

The Role of Archeology on Earth Buildings and Earth Architecture in the World

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Abstract

Many archeologists have carried out many excavations to investigate many archeological sites in various parts of the world. The current paper is aimed at investigating the role of archeology on earth buildings and earth architecture in the world. The current study provides a review of many archaeological studies in collaboration with analyses of the construction techniques applied in various archaeological sites. In fact, in order to draw a conclusion regarding to the role of archeology on earth architecture, diverse investigations which have studied into archeological and structural aspects of vernacular buildings have been presented. Many of these researches put emphasis on archeological aspects of various sites, but none concentrated on the role of archeological sites on earth buildings. According to different investigations, results signify that utilization of the past construction methods applied in construction of ancient vernacular buildings can be developed, and utilized in modern structures. Also, archeologists deemed that further devastating effects such as humid and rain should be considered in order to hamper the deconstruction of vernacular buildings. Prospects for further developments of earth architecture are so bright if engineers augment the quality of earthen materials, and earth construction techniques using the methods which are founded on ancient methods.

Keywords: Archeology, Earth Building, Earth Architecture

1. Introduction

Vernacular architecture is a type of non-engineered architecture that chiefly relies upon accumulated empirical knowledge which contributes to construction of vernacular buildings¹. These buildings aimed at providing the requirements of their locale for the residents². Besides, vernacular buildings are representative of traditions and historical background of a local region. Vernacular buildings mostly are constructed by local materials such as earth, wood, stone, etc. It is worth to be noted that building materials make a great contribution to the environment. Vernacular buildings affect the environment due to the fact that local materials which are applied in these structures do not have the devastating effects of prevailing building materials³. Vernacular architecture commonly used to be deemed as an obsolete

type of architecture in developed countries; thus, the evolution of vernacular buildings was hampered in these countries. However, these buildings constitute a great portion of dwellings in developed and developing countries. In recent years, vernacular architecture reached to a level of maturity due to the environmental issues. According to the studies which have been conducted into the investigation of vernacular buildings, this type of buildings have been understood as the proper response to the global environmental issues; thus, they recently have been categorized as environmental buildings⁴. Many studies have been carried out into the selection of building materials of environmental structures⁵. Earth is one of the materials which has been widely utilized in construction of these buildings. Besides, earth can be applied in diverse compositions and based on the composition and the type of its application has different names such as rammed

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earth, soil blocks, adobe, etc. Scientists are skeptical about the origin of Earth construction techniques although evidence in south western of Asia, the Middle East and other countries such as Spain and Turkmenistan signify that earth has been used as a building material for thousands of years⁶. Evidence in Egypt indicate the foundation of earth buildings in the 11th century B.C⁷. Also, there are some remains of 2000 years old adobe bricks in Turkmenistan⁸. Archeologists also reported the existence of some scattered villages in some remote sections of Iran and Iraq. They also asserted that the origin of these villages dates back to mid-eight millennium B.C⁹. Ancient earth buildings are present archeological monuments which provide requirements of the residents of their locale. In a more detailed description, archeology's scope of science is to study into the culture and origin of different cultures and humans' behavior through recovery and analysis of the cultural and environmental data which have been left. The discipline executed in archeological researches comprises surveying, excavation and in last phase analysis of data. Archeology encompasses an extremely large span of time and method of study. Archeological researches are intended for various purposes such as human evolution, cultural evolution and culture history. In fact, the specific time period and method of study specify archeologist's scope of research. Some archeologists put an emphasis on past societies through investigation into changes of different societies over a long span of time. They apply remains of ancient societies to investigate the past humans' lives. These remains comprise of fossils, artifacts, pottery and ruins of buildings. Earth buildings and Vernacular buildings used to be prevailing building structures in ancient civilizations; thus, archeologists place a high priority on investigation into the ruins of earth buildings and vernacular buildings.

During centuries, former earth building techniques have been evolving conspicuously as it can be observed that they constitute approximately one third of buildings in developed countries and almost half of the dwellings in developing countries. Buildings made of earth are economical, energy-saving, environmentally-friendly and sustainable. Recently, earth buildings constructed by modern methods which are energy saving and sustainable have come to the fore due to the rises in energy costs¹⁰. The aim of the current study is to evaluate whether the past constructive techniques can be used in the present structures or not.

2. Investigations Conducted at Archaeological Sites

Since Earth have been utilized as a construction material in all ancient and modern cultures, many researchers and archeologists have conducted several studies into investigation of earth buildings as a sub-category of vernacular buildings and sustainable buildings. These researcher's scopes of study vary based on different aspects of earth buildings. A group of researchers confined their studies to a specific archeological site such as Temple of Ramse in Egypt, citadel of bam in Iran, etc. in contrast, another group of investigations have been made into the properties of diverse earthen construction materials.

Mateu¹¹, Noudarou¹², Friesem^{13,14}, Frances¹⁵, Quagliarini¹⁶, Balsam¹⁷, Roderick¹⁸, Philip⁹, Stefan¹⁹, Virginia⁷, Schirmer²⁰ and Bar- Yosef²¹ have conducted various studies which were intended for investigation into archaeological sites in which earth architecture exists. Each of these archeological sites were investigated due to the fact that they demonstrated either a special feature of earthen building materials or earth construction techniques. Mateu conducted an investigation, into Sant-Jaume where possesses one of the largest sets of raw earth materials. This research mainly concentrated on constitution of raw earth. SantJaumedelsDomenys is a village in the province of Tarragona, Spain, and also is an outstanding site located in the North East of Iberian Peninsula. Mateu's study encompassed both architectural elements and raw earth building elements of SantJaume. Mateu applied many representative samples for the study, and divided the collected samples into two main groups which comprised constructive elements and furniture elements. These elements have been analyzed and based upon these analyses, Mateu observed that construction elements had clayed and calcitic groundmass, while furniture elements were rich in clay and lime which means that the constitution of these two elements differs significantly. It is worth to be noted that there is yet no justification for the existence of these specific minerals in constitution of raw earth in this region although there are some assumptions that these minerals play a vital role in preserving the integrity of either construction or furniture elements. Noudaro has also carried out an investigation into the construction of prevailing materials in Bronze Age Crete. This study was

intended for determination of composition of earthen construction materials, in particular, mud bricks, which is a term representing handmade unbaked bricks, in Bronze Age sites by utilization of some mineralogical and chemical techniques. For many years, archeologist have been putting a lot of effort into determination of the composition of raw materials applied in construction of ceramics in various archeological sites located in East Crete. As a results, earthen construction materials seems to be ignored although they constitute a wealth of artifacts excavated in this region. Noudaro's study recommended that archeologists should analyze construction materials scientifically while excavating the archeological site in order to understand the construction technologies applied to them.

Like Noudaro, Freisem is another researcher who has carried out a study into investigation of the constitution of mud bricks. However, Freisem mostly concentrated on degradation and parameters intensifying the pace of degradation due to the fact that mud bricks are extremely prone to degradation either in arid environments or humid environments. Besides, investigation into the degradation of mud bricks come to the fore because it hinders archeological researches. In this research, Freisem conducted a study into the process of degradation of mud brick buildings in an arid environment. The study has been carried out into an abandoned house located in Kibbutz Gvulot in the southern Israel that was identified by archeologists. Freisem's research was based on the analyses of samples which were taken from a column of the mud brick house. These analyses were aimed at determination of mineral components and chemical constitution of samples by means of many geo-archeological methods that have been employed in this research. The results of these analyses contributed to the presentation of a model for the degradation of mud bricks which paved the way for further researches. In another attempt, Freisem conducted another research which was intended for investigation into the degradation of mud bricks and the devastating effects of humid environment. Freisem made an observation into the deconstruction process of a village of Kranionas located northwest of Kastoria in the Northern Greece. The main purpose of this study was to present the criteria for identification of degraded mud bricks and to understand the formation of degraded bricks. Freisem's study is founded on samples which have been taken of two mud brick houses. Results

signified that humidity and rain are by far the most influential factors of degradation of mud bricks which contribute to disintegration of them in humid environments. There are many other articles regarding to destruction of earthen construction materials. Roderick have also carried out a study into the mud walls' devastation in the Forest/Savanna Mosaic zone of West Africa. Mud walls of this zone are extremely prone to destruction due to the climate of West Africa. Roderick undertook a study into Hani and ancient Begho, two villages in the region. In fact, Roderick conducted an investigation into Hani which is a modern village in an attempt to obtain to a wealth of information about degradation of mud walls in Begho as an ancient community. The results of this study provided archeologists with some criteria. Besides, evidence gathered from deconstructed mud walls facilitated further investigations into devastating parameters affecting them. Frances has executed a research which is aimed at investigation into performance and deficiencies of the Canaanite of Laish, which is an archeological site located in north Israel. The origin of this archeological site dates back to mid- eighteenth century B.C although it was excavated less than 40 years ago. The three-arched middle Bronze Age gate at Tel Dan which built completely of mud bricks is remarkable not only because of its archeological significance, but also because of the preservation of its integrity during a long span of time. Frances also has proved that these load bearing arches have been constructed many years before the advent of romans' arches, which represents the ancient expertise to engineering soil structures. The other research which has been undertaken by Quagliarini was intended for investigation into adobe walls in Republican domus sited in Suasa (Acona, Italy). These adobe walls were excavated in recent years which initiated the foundation of Quagliarini's study. It is worth to be noted that Sausa is a site that has been discovered by Romans at the beginning of 3th century B.C. later, in 20th century many archeological investigations have been undertaken in this area, which contributed to the discovery of many other historical monuments such as two sepulchral areas, a trade forum, etc. due to the problems regarding to the analysis of the genuine ancient Roman earthen bricks, strict preservation system, and opposition of Italian archeological superintendents, four samples of the authentic adobe walls have been simulated in Quagliarini's study, and have

been tested mechanically. According to the mechanical tests results, compression, shear stress and young modulus have been evaluated. Quagliarini's research paved the way for further exhaustive studies and further seismic studies. In addition to Quagliarini, Baslam has conducted an investigation into adobe walls of Chaves-Hummingbird Pueblo. Pueblo is a village located in west of Albuquerque, New Mexico in which many adobe walls have been constructed in 13th to 15th century by the residents. The chief purpose of Balsam's article was to distinguish different soil types, construction materials and ancestral building techniques applied in construction of soil structures. Results obtained from Balsam's study indicate that materials used in construction of adobe walls were abundant in the locale due to the analogy between materials applied as source of adobe, and materials existed locally. However, the analyses of sources of soil signify that some sources of local soils were not eligible to be utilized in construction of adobe walls. Balsam's research made a comprehensive comparison between the soils available in multiple points of the region, which facilitates further studies into adobe walls of Pueblo. For a couple of years, earth building techniques have been evolving in the Middle East as it can be observed that earth structures in the Middle East attracted several archeologists and researchers' attention. Philip is one of the researchers whose study have been devoted to investigation into the site of GanjDareh that is a local mound located in the Zagros of western Iran. Archeologists have not come to a consensus on the precise age of GanjDareh. According to the observations, Philip found out that most of the structures in the region constructed of mud bricks, various combinations of clay and wood. Philip deemed that the use of soil construction materials is due to the abundance of soil resources in the locale. According to the stratigraphy of the site, two main phases were reported. The first phase had no signs of solid architecture while the second phase comprised diverse types of solid architecture. Philip also asserted that there were no rules in the site, and construction techniques were not confined to any restriction. In fact, design of the buildings were based on trial and error fashion. Philip's research hindered by lack of evidence. As a result, more comparable investigations is needed to be conducted in other sites in the Zagros. Stephan's study is one of the several studies which has been carried out into the investigation of a discovered structure in the Middle East. Stephan's study took place in

Nemrik, northern Iraq between Kurdish mountains and the Tigris valley. The origin of Nemrik village dates back to over ten thousand years ago. Stephan studied into many unique features of this village. For instance, one of these features was absence of any instruments for fire. It is worth to be noted that Stephan's observation, which was based on remains of five distinguished types of buildings, signifies that construction techniques and architectural forms of Nemrik have evolved over a long span of time although the evolution process was mostly experimental and was based on conduction of constructive architectural experiences. At first glance, it seems that ancient Nemrikian architecture have not played a vital role in emergence of new architecture, but in fact, the altered form of architecture of Nemrik has been built on the foundation of the ancient empirical architecture. Virginia is another researcher who has executed a study into the site of El Hibeh in Northern middle Egypt. Virginia's research was mainly aimed at assessment of earth building materials in particular mud bricks applied in ancient Egyptian buildings. This study proposed a great wealth of information regarding to ancient Egyptian practices implemented in construction. Archeologists deem that the origin of this site dates back to 11th century B.C. El Hibeh is an ideal location for investigations into mud bricks due to the fact that all buildings of this site have been made of unfired mud bricks. Virginia has executed a geochemical investigation into fifty samples. Virginia's research was mainly aimed at assessment of earth building materials, in particular, mud bricks applied in ancient Egyptian buildings. This study proposed a great wealth of information regarding to ancient Egyptian practices implemented in construction. In fact, Virginia carried out an analysis of many mud brick samples and analyzed them geochemically; thus, divided them into two geochemical groups which also indicate ancient construction techniques. Many archeological observations have been made not only in the Middle East, but also in the surrounded countries. Schirmer has carried out an investigation into an archeological site placed in Southern Turkey. CayonuTepsi situated near Ergani in the province of Diyarbakr in Southern Turkey. CayonuTepsi shares an eroded limestone border with the village of Hilar. The reported dimension of the site were 100 by 200 although these dimensions have altered as consequence of erosion. The great importance of Cayonu relies upon the wealth of archeological information that can be gathered of the site.

The main aim of Schirmer's research was to investigate into the possible reasons of development of some specific construction techniques and evolution of other ones. According to results of Schirmer's observation, the evolution of some novel building techniques relies upon two chief reasons. Firstly, these new techniques are consequences of newfangled knowledge regarding to construction. Secondly, they are responses to the residents' needs. For instance, during wet seasons residents needed a dry floor, this contributed to the emergence of grill types of platform which contained some channels for ventilation. By the advent of walls, roof and upper stories, there were no need for ventilation channels. As Schirmer asserted, there is no way to investigate all great features of the buildings in the region, so Schirmer's study mainly focused on a few aspects. In fact, there is a need for further investigation into the site of Cayonu Tepsi. In addition to numerous researches into various archeological sites, many researchers focused on earth building materials. Quagliarini²², Oates²³, Adorni⁸, Friesem²⁴, Piattoni²⁵, Rvisankar²⁶ et al. mostly sought for new methods for development of building materials, or investigation into the great features of earth construction materials.

Quagliarini carried out a study into adobes and adobe structures. This research is founded on the excavation of the archeological site of Sausa. Adobe earth constructions were numerous observed in the site. Adobe is a composition comprising raw clayey earth mixed by sand, or coarse sand as stabilizer. Archeologists asserted that residents were used to build adobe and adobe structures based on empirical experiences due to the fact that there were no facility and opportunity for conducting scientific experimental investigation. The main purpose of Quagliarini's study was to analyze diverse factors affecting workability and mechanical properties of adobe earthen bricks. Many tests have been carried out on several samples. The results of these tests signify that the proper percentage of clay content applied in the adobe earth construction is between 12-16%. Besides, results indicate that ancient Romans used to apply natural fibers to regulate plasticity of adobe construction materials. Quagliarini's research provided a great wealth of information about the composition of adobe earth and its workability. In the next phase of the research, Quagliarini intends to materialize the great extent of knowledge presented in the current research. Oates has also conducted an investigation into mud

bricks as an earth building construction. The executed study mainly concentrated on the components and the characteristic of each component utilized in construction of mud bricks. Oates asserted that although mud bricks extensively are used in structures of ancient near East, not sufficient researches have been executed regarding to the structures constructed by mud bricks. Oates observed that two different colors of mud bricks have been utilized by ancient Romans. These colors were indicators of different sources of earth. Also in this study, different properties of these two types of mud bricks have been investigated. Besides, Oates studied into some features of architecture of ancient Romans. However, there is much to be investigated in this field. Adorni is another researcher who has executed a study into an in situ measurement of different characteristics of adobe bricks. Many simple and portable instruments have been applied in Adorni's study to determine the mechanical properties of adobe bricks by means of compression, Brazilian test and three point bending. However, Adorni asserted that the strength measured in this research was not an accurate estimation due to the deconstruction of mud bricks over a long span of time. Also, Adorni analyzed the chemical and mineral constitution of mud bricks. Results gathered from various mechanical, chemical and mineralogical tests provided an overall view regarding to the constitution of mud bricks and also paved the way for further researches into earthen construction materials. Friesem also carried out a study into the structures made of mud bricks, and asserted that these structures are eligible to provide us with useful archeological information. Friesem's study mainly was specified to the roofs of earth building constructions because it was deemed that unlike floors, not enough attention have been paid to the roofs. Besides, deconstruction of the roofs of a mud brick structures contribute to degradation of other sections of an earth building. Piattoni is another researcher whose research mainly was aimed at evaluation of mechanical properties of earthen bricks which in detail is a combination of earth, coarse sand, and straw fibres. Several mechanical tests have been executed in this research on several samples of various compositions. The results of Piattoni's study proposed the correlation between the average compressive strength and the Young modulus of earthen bricks, which contributed to the presentation of a model for elastic property of mud bricks. It is worth to mention that the scope of the Piattoni's study is almost analogous with Adorni's study although the applied tools and methods

are different. Also, Raviskar et al. focused on the firing temperature of ancient potteries of Tamil Nadu located in India. According to Raviskar et al., firing temperature of ancient pottery paves the way for better comprehension of the ancient technologies applied in a specific region.

Many other researches have been carried out into the investigation of earth buildings which commonly were based on archeological evidence regarding to earth building and earth building materials. All in all, all researchers and archeologists intended to investigate if the past construction techniques are eligible to be applied in modern structures or not

3. Conclusion

The current study which was founded on many archeological excavations conducted on various archeological sites such as CayonuTepsi (Turkey), El Hibeh (Northern middle Egypt), Nemrik (Northern Iraq), GanjDareh (Iran), etc. signified that previous architectural methods in construction of vernacular buildings can be applied in modern structures although they should be modernized and developed. The materials applied in vernacular buildings are constructed by abundant resources of each particular locale. However, degraded remains signify that local resources such as mud bricks and adobe are extremely prone to deconstruction. Also, results showed that most of the construction methods of ancient vernacular buildings are not restricted to any regulations. In fact, these buildings were constructed based on a trial and error fashion due to the fact that there were no opportunity for scientific investigations. Results of the previous researches indicate that these developments are mostly exerted in proportion to residents' needs and novelty of technology.

Many other studies have been devoted to investigation of the constitution of vernacular and earthen buildings. Results obtained from these researches determined the proper proportion of each components of local building materials. These researches also determined the mechanical, mineralogical and chemical properties of each material applied in construction of vernacular buildings; thus, provided a model for many properties such as plasticity of aforementioned materials. As an exemplary case, ancient Romans utilized fibers to regulate

plasticity of adobe construction material.

Besides, the results gathered in different researches which were carried out on various archeological sites indicate that many external parameters affect devastation of vernacular building materials such as mud bricks. However, humidity and rain have been asserted as the most contributing factors of degradation of vernacular building materials. It is also recommended that further studies be carried out on archeological sites in order to analyze structural methods of past buildings thus applying them in modern structures.

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