945, a United Nations Conference for the establishment of an educational and cultural organization was convened in London with representatives from 44 countries. Initiated by France and the United Kingdom, the delegates decided to create an organization that would embody a genuine culture of peace. Turkey signed this Act and is the tenth country to do so among the top twenty states. The UNESCO Convention was endorsed by the Law No. 4895 of 20 May 1946 in our country. Pursuant to Article 7 of the Law, the Turkish National Commission of UNESCO became operational on 08.25.1949 [5].

With the increase of environmental problems in the 70s, a number of ideas started to be introduced. Prominent people in the political, educational and scientific fields began to make investments in this regard and the issue of environmental education started to gain importance. The local and then the national awareness gained a different dimension with these studies and the United Nations Conference on Human Environment. As a result, UNESCO was established with the aim of eliminating the negative situations that attracted attention with environmental education [6].

The Hevsel Gardens and the Diyarbakır Walls of UNESCO's World Heritage List in 2015 are the most important cultural heritages of Diyarbakır Sur District. The most important feature of the walls is that they are the second longest structure after the Great Wall of China. The walls are long and quite imposing. They have inscriptions and signs, reflecting many historical periods.

The walls surround Diyarbakır and form a protected area. Today the region is used as an open air museum. The reliefs on the walls, the architectural form of the should be separately examined. The walls of Diyarbakir are over 9000 years old and they preserved their historical and cultural identity. They have become one of the most important cultural values of our time by adding a part of them to all civilizations in the past.

3.2. Present Situation of Sur District and People's Migration Causes

Sur district has lost its historical identity recently and has became a depressed area. Numerous problems emerged. The recent political problems have resulted in a ruined town. People have moved out of the city. The historical heritages face destruction. Most of mosques, schools and houses are damaged. The Hocaoglu Mosque has totally disappeared. Hagi Hamid Mosque has only its dome. Suleyman Nazif Elementry School had three blocks and only one block survived. The Cumhuriyet Elementry School was totally demolished. The Pasa Turkish Bath suffered irreversable damages [7].

Figure 7. Sur Surroundings

3.3. The work of UNESCO in the Protection of the Cultural Heritage in Sur District and Suggestions

3.3.1. A city designed by UNESCO for the District

UNESCO Natural Heritage Criteria

1- to represent a masterpiece of human creative genius,
2- to exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design,
3- to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or has disappeared,
4- to be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history,
5- to be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change,
6- to be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria),
7- to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance,
8- to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features,
9- to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals
10- to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

Diyarbakir and Sur District meet the criteria number 7, 8, 9 & 10 and thus, they are included in the UNESCO Natural Heritage List.

3.3.2 Restoration and Renovation

The recent incidents caused considerable losses for Sur District. The clashes and curfew made people uncomfortable and forced people to leave their homes and move to safe areas. In the meantime, people actually wanted to come back to their hometown. But people are not happy to come back to a damaged and totally changed place. They would like to see the same historical Sur district. Approximately nine thousand buildings in the district with historical and cultural value are intended to be taken under protection. The government promotes urban regenaration in Sur district because the government would like to re-open the area, which covers Sahabe Graveyard, for visitors. An area of 1 million and 870 thousand square meters will be restored. The main idea of the project of Ministry of Environment and Urban Planning is related to residential buildings and a higher number of shops for tourists [9]. Another one of the most important rules on that project is that new constructions will not exceed four floors and they have to be lower than the wall. The famous art historian Albert Gabriel's photos taken in 1930 will help architects to preserve historical structures. [10]

According to the project, the damages will be estimated and then, the government will decide whether the area is safe for living or not. If the inspector finds out any severe damage in residential area, the building will be demolished and re-building process will start. In the meantime, people will be temporarily re-located to other places. Architects will closely examine the building designs and try to reflect the original texture in the new designs.

Figure 8. Current view of Sur Province

3.3.3 UNESCO's Studies for Preserving the Old District in the District

Turkey has not made a big jump for taking care of its historical and cultural heritage although it has hosted many cultures, religions and civizilations. Sur district is one of these examples. The primary goal has always been to include the name of Sur on the list of UNESCO World Heritage List and promote it to the entire world. Protecting the natural texture of this region is one of the roles of UNESCO. The recent political problems and their damages affected the region. UNESCO has been a pioneer of the urban regeneration. The extent of destruction in the area illustrated us that the values faced the risk of disappearing. The urban regeneration is the best solution for the values. When UNESCO team makes the inspection, we will see that the historical and cultural heritage has been protected during the clashes. Therefore, UNESCO has to add Sur on the protection list. However, UNESCO avoided any reference to the protection of Sur district during the 40th Session of the World Heritage Committee held in 2016, in Turkey.
However, during the 40th Session of the World Heritage Committee, Sur District drew considerable attention. The audience asked questions about the statement made by Diyarbakır Field Head and the extent of destruction [11]. What actions should be taken to preserve the region and thus, the cultural heritage as well as recommendations will be shared.

3.4 Recommendations for the Protection of Sur District

Sur has always been an important place for Turkey. All the heritage is damaged and is about to be lost. Theregore, the project of urban regenaration is important to protect the heritage and preserve the original texture. When the project is completed, the region will be a major landmark in Turkey for religious tourism. The renovation process started in 2008 but made little progress at that time due to political decisions. But the government has been supporting the project for some time and thus, it is processing faster now.

The region has to be renovated as soon as possible. And people should return to their homes and continue their life in the region. During the renovation process, all structures should be restored by using original materials and keeping the orignal texture in mind. Historical palaces will be created just like in the past. Illegal buildings should be demolished and the city will gain a fresh look, supplemented with the traditional texture of Diyarbakir.

4 CONCLUSION

Sur has hosted many civilizations and cultures. Its cultural and historical heritage, mosques and ancient road houses and its location on the path of a trade center have made it an invaluable region today.

The region has a great value both for Turkey and the world. Walls of Sur and Hevsel Gardens are now under the protection of UNESCO. Unfortunately, migration damaged the historical texture and turned the city into a ruined one due to the increasing number of shanty houses. The political events also negatively affected Diyarbakir and Sur Districts. Diyarbakir and Sur district need to be renovated to be reinstated . However, UNESCO failed to comment in the session that the urban regeneration was suitable and a necessity and created a paradox on the project. Ideas were exchanged regarding the continuation of urban regeneration. The discussions also aimed to define the priorities. The consensus was to preserve the original texture and identity. If the suggestions are taken seriously and action is taken accordingly, Sur district can preserve its identity and become a crucial region for Turkey.

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The Mudbrick Structures in Van and Their Importance

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ABSTRACT

The first building material that has been produced for a long time and can be given the desired shape is mud-brick. In order to meet the need for accommodation, every person in the field used the soil, in the most primitive way, mixed the soil with water and straw, poured it into wooden molds and dried the product in the sun and named the rectangular forms as "mudbrick". Adobe usage in Turkey is based on ancient times, mainly used after the transition from nomadic life to settled life. Van is one of the examples of the regions with adobe structures that are found in many parts of Anatolia. In this area, it was used for construction of walls, churches and mosques, and for housing construction.

The use of mud bricks on the buildings has many advantages. Using this abundantly available material gives us the most efficient energy saving, creating the most suitable living conditions in the building, making the best use of solar energy with the easiest methods and providing the minimum cost for living space design.

The most important properties to be examined in adobe material to be used in the construction are pressure resistance, resistance to atmospheric effects and dissolution in water. These properties make it possible to survive for long periods without any damage. At present, the lack of adequate maintenance and Van earthquake damaged the structures. At the same time, the dismissal of mud brick houses in the post-earthquake reconstruction plan deteriorated the architectural value.

In the scope of the research, the usage of the mudbrick in the construction area in Van, the samples of the mudbrick structures which have reached to the present and continue to be used today are examined, and the reasons for the importance and the deterioration of these structures are put forward.

Key Words: Mud brick, Van, Masonry work construction, Vernacular architecture, Adobe

1 INTRODUCTION

Soil is one of the traditional materials used in the construction of shelters since ancient times. Today, people live in houses made of materials produced from the soil. This results from the fact that the soil is both healthy and easily available. Today, the land structure is one of the most studied and researched topics from the least developed countries to the most developed countries. The use of soil as a building material contributes both to the prevention of environmental pollution by providing energy saving and to the national economy. The adobe material called Alker provides a healthy indoor space on the one hand with the number of heat transfer coats and reduces the total heat loss., on the other hand. The heat saving provided by the insulation-free structure contributes to the reduction of carbon dioxide emissions by up to 30 percent and the protection of the environment. The soil structure system resembles in many respects to other building materials, even though it is seen only as a primitive system for rural areas and contemporary materials.

Adobe that contains clay, which binds the soil granules together, is made by adding fibrous additives such as straw. Mortar is prepared by mixing soil with water and then this mortar is filled into simple wooden molds. It is shaped and removed from the mold and left to dry under sun.

The mudbrick, which has been used in the Americas and Europe since ancient times, continues to integrate with many different construction technologies. The adobe construction system is mainly found in many other countries, including Anatolia, Central Asia and Africa.

Figure 1. The scanned areas on the earth show the places where the mudbrick was used.

Single and double-storey structures as well as skyscrapers, ramparts, castles, water cisterns, temples and cemeteries can be constructed with mudbricks.






Figure 2,3,4,5,6,7. Examples of mud brick structures on the earth.

As a method of study, literature review and analysis were conducted on the subject. The study consists of 4 main sections. The entrance section gives brief information about the mudbrick structure and its place in the world. In the first part, today's mudbrick construction technique is explained. In the second part, the importance, advantages and disadvantages of adobe structures are mentioned. In the third chapter, the history of Van city, the adobe structures that reached to this area and the causes of deterioration are explained. In the fourth chapter, the protection of the mudbrick structures in the region is given. In conclusion, there are some conclusions about the inferences.

2 TODAY’S MUDBRICK CONSTRUCTION TECHNIQUE

When preparing mud bricks, first check whether the soil is permeable and whether there is proper clay and sand ratio. If it is not enough, add enough clay and sand to make adobe mud. Then pass the soil through a 4mm sieve. To determine whether a piece of land is suitable for the mud-brick, make a sample of the most appropriate shape and leave it exposed by protecting it from moisture. It is dry without bending or cracking. The land can often be obtained during the excavation of the courts. [1]

In order for mud to be good, the amount of water to be added to the soil should also be adjusted appropriately. If excessive water is added, both the mud brick and the resistance decrease. If additives such as plaster, cement and lime are added to the mudbrick mud, some of the water is separated and some of it is thoroughly mixed with the soil. The additive to be added is mixed with the separated water. Then add the homogenous additive mixture and the resting sludge together and mix them well. Not being mixed enough is the effect of adverse weather on the adobe strength. After this process, the mudbrick molds are ready to be placed.

The mud brick wall production with the prepared mixture takes place in two forms. One form is to produce with the help of wooden molds and the other is to produce by pouring the mixture into wooden mold system. When parts are produced, the pieces are dried, then stacked, the stacked pieces are sent to the worksite, where they are stored for a while. Then there is a mudbrick master, a mortar is made and knitted. This process is both costly and time-consuming. Therefore, less expensive and faster casting should be preferred. Sizes of parts vary, but the maximum length is 30-35 cm. width: 30-35 cm. height: 10-12 cm. Mud bricks with length: 30-35 cm. width: 15-17 cm, height: 10-12 cm are used.


Figure 8. Mud brick cast in place, **Figure 9.** Mud brick that is produced fragmentally

The mudbrick, ready to be placed in a mold, is placed in a mold and is tightly pressed. The top surface of the hull is polished with the help of a trowel, then removed from the mold and allowed to dry thoroughly. Horizontal dried mud-brick is kept vertically and dried for several days in order to dry homogeneously. Adobe should be dried in summer without rain and extreme hot weather. Wooden adobe molds should be cleaned before and after each use to obtain smoother surfaces. Finally, the mudbrick is stacked and ready for use.

Figure 10. Preparing adobe blocks **Figure 11.** Drying adobe blocks

After all these processes are completed, the structure is laid on foundation and construction work is started. The most commonly used method to build a mudbrick structure is to use the mud brick and the stone together. With this method, the building is built up to the level of the water basin, followed by the mud brick. Thanks to the stone mesh made of water basin, rain water and ground water are prevented from being worn out [2]. Masonry wall is used while mortar is used and joints are made in an astonishing way. By adding some lime into the mortar, it is plastered inside and out with the help of wooden trowels. Afterwards, the wooden frame is laid and the plasterboard is placed on it.

3 THE IMPORTANCE OF ADOBE STRUCTURES

A traditional mudbrick is an environmentally sensitive, recyclable, energy-saving, ecological building material. It is an economical material that can be used both as a plastering material and as a carrier. Usage from the earliest times to the present day is especially indispensable for rural areas. At least the cost of thermal insulation is a high value material with the necessity of establishing a production facility. In every season, the resident in the building enjoys the most suitable living conditions. In this respect, it does not need a separate thermal insulation material and provides economy [3].

The mudbrick is heat retaining and because of its porous structure, it absorbs airborne niches. For this reason, it maintains the balance of heat and humidity in the structure and creates a cleaner and healthier environment.

Figure 12,13,14. Examples of mudbrick wall

No mechanical energy is required during production and use. For example, energy of 300 - 500 kWh is needed to produce 1 m^3 of concrete, while 1% of this energy is enough to produce mud bricks in the same amount. The researches have shown that an average of 5.5 g SO_2 and 2.5 g NO_2 are transferred to the atmosphere for 1 kWh power energy production. [4]

The masonry walls collect heating energy. Even if the outside air temperature is low, the inside temperature will be transferred to the internal atmosphere, so that the temperature is balanced. It offers protection against unwanted temperature fluctuations.

There are disadvantages as well as advantages of adobe material. It needs continuous care. It is very sensitive to water. This causes the materials to deteriorate and the strength to decrease. Pressure resistance is low and unit volume weight is high. In order to eliminate the disadvantages, studies are carried out to improve the properties of adobe soil. Due to the high cost and high technology requirements, it has not been completely successful. If these disadvantages are completely eliminated, the mudbrick structure is thought to be revived.

4 INVESTIGATION OF THE SAMPLES OF THE ADOBE STRUCTURES IN VAN THAT REACH TO THE PRESENT

4.1 The history of Van city

Van city has been home to many civilizations throughout the history and is an important settlement with its historical, cultural and architectural heritage. First, the Hurrians settled, then the Urartians ruled for over 200 years. Afterwards, Medlar, Persians, Macedonians, (Great Alexander), Parthians, Sasanis, Byzantines, Seljuks, Ilkhanids, Celayiroğları, Karakoyunlu, Akkoyunlular, Safeviler and Ottomans became dominant. The citizens of Van were sent to Bitlis, and the Armenians with the Russians burned the city down. They caused great damage to the civil and religious architecture and made the region inhabitable. Most of the houses in Van City have been repaired and some of them have reached the present day. At the end of the Van occupation, the locals were placed in this area again, but the old center of the ruined city became too insufficient to live. Because of this, locals settled in the gardens outside the city and began to form the settlement of today's Van. The city of Van is located in the Eastern Anatolia Region. The east of the city is surrounded by the western and southern walls, and the north by Van Castle. The entrance to the city is provided by four doors in the city walls. The Armenians in the eastern region of the city, the Kurds in the northwest corner, and the Turks in the central part lived mainly by establishing good relations. This diversity of culture is also felt in urban structure.

4.2. The use of adobe in Van city

Geographical conditions, customs, materials and lifestyle are the factors in the formation of housing architecture in Van. Stone, earth or wood is also used as building materials. Generally, the bases are made of stone and at the same time, they are one of the building materials that make up the walls. Soil is a building material in the form of mud bricks used after being formed in certain standards. The sizes of these bricks vary. Width is 15 cm in fine mudbricks, 20-25 cm in medium width mudbricks and 37-40 cm in wide mudbricks. Other materials may be added to the ground at certain ratios and used for plastering. Wood is used as a binder in mud brick structures such as door, window, covering material, rafter, pole and beam.

Although the Van houses are different from Erzurum and Bitlis houses, they are similar to the houses in the middle Anatolian region. Kerpiç (Adobe) is the most important architectural building material of Urartu Civilization, especially in the rural settlement area. The first examples of houses constructed with traditional mudbrick materials as one and two storeys were formed in Old Van City, which is surrounded by three sides of the city walls in the south of the historical Van Fortress. There are too many mudbrick mounds built on Van road in Van's Erciş district. There are examples of the mudbrick remaining in the Urartu Period in Ayanıs Castle located in the north-west of the city, in the civil settlements of Yoncatepe in the east and in the Lower Anzaf and Upper Anzaf Kaleleri in the north-east.



Figure 15,16,17. Photos of mudbrick structure in Van city

The above structure is an example of a mudbrick structure built in Erciş town. In this two-storey building, wooden beams of 1 meter are used and the corner connection details are designed in a strong way. Therefore, it did not suffer much damage from the Van city earthquake in 2011 with a magnitude of 6.7.

The walls of the rubble of the Ottoman period in the Van Castle were made of mud brick. However, it is not known exactly when these walls were built.


Figure 18,19. Example of mudbrick at Van castle

In today's city of Van, every house is built independently in a discrete manner, in a garden, life and street relation. In the houses, garden, living rooms, barn, straw and the surrounding area are surrounded by walls. This situation in today's Van city's urban fabric is due to the width of the land. However, the situation is not the same for the old city of Van. Due to the limited urban space, all of the houses were built as two storey mud bricks and flat roofs in the adjoining order. The houses in the city are not divided into a specific area, but are scattered all over the city in an inhomogeneous manner with civil and religious architecture. Within this structure, there is no difference between the outer facades of Muslim and Armenian houses. It is seen that all kinds of architectural works in the city are developed in harmony. Evliya Çelebi, an Ottoman traveler who visited the region in the middle of the 17^{th} century, explained that the city had 10 neighborhoods and that the majority of the Muslims were living in almost all districts of the city. The Armenians solely lived in 3 districts in the city. The city has a total of 8,800 houses constructed from two-storey flat-dated pagodas. On the map prepared by Lynch in the last quarter of the 19^{th} century, it is seen that the city consists of 12 districts, 9 of these neighborhoods are Muslims and 3 of them are non-Muslims. [5]

Figure 20. The miniature that shows Van city in the 17th century
Figure 21. Ancient Van city a long time ago

4.3. Causes of deterioration of mud brick structures in Van city
The deterioration of mudbrick structures is mainly due to sinking in the foundation, cracks in the wall, deterioration of the materials used, and shape change. These cracks formed in the wall directly affect the bearing system in the masonry structure.

These damages are linked to many reasons. One of them is the Van earthquake in 2011, which resulted in loss of life and injuries and caused many buildings to collapse. The mud brick structures are very weak against tensile stresses. Horizontal forces that are affected by the damages force the walls with shear force. For this reason, cracks and partial collapse occurred in the walls. It affects the structure of construction negatively.

Mud brick is not water-resistant. Extreme rainfall and water floods in the region decrease the resistance of the building materials every time.

In order to minimize the effect of water on structure, subbasement is usually made of stone wall and continues with adobe. Or the mudbrick structure is being plastered, whitewashed and painted to protect it from external influences. The mudbrick structure to be built should be built in places where the risk of flooding is low and avoid stream beds.

Another factor for the poor condition of mud brick structures in the Van region is the indifference and recklessness of the structure. For this reason, the window doors on the façade have become decayed. This has caused the elements to become unusable.

Vandalism is another reason that negatively affects the buildings. Deterioration is often the result of unqualified repairs and lack of conscious destruction. This is why constructions lose their authenticity. They have become a shelter for homeless people and not been regularly maintained. Not only mud brick structures but also constructions built by using different building materials suffer greatly from the same reason. The building which represents the Ottoman classical period architecture and has the signature of the architect Sinan is Hüsrev Pasha Kulliye, the only building with Islamic-Ottoman social complex in the region built by Hüsrev Pasha, the Governor of Van, in 1568. In today's extremely rundown and neglected situation, the tiles of two meters high of the glass bullion camouflage were removed from the walls of the Russian occupation and taken to the Leningrad Museum in Russia. [6]

The most important factor in the deterioration of adobe structures is the work of unaccustomed masters and architects do not have enough detailed knowledge to guide the master about the material.



Figure 22,23,24. Examples of deterioration in mudbrick structures

5 CONSERVATION OF THE MUD BRICK STRUCTURES

It is necessary that the mudbrick structures, which constitute the cultural heritage of an country, are protected in a serious manner and the culture of mudbrick structure is widespread. In some countries, measures have been taken to protect the mud brick structures. The US is one of them. Construction rules and regulations related to the adobe structure have been prepared. In some regions, it was decided not to construct any other structure, apart from the mud-brick structure, and thus, urban fabric was tried to be maintained.

Santa fe is a city in the US with lots of adobe buildings. The visual continuity of the original mud-brick architecture tradition has deteriorated in this city until 1912 with the recognition of new materials. In the 1900s, a group of architects who were sensitive to traditional life and local culture made their first work on the concept of mud brick building protection. Thus, buildings such as schools, hotels, museums and houses are built only in the historical adobe architecture style. Even if concrete and brick are used in the new buildings, the exterior plaster, color, door, window and other details are simulated. Thus, the urban fabric of the city of Santa Fe has been successfully preserved and the architecture has become one of the important examples of urban conservation.



Figure 25,26,27. Urban fabric in Santa fe

6 CONCLUSION

As a natural and sustainable building material, mudbricks are produced without being baked and pressed. So, they have low pressure resistance and are sensitive to moisture. The material should be made more durable. It is much more advantageous to use these materials compared to other building materials if these disadvantages are overcome by the improvement of the mudbrick. This building material that has a low energy requirement and is healthy has been used in Van city since ancient times. However, these cultural heritages are damaged due to lack of adequate care and solidification and strengthening efforts by specialists and by the right methods. To ensure that our important cultural heritage is not damaged further, successful and decisive conservation policies should be applied to the mudbrick structures as soon as possible and the practice of historical buildings and building materials must be preserved and maintained in the contemporary urban environment. Both the technology and the construction process should be updated.

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Gaziantep Province Oğuzeli District Barak Plain Traditional Adobe Houses

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ABSTRACT

Gaziantep is a city that has developed continuously in the historical process and has hosted a great many of civilizations. Many construction activities are ongoing under the effect of commercial mobility due to the geographical location in the city and the demand for house production is increasing continuously due to migration.

The general characteristics of the city of Gaziantep are examined in terms of geographical, historical, socio-demographic aspects. After the concept of housing was conceptually examined, the advantages of the daily use and exploitation of the adobe houses of Oguzeli District in Gaziantep were investigated and the characteristics of the constructions were examined. Building production is a process that works within a unique system. Different techniques have been studied within the building production process. It was observed that these structures were durable due to the construction of the mud-brick.

The spread of the use of land, which is a natural building material, in the building construction system is very important not only for us but for the future of the whole world. In order to leave habitable environments for future generations, it is necessary to select not only durable materials but also environmentally sensitive, recyclable, low energy consuming and economical materials in the building production system.

Key Words: Gaziantep, Barak culture, Traditional Architecture, Adobe Houses

1 INTRODUCTION

Technological developments that have influenced all the countries of the world in recent years have affected all sectors, but also high technology costs brought about environmental pollution that nature cannot clean anymore. As a result, the practitioners and planners, who are in the forefront of environmental protection, have turned to use of materials that require little or no energy in their production and provide the least energy and brings upon comfort conditions during their use.

In recent years, we see that two different trends are spreading in the selection of materials in the construction sector all over the world. While one of these is high-tech, contemporary materials that consume a lot of energy in its production and use, there are various opinions on the dissemination of the use of the materials we use in the past, which consumes less energy in production and use. While the development of technology creates positive effects in the building material market, it also causes pollution in the environment we live in. The production of contemporary building materials, which are high technology products, has a great role in the emergence of environmental problems. These materials have an impact on the environment at all stages of their life cycle, not only during production, but also during construction and consumption. In this case, it is inevitable to take measures to prevent environmental pollution in order to leave livable environments for the future generations. As the use of the modern materials is widespread, the environmental and human health effects of these should not be overlooked. As a traditional material, adobe is an ecological building material that is sensitive to environment and has a minimum energy requirement from production stage to use and consumption stage.

Carrier material, which is clay soil obtained from binding nature, is an economical material which can be used as plaster material if necessary. Its usage is indispensable for the rural areas, which are as old as the oldest days, and at the least cost and it is a material with a high value of heat insulation that does not require the establishment of any production facility. In every season, the resident in the building enjoys the most suitable living conditions. In this respect, it provides economy by not requiring a separate thermal insulation material. Due to the economic crises that started in recent years in an earthquake-stricken country, care should be taken in selecting the materials to be used in building production. The soil used in the production of mud-brick is known to be used as the first materials that people used to shelter themselves since ancient times. Soil can be supplied easily and abundantly almost everywhere as building materials and the structure formed from the soil is more useful than other structures in comparison with other materials.

Today, the soil structure is one of the most studied and researched topics in the world, from the least developed countries to the most developed industrial countries. The use of soil as building material will provide significant savings both in the prevention of environmental pollution and in the economy of the country by providing energy savings. The soil structure system should not be seen only as a primitive system used for rural areas and without contemporary materials. On the contrary, it is a type of structure which fulfills the most advanced comfort conditions by providing significant energy and cost reduction. In developed countries, due to reasons such as energy shortage and environmental pollution, and in the developing countries due to the problem of settlement, soil structure has become a solution to these problems, and the whole world is turning to the usage of soil structure.

The mud-brick construction system is mainly found in many countries, including Anatolia, Central Asia and Africa. As seen in Figure-1, it is a common practice in the south of Asia, the entire Africa, the Central and South America.

Figure 1. The scanned areas on the earth show the places where the mud brick was used.

In addition to soil-based monolithic and double-decked structures in the world, there are also many multi-stories original local architectural examples. Savings can be achieved in the use of materials that require a lot of energy for the production of iron, cement and bricks that are currently used in rough construction. Using rough construction in an easy and quick system will contribute to the resolution of the increasing housing problem in our country. Although the soil structure has a very ancient background, it is not capable of meeting all of the present requirements. For this reason, researches and studies for improving the earthen construction are in progress.

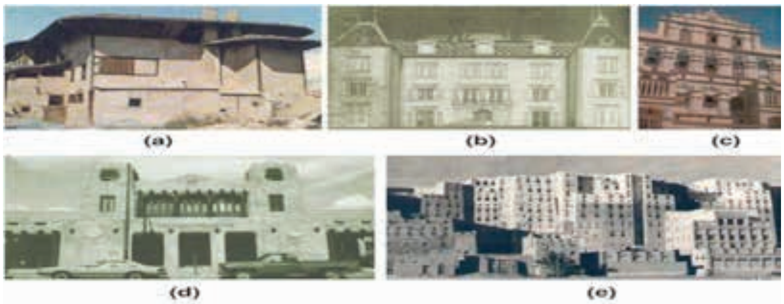

Figure 2. Examples of Traditional Adobe Construction

a) An example from Anatolian houses,
b) Historical castle structure with mud brick walls in France,
c) In Yemen, Ishah palace with mud-brick walls,
d) Mud-brick bank building in Yemen,
e) Bulk houses with mud-brick walls in Yemen.

2 LOCAL ARCHITECTURE IN TURKEY

Many buildings built in the countryside are a part of this type of architecture. In addition to residential buildings, other constructions that are necessary for rural life and constructed with local materials and methods can be included in the same group. The rural areas hold an important place in Turkey as it is an agricultural society. This is why it exhibits examples of different architectural culture and geography of rural life in Turkey. Another issue that can be described as positive or negative is that some parts of the country's land cannot provide any wood material to be used in the constructions. The same interpretation applies to stones that can be used in construction. Due to this, the use of dried brick (mud brick) under the sun dominates much of Anatolia. Poplar tree is widely available in the region and is used as building material. These conditions determine the vernacular architecture of Turkey's geography.

Figure 3. Adobe Houses / Malatya Kozluca, Akçadag Photograph: K.Aran

The characteristics of the formation of "Regional Architecture" can be listed as follows:

Local architecture does not have its own design method; the form of use, structure, building material and local characteristics determine the form of building. The structure and technique may change, but the building material is produced from nature (such as brick and tile). Surely there is a technical glossary. It is provided in compliance with the current site and climate.

As required by traditions, respect is shown to neighbors, the presence of trees, streams, and other elements of nature. The building system is simple and easy to understand. An aesthetic quality is not determined for each building; aesthetic quality is formed in time and thanks to the tradition transmitted from generation to generation.

2.1. Production Systems

Traditional construction system in Turkey is based on three types of building materials: stone (masonry), sun-dried brick and wood. Sun dried brick is a building material used in Central and

Eastern Anatolia since antiquity. "Mud brick", prepared from mud in Anatolian steams and cut and dried as a package, can sustain its existence for a long time as long as it is well protected from contact with water. The houses built with this material are usually covered with open, external halls. The mud-brick walls are built on the foundation made from collected stones that are placed beforehand and then covered with a roof by means of beams made from poplar trees. The measurements of dried bricks obtained during the excavations in 1961 at the ruins of the "Haldi Temple" near Agri province, Patnos province are found to be 21x2 = 42, 9x2 = 18 and 6x2 = 12 cm and it is fascinating that these measurements are the multiples of the brick measures of DIN.

2.2. Mud Brick Residence Type

Another type is the dry brick (mud brick) houses of the Central Anatolia. It is a floor on top of the ground floor consisting of collected stone walls built with mortar. In general, there is a life (open halls) in front. Inside, there is an axial passage and two rooms. Ground floor is often used as a barn. Some parts of Anatolia have used this type of housing for centuries (Naumann, 1975).

3 HISTORY OF GAZİANTEP

Gaziantep is one of the first settlement areas of Anatolia and is located between Mesopotamia and Mediterranean Sea where civilizations were born. Settlements such as Sıccagozu, Zincirli, Karkamıs, Yesemek, Duluk and Zeugma (Belkıs) testify to the prehistoric development of the cultural and political structure of the region. Halpa Kingdom was located in Aleppo. After the death of Alexander the Great, it was included in the kingdom of Selefoz in the vicinity of Gaziantep and the surrounding region. The region was subsequently added to the Commagene lands and continued its existence for a long time due to the Roman Empire. Christianity spread during the Icelandic domination. After the Battle of Manzikert, a Turkic state affiliated to the Seljuks was established. The Anatolian Beylik of Dulkadir and Mamluks settled in the city until it was destroyed by the Mongolian invasion. The city entered under the rule of the Ottoman Empire after the Battle of Marj Dabik. Production, trade and handicrafts were sources of living in the city. At the end of the World War II, English and French occupation was on the agenda. Antep was invaded for 11 months and honored the title of "Gazi" (Veteran). The most striking historical monuments of Gaziantep are on the Silk Road from the Hittite, Roman and Ottoman eras.

4 HISTORY OF GAZİANTEP HOUSES

Historic Gaziantep Houses: Behind the high walls are structures directed towards the Courtyard as far away from the outer border as possible. On the second floor of the houses, there are bay windows viewing the streets. Such structures, which are externally covered by metal, are also referred to as plumbed houses. The houses are provided with entrance through the court yard to the street. The courtyard is surrounded by the cooking area (kitchen), hazna (cellar) and hela (toilet). The houses are built as single, double and triple story. Generally two-story houses can be seen. Due to the fact that women spend most of their time in the house, the courtyard has a special importance, especially in summer. On the courtyard floor, there are usually embroidered stones. In the vicinity of the courtyard, flower beds are present, usually in the middle of the courtyard, there is a pool called Gane. The upper floors of the house are accessed from the outside by stairs. Often lined around the hall, there are rooms with iwan rooms. This section, locally called "iwan", has a closed upper side and a front side courtyard. It offers a shady place on hot summer days. The rooms that open to the hall are rooms with multifunctional features. These rooms are built so that people can fulfill daily functions such as eating, lying down and sitting. They also have a place called threshold, where the function of showering takes place. There are rooms where mattresses are stored, and cupboard niches called cupids for food containers. These have very nice woodworks called nacar. There are sections of stairs and the roof that are reflected from outside of these rooms. The houses used to have soil roofs but they now use pantiles. The attic is also used as a pantry because of good ventilation. In general, the ceilings pass over wooden timbers, and some pass to the ligature. These are painted with ceiling ornaments. Facades often reflect the functions of the form of social life. For example, in order to ensure privacy, the window facing the street on the ground floor is not opened and it totally faces the courtyard. On the upper floors, there are large cage windows overlooking the street. All windows have 'kustaga' enabling light and air to circulate. Kustaga is also the place where pigeons and birds live. Some windows also reflect the religious views of the owners. For example, in non-Muslim homes, there are crosswind windows. In addition to meeting the need for air and light, the windows are also the decoration of buildings. Splinters, minaret rocks, atara stones and black stones were used. Black stones are often used in courtyard decorations. The trunk under the houses is called treasure. The bowls are generally used for pantry purposes. This is a cool place, a good place to hide food.

5 BARAK

The word Barak has different meanings in our history. We can list them as:
1. The Mongol historian calls the Reshidhdin Baraklilar 'Kılbarak'
2. Clear, pure, clean, bright, out-of-the-way, bold, derived from the word 'Berry'
It later became 'Barak'. (Dr. K.M. KORKMAZ, Barak Türküler)
3. Barak word means the head of the wolf, which is the symbol of courage and heroism. (Ali ŞAHİN, Güney Beydili Turkmens and Baraks in Anatolia)
4. Since the Baraks are the banners of the settlement, the word "Bayraktar" changed over time.
"Barak" has been transformed into a shape.
5. Divani Lugat, the work of Mahmut Kashgar, means "Barak is very hairy" in Turkish. It is said to be a hairy, hairy cloth. Lightning in the Arabic language is known as the moment of shining brilliance.


Figure 4, 5. Barak Culture

It is also meaningful to say "Flag" beside the great grapevine that surrounds the trees. The book titled "Religious Social History of Anatolia" by Prof.Dr. Hilmi Ziya Uken is related to this subject: Shamans were sitting in Barkta. There was an oven in the room, a few stairs made of wood. This ladder was a means to reach the sky... It is said that "The shaman went to see the Gods when they went on this bark."

5.1. Origin, History And Place Of The Barak Tribe

Barak Turkmens who left their marks on most of the Anatolian and other Turkic dynasties were first mentioned in the Oghuz Khan Epic. The Barak are a Turkmen Tribe and the right arm of Oguzhan whom bound to Yıldızhan's sons from Bozok.

In Oghuz Khan Epic: The Baraks are said to be a Turkmen community living in a region known as the Land of Darkness, north of Itil River. In this text, the Baraks are referred to as Hairy Baraks and Black Baraks. According to the epic, the Baraks who were living in the Land of Darkness united with Oghuz Khan after a fierce battle against him. A battle between the Baraks and Genghis Khan began when Genghis Khan was returning from another battle in India. When Genghis Khan realized that the Baraks were a Turkish army; they embraced each other with joy.

'Barak is the name of a Turkmen tribe and the name is derived from the region that had four other smaller tribes (Beydili, Elbeyli Turkmen) that were a part of the Baraks. The region of the Baracks include Karkamıs, which is called Oguzeli in the west, and in the north, it extends to the Nizip Birecik road, Barak Plain surrounded by the Syrian hills in the south. The name Barak Plain is also derived from the Baraks. The Baraks appear in the records from the period of Suleiman, the Magnificient.

With the beginning of Turkish domination in Anatolia, it is known that the Baraks moved to Anatolia in the 11th century. The last migrations from Horash occurred in the 16th century. A Barak Turkmen, the Ruler Feriz led the tribe through Erzurum, Sivas and Yozgat, and settled in Yozgat. After settling in the Yozgat region, disagreements with other localities began to arise. As the complaints increased about them, the Ottoman Sultan sent Kadıoglu Yusuf Pasha to end the disagreements. When Yusuf Pasha became aware that the tribe comprised of the Turks and Muslims, he did not want to offend them and he summoned three of the tribe's elder men to the Padishah. The Sultan was very pleased with them as they were Turks and allowed them to stay in Yozgat. Shortly after the settlements, Rakka and its vicinity turned into a buffer zone for the disagreements near the border of Syria and Iraq. These migrations were very heavy, 84 thousand households migrated to Culap and Rakka regions and they coped with the struggles caused by Arabs on the coasts. As complaints about them increased in this region once again, Abbas Pasha of Aleppo came with his forces and set up his headquarters against Culap, ordering the Ruler Feriz to deliver some of his men to them and pay taxes. After this, the Ruler Feriz notified the situation by gathering Abbas Pasha and some of the tribe leaders. The Ruler Feriz said, "I am going back to my homeland and whoever wants may come with me". A group from his tribe tried to persuade the Ruler Feriz to return. Losing his temper, he killed his child by throwing him off the horse. The people witnessing this event said, "A wolf that kills his child will never return from his path". Upon this, they gave up and returned to their homeland. Later on, the Ruler Feriz was invited by the Shah of Iran. On the return of the Ruler Feriz to Iran, the Baraks got angrier because they had to pay taxes and the tribunal's displeasure grew. There were still wars in the region, and when complaints were made about them once again, an Ottoman army distributed them under the command of Abbas Pasha, the Governor of Aleppo. A part of the Baraks ended up in Gaziantep region, settled on the Tilbaþar highlands in the southern part of the plateau, where Antep is located. This geographical region extends to the Euphrates (Culap suy) in the east, the Nur Mountains in the west, Aleppo and Amik Plain in the south and southwest. Thus, the tribe was scattered to the Central Anatolia. 18 of the 97 villages are in Gaziantep within Turkey, while the rest remained in Syria. The name of this tribe, which is on the Syrian border, is still known as "Barak Tribe".

Figure 6, 7. Barak Culture

The Ilbeys, Turkmens and Baraks are guardians to the Syrian border. The social and political events that took place in the Baraks region and the wars and migrations that caused the great hunger caused the formation of the "Epics", "Weeds", "Turks", "Games", "Dances" belonging to the locality. (http://www.alaturkaonline.com/barak-kulturu, -02.08.14)

6 GENERAL OVERVIEW OF BARAK CULTURE

6.1. Belief System

While Turkmens were living their godly religions, they met with Islam in the Central Asia through Iranians. For this reason, they were likely to be influenced by Shiite belief in Iran. Alevism: It is the fusion of Old Turkic belief with Islam spread from the Central Asia to Anatolia. For this reason, the Anatolian Alevism carries the traces of Shiite faith. The Barak are also likely to be Alevis because of their presence in the communities that immigrated to Anatolia through Iran. Although they wandered in Anatolia, they continued their traditions. In the time of the Ruler Feriz, the last immigrants of the Baraks and Turkmens to Anatolia, they adopted Sunnism. (Friday KARATAŞ, Last Nomadic Baraklar History ... Life ... Folklore)

Figure 8, 9. The belief system in Barak Culture

6.2 Reflection Method

Barak marriages draw attention with their different wedding customs. Upon the mutual agreement between two families and daughters of legal age and the son, the couple will marry. Apart from this, marriages are allowed after paying money for the bride. This practice was abandoned and instead of money, taking gold from the male is more common. Thre Baraks love entertainment and festivals, they have colorful weddings. On the last two days of the weeding, the drums and local folk dance continue without interruption. On the last day of the wedding, 'Sabas' and guests from the wedding donate money to charity, the amount varying according to the degree of kinship. It is the best example of social aid. The participants of the wedding make a line and someone holds a bag to collect all the jewelry that the participants are willing to give to the groom or bride to hand over to the groom's father. Guests are invited over for dinner by distributing handkerchiefs or socks. Most of the traditions originate from the East. It would be unfair to continue without mentioning a few interesting examples of the practices related to birth, which were abandoned. A puerperant woman called 'Nevse' is not left alone until the baby is forty days old. Putting dough, scissors, needle knife and broom under pillow is a practice that survived. Höllük (a type of fine soil) is sieved to be laid under newborns. As of burial traditions, the deceased is burnt down and other religious duties are performed. Staying in the home of the deceased for forty days, eating and distributing meals brought by friends or relatives and sharing a meal with everyone on the fourth and fifty-second days are some other practices. In the Barak culture, verbal sources are as important as written sources. A mother who lost her child during the preparation for marriage was crying and singing zilgit (a high pitched vocal sound). Zilgit is also an indication of joy during marriage celebrations. People also make dance figures very slowly at the funeral. This has a different meaning in the Barak culture: a half-married son, along with symbolic wedding figures and eternal life.

Halayin (known as halay, but quite different from the folk dance) is exhibited in such a painful process. Sometimes women press their fingernails on their faces to suppress their suffering, which is described as trying to suppress emotional wounds with physical pain and is a very common practice. The Barak culture also has examples of tattooing. Tattoos are believed to protect people from magic and evil and they are also made for reasons such as fertility and recovery from disease. Both the young and old share the same belief. Three corners of the triangle - women's triangular shape represents Prophet Ali, Prophet Osman and Prophet Abu Bakr. It is believed that these three holy people will remove the evil and destroy it. According to another belief, tattoo is also made to a newborn if the mother died short after the birth to protect the newborn. Hedile – a girl from

Doganpinar village, has a tattoo from her childhood. Her mother gave birth to 9 children but only 2 of them survived. The ones that were tattooed.

6.3. Communications in Room

Another important element in the culture of the Barak is undoubtedly their "room" tradition. Barak "room" tradition is gradually disappearing. In the villages, every wealthy family has a separate room built for their guests. There are also coffee rooms for Mirra, an indispensable beverage. Chats, songs, stories, and traditional drink – Mirra- are shared in the room. These rooms are enjoyed by the village men.

Figure 10, 11. Chamber Culture in Barak Culture

In these rooms, which are the venues for guest hospitality, meetings and conversations; a coffee stove is in the centre and cushions are on the ground. In addition to serving for guests' accommodation, Barak rooms are also places where hostilities are resolved, peace meals are eaten and songs are sung and celebrations are accepted. Therefore, a verbal culture accumulates in the Baraks' rooms.

Based on this oral tradition, many of the elements of culture are exchanged in chats and passed from generation to generation. We share with you the information we have gathered from written and verbal sources based on this oral culture. For example, if a guest hosted by the Baraks does not say anything, he will be treated with respect and welcome for three days. At the end of the third day, the reason of the visit will be asked to the guest and if the home owner can do anything to help him/her.

6.4. Folk Songs

The Baraks are nomadic Turkmen. Although they are Turkmen, "halay" has an Arabic origin. They were influenced by the culture there. Hence it influenced their folk dances, cultural products and music. In these Turkic communities, folk songs are generally about painful situations that the society has gone through rather than an individual's love pain. The Barak's unmetered folk songs are about migration, settlement, tribal quarrels, group identity, heroism and brides. Turkmen tribes express their troubles with Arab and Kurdish tribes. In particular, Oguzeli, Karkamış, Beydili, Elbeyli and Barak Türkmen live in the regions and soul-touching music that fell from the depths of history is created.

Özo Gelin: Özo Gelin, whose real name is Zöhre BOZGEYİK, is one of the six children of Emir Dede, who came to the world in Dokuzyol (Uruş) village of Oğuzeli district of Gaziantep province in 1325 (1909). Zouhre, a beautiful and loved girl; 'Özov, Özo, Ezo, Özey' are her nicknames. Türkoğlu wrote stories about Ezo Gelinin. Bekir KARADUMAN, known as İzlenli Bekir, wrote songs about her. Ezo (Özo),became a legend with her unhappy marriages and longing for her homeland. The folk song is dedicated to her. She was buried in Syria in 1956 and brought back to her motherland Dokuzyol (Uruş) in 1999.

Haco Gelin: Her real name is Hatice and the Baraks call her Haco. The sad story of Haco bride: Haco is given permission to marry her father's nephew but marries to someone else and on the day of the weeding, she is killed by her uncle's son out of jealousy.

     

Figure 12, 13, 14, 15, 16, 17. Turks in Barak Culture

7 BARAK HOUSES AND HISTORY

The need for a building for shelter begins with the history of humanity. Human beings build their barns with the materials they obtain from the Nature. The examples of the first building for the purpose of the settlement and cultivation in Northern Syria dates back to BC. 3000 - 2000 (Early Bronze Age) Tilmen Höyük, Sakçagözü, Carablus, Zencirli settlements. These structures are made of stone-based adobe cloistered soil. The Hittite Kingdom Carablus (carcass) are structure examples that show much similarity with today's Barak Plain structures. For this reason, we can say that time almost froze in Barak Plain during the Hittite Kingdom. The materials used (stone, slate, wood) and construction techniques are identical to those used in the Hittite Kingdom period.

Settlement: Barak Plain settlement, North Syrian and Anatolian village settlement structure. Villages were built as agricultural production units with their fields. There are two types of settlement structures in Barak Plain: plain settlements and large settlements. In the Plain Settlement, constructions do not form the street layout, a free order is formed, and a scattered order is the characteristic. There are no space and security concerns. Settlements located at Yamaçta or Höyük at the Mound Placement are positioned to observe and control their agricultural lands. It is estimated that this kind of settlement has place and security concerns.

 

Figure 18, 19. Barak Home in Construction

Barak house: We can review the Barak house under two headings: Spatial and Structural. We can examine the function of the house in spatial sense, the processes of agricultural production and the way of life, and the material and construction technique in a structural sense.

Venue: Concerning space, Barak Plain has a broad space whereas Barak house has a narrow space. Every building is a crust formed around the needs of people. In the Barak house, crust is shaped only by human size and needs without considering visual and monumental aspects. The structure has no sharp or rigid lines at all. Corner and edges; formed curvilinear lines. The building is like a plastic sculpture with internal and external lines, as if it was a human scale rising from the earth. The most important factors for the formation of the Local Architecture are: Culture, environment and materials. Culture comprises of social structure, life style and production relations. Environment comprises of climate, geological structure and production resources. Building materials are obtained directly from the nature. The influence of these factors: Barak houses have continued spatial and structural development since the Bronze Age through the master and the residents. The structure needs maintenance every year, allowing the structure to be renewed to respond to ever-changing and evolving needs and functions. Every room is a unit of living on its own; the separation of function between rooms is not clear. While a room was sufficient for the family at the beginning, the changing needs and the increase in the number of individuals required a second room, the space between two rooms is covered with the second room. Efforts to expand the common area between the chambers created the T-type Balinese house specific to the Barak Plain.

Figure 20, 21. Barak Home Venue

Building Technique: The adobe construction technique protects the archaic style from the Bronze Age. Building materials are the same. Construction tools are tools used in agricultural production. Master is a person who is competent in the culture and economic environment of the society in terms of construction. Materials used in construction technique: the building materials of the rural settlement are stones, soil, mud brick and wood.

Stone: It is the first material of the building art. It is a material that is easy to find in the country and is highly resistant to bearings and natural conditions. North Syria and the Anatolian peninsula are the only places where the Spray (Volcanic) Rocks and the Crumb Rocks are found together. Basalt and Diorite Rocks in the Northern Syria are used for buildings. Stone is usually taken from the nearest quarry to the area of use.

Soil is the most abundant building material. Soil used for mud-brick casting and soil filling purposes is obtained from the quarry that is at the closest proximity to the construction site to reduce transportation costs. Soil used for slime; clay and organic waste is the reason for preference.

Adobe (Brick): Clay-rich soil is taken from the closest source and gravels and stones and straws are mixed with water and clay is added. Rested clay brick will be removed by pouring the wetted area in the wood block structure again by adding water. The mud-brick must be dried, far away from the shaded area to avoid cracking. Average adobe dimensions are 40 X 20 and 50 X 25 cm. The thickness is 15 cm. Although expressed in cm hereunder, the practical measurement is made by palm and fingers. The designated construction masters prepared 5000 adobe bricks for a house because it is not possible to use disintegrated bricks. Complete (Home) and half (lamb) were two types of adobe bricks.

Figure 22. Mud brick construction

Tree: The tree used for construction is poplar tree logs of 15 - 18 cm in diameter, which are used in the construction of the uplift. They are usually grown at the edges of the fields and at the edges of the creeks. The poplar trees, which are defined as poles with a diameter of 6 - 8 in diameter, are used for gluing purposes.

Construction: Two essential elements for construction are materials and construction master. In the course of the field work, a master, in the true sense of the word, was not available. The person who is defined as master hereunder is a member of society who is competent in the construction field. The wage of the master was often nothing more than a 'God bless you'. The construction process is implemented with the control and support of the building owners and the helpers. Often, building owners are capable of building their own houses. The tools used in construction are the tools used in agricultural production or simple tools such as molds for mud and mud pellets used for mud and mud brick construction.

Foundation: Foundation construction begins with the opening of a foundation pit for the construction of foundation walls in the ground. The basic structure is wood flooring up to the floor level. The knitting technique involves wooden blocks with crushed stone, dry (without mortar) stone walls. It is known that the same technique was used in the Bronze Age settlements.



Figure 23, 24, 25. Adobe House

Wall: The wall braid starts with a mud-brick wall braid on the surface, which is made up of wooden beams mounted on the stone foundation wall. The unit of measurement for the building is adobe. The width and height of the building are defined by the amount of the mud brick. The mortar used in joints has the same properties as the mortar used in mud-brick casting. The lattice used on the bedside and ceiling tile flooring, where the mud-brick masonry starts, is uninterrupted. Door, window and recessed cabinet openings are passed with wooden lintel. Door blanks are wide enough for a person to pass. The height of the door is high enough that a person can enter by slightly tilting or paying attention to the entrance. The door wings protect the Archaic style from the Bronze Age. Window gaps have the minimum dimensions that will provide sufficient light and ventilation for the interior. The upper limit of the window opening is the height of the human body, the level of the cushion and the pillow that is laid down at the bottom. Window inner sills are suitable for indoor use. The walls are plastered from the outside and inside to obtain a smooth surface. Plaster is prepared by using the same soil used for mud brick casting and by adding straw. The soil and straw used should be screened differently from the mud-brick in order to obtain a smooth plaster surface. Application of lime whitewash on fine plaster on the exterior and interior walls of buildings is a general application. In Bronze Age applications, we know that the walls are made of oxide paint and ground limestone, using coal coloring and wall paintings. Such an application can still be found in a house in Oguzeli / Karaman village. Interior and exterior faces can be colored with oxide paints. We do not know how it could be done during the Bronze Age, but in today's Barak region, the annual maintenance works of the houses are usually determined as the duty of the plaster and painter women.

Ceiling and flooring: Ceiling and flooring construction begins with the preparation of the bedding for the floor beams, filled with beams and lattices arranged at the ceiling floor level. Cutting poplar tree for the floor, logs are peeled off the logs, dried and prepared for the deserters. Hezens at 25 - 30 cm intervals between the root and top parts are laid astonishingly. The walls are filled with stone slime or mud bricks. Beams must be inside the walls' outer surface. If it is done for the dam, it should overflow the structure as much as the width of the fringe. Generally, the wicker is laid out from the reeds that grow in the region. The wicker is covered with thin poplar branches and leaves. Flat stones are used for the legs. It is compressed and fixed with the soil. Screed in the soil is compacted and fixed. Screed application uses sieved soil and straw. The use of salt during screed makes surfaces harder and prevents plants from growing. In current screed applications, we find apples that use low-grade cement for the mixture of sieved soil and straw. In the case of soil-flat dam application, the dam curve is correct, the dam circumference is raised and the water is collected in the middle and it is discharged by plastic or tin canals.

Figure 26. –Adobe House in Gaziantep Oğuzeli / Barak

Figure 27. Tüzel Village Oğuzeli / Gaziantep

Figure 28. Tüzel Village Oğuzeli / Gaziantep

Figure 29. Büyükkaracaören Village Oğuzeli / Gaziantep

Figure 30. Sevindi Village Oğuzeli / Gaziantep

Figure 31. Hötoğlu Village Oğuzeli / Gaziantep

Figure 32. Karaman Village Oğuzeli / Gaziantep

8 CONCLUSION AND RECOMMENDATIONS

Due to the mobility required to shop in the city centre, costs are at reasonable levels when freight arrivals, migrations and housing in the construction sector are taken into account. In this respect, construction fees of traditional Gaziantep Houses comply with the standards. General characteristics of Gaziantep city; geographical, demographical, architectural and engineering constructions and features of adobe constructions in Gaziantep were examined. Building work is a process that is spontaneously studied in a systems engineering. Different techniques were examined within the scope of the building production process. Adobe engineering was observed by providing these structures with durability. The spread of the use of land, which is a natural building material, in the construction of the buildings is not only beneficial to us but also to the future of the world. Mud brick quality should be increased with plaster. Just like other building materials, the work should be done correctly or consequences may be severe.

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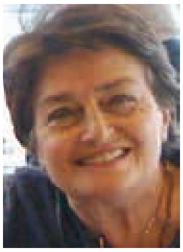

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Consulting the earthen construction projects: 22. Viranşehir Kerpic project, 23. Yılmaz Erdoğan Film producing plato project, 24.Göbeklitepe visiting center project, 25.Van housing demand after "earthquake2011", 26.Çanakkale housing demand after "earthquake 2017", 27.Kınık Çömlekçilik Research center.

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