ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AT ARCHAEOLOGICAL SITES AND THEIR IMPACT ON CONSERVATION OF REMAINS

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Necmiye Funda YAKA ÇETİN

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İZMİR

We approve the thesis of **Necmiye Funda YAKA ÇETİN**

Examining Committee Members:

Prof. Dr. Başak İPEKOĞLU
Department of Architectural Restoration
İzmir Institute of Technology

Assoc. Prof. Dr. Tahsin BAŞARAN
Department of Architecture
İzmir Institute of Technology

Assoc. Prof. Dr. Selim Sarp TUNÇOKU
Department of Architectural Restoration
İzmir Institute of Technology

Prof. Dr. Cemal ARKON
Department of Architecture
İzmir University

Prof. Dr. Zeynep MERCANGÖZ
Department of Art History
Ege University

12 July 2013

Prof. Dr. Başak İPEKOĞLU
Supervisor, Department of Architectural Restoration
İzmir Institute of Technology

Assoc. Prof. Dr. Şeniz ÇIKIŞ
Head of the Department of Architecture

Prof. Dr. R. Tuğrul SENGER
Dean of the Graduate School of Engineering and Sciences

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ABSTRACT

ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AT ARCHAEOLOGICAL SITES AND THEIR IMPACT ON CONSERVATION OF REMAINS

Protective structures are built to provide long term protection for the immovable cultural heritage against the possible damage that may arise from environmental conditions such as rain, wind and sun as well as the activities of the living like vegetation and uninvited animals. Most of the protective structures have been found to be inadequate to fulfill this purpose and conservation problems were observed on the remains under those structures. The inadequacies are mostly related to the architectural design of the protective structures.

The aim of this study is to identify the architectural characteristics which have an impact on protective efficiency and how they are related to the deterioration factors. With this scope, sixteen protective structures that were selected from Turkey and abroad were analyzed through site surveys and literature studies. In order to identify and assess the role of protective structures on creating deterioration factors, this study groups the design characteristics under typology, structural system, roof system, roof material, façade system, façade material, thermal control system and drainage system and the deterioration factors under sources of water, instability of microclimate and the activities of the living. The relationship between these groups were analyzed and evaluated.

As a result, the type of the protective structure as a shelter or an enclosure, selection of the design elements such as roof and façade systems as well as the materials, proper application of thermal control systems and drainage systems are the main characteristics of the design that determine the efficiency of the protective structures. The study will make important contributions to the theoretical and practical aspects of the design process of protective structures.

ÖZET

ARKEOLOJİK ALANLARDAKİ KORUYUCU ÜST ÖRTÜLERİN MİMARİ TASARIM ÖZELLİKLERİ VE KALINTILARIN KORUNMASINA ETKİLERİ

Koruyucu üst örtüler, taşınmaz kültür varlıklarının yağmur, rüzgar, güneş ışınları, bitki ve hayvanlar gibi çevre koşullarının bozucu etkilerini azaltarak uzun süreli koruma sağlamak amacıyla uygulanmaktadır. Ancak bazı koruyucu üst örtülerin kalıntıları bu etkenlerden korumakta yetersiz kaldığı ve bozulma sürecinin devam ettiği anlaşılmaktadır. Bu durum daha çok üst örtünün mimari tasarımı ile ilişkilidir.

Bu çalışmanın amacı, üst örtülerin mimari tasarım özelliklerinin kalıntıların korunmasına etkilerini incelemektir. Bu amaçla yurt içinden ve yurt dışından toplam onaltı alanda uygulanmış koruyucu üst örtü seçilerek tespit ve analizler gerçekleştirilmiştir. Buluntuların bozulmasına neden olan etkileri belirlemek amacıyla, koruyucu üst örtülerin tasarım özellikleri tipoloji, yapım sistemi, çatı sistemi, çatı malzemesi, cephe sistemi, cephe malzemesi, termal kontrol sistemi ve drenaj sistemi olarak; bozulmaya neden olan etkiler ise su kaynaklı etkenler, değişken iç ortam koşulları kaynaklı etkenler ve canlıların etkileri olarak gruplandırılmıştır. Bu gruplar arasındaki ilişkiler incelenerek değerlendirilmiştir.

Sonuç olarak, bir koruyucu üst örtünün koruma çatısı veya koruma yapısı olarak tipolojisi, çatı ve cephe tasarımını oluşturan sistemlerin ve kullanılan malzemelerin seçimi, uygulanan termal kontrol yöntemleri ve drenaj sisteminin doğru bir şekilde uygulanması üst örtünün korumaya katkısını belirleyen temel unsurlardır. Çalışma, koruyucu üst örtü tasarım sürecine teorik ve pratik yönlerden önemli katkılar yapacaktır.

To my family

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CHAPTER 1

INTRODUCTION

Archaeological remains are sensitive to effects of atmospheric events before, during and after excavations. Taking measures against rain, wind, solar radiation, extensive plant growth and intrusive animals as well as providing permanent conservation, protection and maintenance of the archaeological remains is necessary. Removal of decorations such as mosaics, frescos, and other furnishing from their original location to museums with the aim of protection was applied as a common practice. With the development of modern conservation theory *in situ* preservation of the monuments and archaeological remains has become the objective of archaeological heritage management[1]. For *in situ* conservation direct material treatments with synthetic consolidants, reburial of the excavated remains and construction of protective structures such as shelters or enclosures can be applied as conservation methods.

Among these methods, temporary and permanent protective structures have been frequently constructed to house and protect remains and places of cultural significance since they offer the advantages of presentation in their original context. Remains protected under protective structures are composed of fragile and valuable objects of immovable heritage such as remains of stone, brick or mudbrick structures and their associated features like mosaics, plasters and wall paintings. Size and extent of the protected remains may vary from a single object to a monumental structure or an excavation site. Prehistoric settlements (Çatalhöyük, Turkey; Akrotiri, Greece), prehistoric rock-art site (Peterborugh, Canada), dinosaur trackway (Lark Quary, Australia), fortification walls (Karatepe Aslantaş, Turkey; Fortification Walls of Capo Soprano, Sicily, Italy), ancient theatres (Heraclea Minoa, Sicily, Italy; Orange, France), baths (Badenweiler, Germany; Xanten, Germany), villas and palaces (Alaeddin Kiosk, Turkey; Fishbourne, UK; Piazza Armerina, Sicily, Italy), temple, church or synagogues (Petra Church, Jordan; Ein Gedi Synagogue, Israel; Hamar Cathedral, Norway) are

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[1] Charter for the Protection and Management of the Archaeological Heritage 6th Article "The overall objective of archaeological heritage management should be the preservation of monuments and sites in situ, including proper long-term conservation and curation of all related records and collections etc. …" (ICOMOS 1990).

amongst the monuments protected by protective structures. In relation to type and size of remains to be protected, protective structures are built in a variety of sizes, shapes and materials ranging from simple lightweight roof structures to heavy concrete slabs and masonry constructions. Decision to build a protective structure is an important subject that has been conducted by the site management and it is related with the issues of architectural design, construction and maintenance of the protective structure as well as conservation and presentation of the remains.

1.1. Problem Statement

Protective structures have been constructed as a conservation method to protect archaeological structures and decorations since 19th century. At the present time, there is a large number of protective structures ranging from simple temporary shelters, to reproduction of original forms with modern materials, and to uniform container- like structures covering the entire site. This variety is due to architectural design process that is related with protection and presentation of the remains in the original context, as well as site interpretation, aesthetic and architectural statement of the protective structure.

Recent studies have shown that some of the protective structures have failed protecting the remains they were built to provide protection against extreme climatic conditions and invasion of animals and plants (Aslan 1997, Stewart et al. 2006). When protective structures are constructed without considering the influence of atmospheric factors on the inner environment, they are likely to create an inappropriate microclimate such as extremely high and low temperatures, high relative humidity, thermal fluctuations, inefficient ventilation, rain penetration, rising damp, condensation, freeze-thaw cycles and wet-dry cycles (Aslan 2001). A considerable number of well known protective structures had to be removed due to certain problems that resulted in deterioration of remains, instead new structures were constructed (Terrace Houses 2 at Ephesus, Turkey; Roman Villa at Piazza Armerina, Sicily, Italy, dinosaur trackway in Lark Quarry, Australia; Fortification Walls of Gela, Sicily, Italy) or the site was reburied (hominid trackway at Laetoli, Tanzania). In addition some were modified to improve their efficiency in protecting the remains (Fishbourne Roman Palace, UK; the Roman Town House in Dorchester, UK). These cases illustrate that deterioration of the protected remains is possible in the absence of a thorough approach based on conservation of the remains. Therefore, a complete understanding of the needs specific to the site, risk factors and prevention, in addition to predicting the effects of sheltering or enclosing is necessary to provide better protection.

1.2. Aim of the Study

Knowledge of earlier sheltering experiences and their contribution to either deterioration or protection of the remains may help to understand the issues related with the design of protective structures from the practical and technical aspects. The primary aim of this study is to assess the relationship between the architectural design of protective structures and their efficiency in protecting the remains. In order to understand the efficiency of protective structures the condition of the remains and the deterioration factors in the environment created by the protective structure have been analyzed.

The ultimate aim is to identify the architectural characteristics which have an impact on protective efficiency and how they are related to the deterioration factors. Knowledge of the conservation problems and their causes experienced in the earlier protective structures would help to reduce the risks and improve the architectural design process in terms of the theoretical and practical aspects.

1.3. Methodology

This research seeks to understand the relationship between the architectural design of protective structures and their efficiency in protecting the remains. The primary questions of the research are:

- What are the effects of the protective structures on the protection of the remains?
- Why do some of the protective structures fail to protect the remains they were constructed to protect?
- What are the deterioration factors of remains under protective structures?
- Which design elements of protective structures are related to these deterioration factors?

The hypothesis of this thesis is that there is a relationship between architectural characteristics of protective structures and their efficiency in protection.

Case study research methodology has been applied to answer the research questions. A large number of protective structures ranging in typology, material, location and climate were investigated to understand their impact on the remains. Among them sixteen protective structures were selected and analyzed in order to understand their efficiency in protecting the remains. The cases were determined according to the below criteria:

- permanent protective structures, which have been designed through architectural planning and has been a part of site management plans,
- protective structures that were built to protect wall paintings, mosaics and earthen structures, since they are fragile to effects of atmosphere,
- protective structures that were built before 2010.

According to their location, the selected protective structures have been studied in two groups. First group consists of eight protective structures that are located in Turkey. They are Terrace House 2 at Ephesus, Building Z at Pergamon, Archaic and late Roman remains at Sardis, Villas Dionysos and Danae at Zeugma, Neolithic houses at Çatalhöyük (south and north shelters), Alaeddin Kiosk in Konya, Citadel Wall and the Megaron at Troy.

Second group also consists of eight protective structures from other countries. They were selected among the ones which have been subjected to condition assessment studies and formed a proper sample for the protective structures with a wide variety of conservation problems. They are Fishbourne Roman Palace at West Sussex (UK), Chedworth Roman Villa at Gloucestershire (UK), Roman Town House in Dorchester (UK) Roman Villa at Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Nile Festival Building at Zippori (Israel), Great House Ruins at Arizona (USA). All of the selected protective structures were investigated and the information has been classified and systematically recorded on the identification cards.

1.3.1. Protective Structure Identification Card

The collected information about the studied protective structures is recorded on cards titled "Protective Structure Identification Card" (Table 1. 1). The identification card aims to collect necessary data about archaeological remains and the protective structure. The first section consists of brief information about the archaeological site and the remains as well as illustrations. It consists of:

Archaeological Site: Name of the protected remains, the archaeological site and country is stated.

Characteristics of the Site: General characteristics of the protected remains are described.

Identification of Remains: The featured parts of the structure which increase the values of the structure are described.

Period: Approximate construction date and usage period of the structure is stated.

Excavation and Preservation Work: Date of excavations and earlier conservation studies such as temporary shelter, reburial are stated.

Second section is about the protective structure built to protect the aforementioned remains. Information about the design and construction as well as the conservation problems and possible causes are summarized in this section. It consists of:

Type: Typology of the protective structure according to level of protection on the sides (*shelter or enclosure*) and its locational relationship with the remains.

Architect / Contractor: Architect and contractor of the protective structure.

Construction Date: Construction completion date.

Size: Area of the protected site.

Aim: Objectives of the design (as stated in cited publications).

Design Principles: Description of the design principles (as stated in cited publications) according to the criteria stated under the sections 2.2.2.

Structural System and Material: Description of the structural system and materials used for the construction.

Design Characteristics for Climate Control: Existence of special design elements for air flow, ventilation, heating and cooling the inner environment.

Monitoring Internal / External Environment: Current assessment method (such as monitoring the remains, monitoring the inner / external environment, rapid site survey) to understand the efficiency of protective structure in protecting the remains is stated.

Conservation Problems and Possible Causes: Conservation problems detected through site surveys for the cases in first group and for the second group cases literature studies were examined.

Modification of Protective Structure to Mitigate Problems: Improvement of the protective structure to overcome the existing conservation problems / deterioration factors created by the design.

Ambient Climate of the Site: Climate region according to the Köppen Climate Classification System and brief climatic properties of the region are stated. For the first group which consists of sites in Turkey, the analysis was based on the meteorological data (outdoor dry bulb temperature, precipitation, relative humidity, wind speed) obtained from the nearest meteorological measuring station recorded between 2000 and 2010.

References: Sources of the information.

The identification cards, describing the protected sites and architectural characteristics of studied protective structures are filled for each of the studied cases. The cards, which are used for the first time in this study, are significant to gather necessary information about the protective structure and the site.

Table 1. 1. Protective structure identification card.

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site</td><td rowspan="5">Illustrations</td></tr>
<tr><td>Characteristics of the Site</td></tr>
<tr><td>Identification of Remains</td></tr>
<tr><td>Period</td></tr>
<tr><td>Excavation and Preservation Work</td></tr>
<tr><td rowspan="9">Protective Structure</td><td>Type</td><td>Architect / Contractor</td></tr>
<tr><td>Construction Date</td><td>Size</td></tr>
<tr><td colspan="2">Aim</td></tr>
<tr><td colspan="2">Design Principles</td></tr>
<tr><td colspan="2">Structural System and Material</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment</td></tr>
<tr><td colspan="2">Conservation Problems and Possible Causes</td></tr>
<tr><td colspan="2">Modification of Protective Structure to Mitigate Problem</td></tr>
<tr><td colspan="3">Ambient Climate of the Site</td></tr>
<tr><td colspan="3">References</td></tr>
</table>

1.3.2. Site Survey Questionnaire

According to the literature, efficiency of a protective structure can be measured both quantitatively and qualitatively, but still both methods need to be developed (Tringham and Stewart 2008). In this study, efficiency of the protective structures in the first group of cases (country-wide cases) has been assessed through site surveys which are based on empirical observation. Site surveys aim to analyze physical characteristics of the protective structure such as form, material, façade and roof openings, rain water drainage system and insulation system. In addition, condition of the protected remains and possible deterioration factors created in the environment of the protective structure are observed. During site surveys, conversations with directors or conservation specialists of the related excavations contributed to understand the current condition of the protected remains. Data collected in the site surveys are recorded on the Site Survey Questionnaire (see Appendix A). Site Survey Questionnaire is composed of three main sections:

- **A.** Identification of the Protective Structure.
- **B.** Condition of the Sheltered Remains.
- **C.** Investigation of Natural Features of the Site.

A. Identification of the Protective Structure consists of the first fifteen questions. They inquire the physical characteristics such as typology, construction date, size, structural system, materials of the protective structure. Condition of protective structure in terms of aging of the construction materials, and technical installation systems such as drainage system, thermal insulation, ventilation system are observed. Other questions query the existence of main deterioration factors such as moisture, instable climate, animals and plants. This section ends with the evaluation methods for the protective structure and its efficiency in protecting the remains.

B. Condition of the Sheltered Remains consists of latter four questions. They inquire the type of remains and their state of protection under the protective structure. Although deterioration factors are similar in basis, their effects can be varied according to the type of remains.

In order to analyze the deteriorations and their factors thoroughly, eighteenth and nineteenth questions both have three sections, that are specialized according to the analyzed remain type, named a, b and c. Section a refers to possible deterioration phenomena and their factors of mosaics, section b refers to wall paintings and section c refers to earthen structures.

Eighteenth question consists of the tables that inquire the basic deteriorations observed on the protected mosaics, wall paintings and earthen structures. If the phenomenon is present, they are marked considering to its severity and the extent. The physical impacts on the remains are defined with a scale of very severe (A), severe (B), moderate (C), slight (D) and very slight (E) (Table 1. 2).

Nineteenth question inquires the possible factors of the marked deteriorations in the previous question in relation with the environment created by the protective structure. Possible factors are marked with the severity letters of the concerned phenomena.

C. Investigation of Natural Features of the Site consists of the last three questions which inquire the location, topography, climate and hydrology of the site.

Table 1. 2. The criteria for deciding severity of the problems.

Very severe (A):	The structural elements and the decorations have structural deterioration and the condition or deterioration is observed frequently. - Wall plasters and paintings: loss of plaster layers, disintegration of plaster layers, cracks. - Mosaics: detachment or bulging of tessellatum, depressions, cracks. - Earthen structures: basal and surface erosion, loss of mud mortar, structural cracks, presence of lacunae.
Severe (B)	The structural elements and the decorations have surface deterioration and the condition or deterioration is observed frequently. - Wall plasters and paintings: loss of paint layers, disfigurement and color loss, fungal growth. - Mosaics: detached tesserae, deteriorated tesserae, color alterations, deposit. - Earthen structures: cracks, crust of clay, fungal growth as moulds.
Moderate (C)	The structural elements and the decorations have structural deterioration and the condition or deterioration is observed rarely. - Wall plasters and paintings: loss of plaster layers, disintegration of plaster layers, cracks. - Mosaics: detachment or bulging of tessellatum, depressions, cracks. - Earthen structures: basal and surface erosion, loss of mud mortar, structural cracks, presence of lacunae.
Slight (D)	The structural elements and the decorations have surface deterioration and the condition or deterioration is observed rarely. - Wall plasters and paintings: loss of paint layers, disfigurement and color loss, fungal growth. - Mosaics: detached tesserae, deteriorated tesserae, color alterations, deposit. - Earthen structures: cracks, crust of clay, fungal growth as moulds.
Very slight (E)	The structural elements and the decorations have some problems, but visually not damaged yet. Deterioration factors are observed rarely (at specific times and locations).

1.3.3. Evaluation and Results

To understand the relationship between the architectural design of protective structures and their efficiency in protection, an evaluation method has been developed. The evaluation work is based on the analysis of the collected data, which will be explained in depth in the third chapter. Analysis and evaluation is composed of tables and bar charts. The tables focus on classifying and organizing the collected data while the bar charts intend to explain and illustrate the outcomes of the research.

Initially, general information about the selected protective structures is listed in terms of characteristics of the site, type of the remains they protect and type of the structure (Table 1. 3). Then the selected protective structures are analyzed according to common architectural features (Table 1. 4). In order to better understand the protective structures, they are divided into subgroups according to the morphology and material of the architectural elements. Analysis of the decay factors at the selected sites are marked in the table according to the level of phenomena that ranged between a scale of A to E (Table 1. 5). Subsequently, possible causes of deterioration phenomena in relation to the architectural design characteristics of the protective structure is evaluated (Table 1. 6). Finally, the data obtained from all of the sites are cumulated and tabularized in one table in order to identify relations between the architectural characteristics and the deterioration factors in detail (Table 1. 7). The numeric values in the cells illustrate the number of cases with the mentioned phenomena and the letters illustrate the level of deterioration factors, as in Table 1. 5. Intensity of the letters and numbers present which of the design characteristics are either directly and indirectly related with the particular deterioration factors. In addition, intersection of rows and columns briefly represent the relation between the deterioration factors and building elements. Eventually, intersection of vertical and horizontal groups (columns and rows) in the Table 1. 7 are separately illustrated and explained in the bar charts in Chapter 4.

Table 1.3. Identification of the selected protective structures.

	SELECTED SITES	Site Characteristics					History of Protective Structure					Typology of Protective Structure				Remain Type		
		Climate region	Urban area	Rural area	Marine	Topography	Excavation date	Construction date of temporary / earlier protective structure	Construction date of the studied protective structure	Modificaiton of the protective structure	Replacement of a new protective structure	Shelter	Enclosure	Built on remains	Built above remains	Mosaics	Wall paintings	Earthen structures
First Group	Neolithic Houses (South) Çatalhöyük, Turkey																	
	Neolithic Houses (North) Çatalhöyük, Turkey																	
	Alaeddin Kiosk Konya, Turkey																	
	Terrace House 2 Ephesos, Turkey																	
	Z Building Pergamon, Turkey																	
	Archaic and late Roman remains Sardis, Turkey																	
	Citadel Wall and the Megaron Troy, Turkey																	
	Villas Dionysos and Danae Zeugma, Turkey																	
Second Group	Fishbourne Roman Palace West Susex , UK																	
	Roman Villa Piazza Armerina, Italy																	
	Fortification Walls of Capo Soprano Gela, Italy																	
	St Stephen Complex Um er-Rasas, Jordan																	
	Roman Town House Dorchester, UK																	
	Nile Festival Building Zippori, Israel																	
	Great House Arizona, USA																	
	Chedworth Roman Villa Gloucestershire, UK																	

Table 1. 4. Analysis of architectural design characteristics of protective structures.

	SELECTED SITES	Structural System				Roof System			Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System			Modifications						
		Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Tiles	Concrete	Membrane	opaque (steel, copper plates, ..)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Roof Insulation	Facade Insulation	Natural ventilation	Heating	Mechanical ventilation	Roof drainage	Surface drainage	Site drainage	Installation of gutters / drainage system	Installation of roof insulation	Installation of shading	Installation of solar reflective glass	Minimize the window area	Minimize the louvers area	Construction of a new structure
First Group	Neolithic Houses (South) Çatalhöyük, Turkey																																					
First Group	Neolithic Houses (North) Çatalhöyük, Turkey																																					
First Group	Alaeddin Kiosk, Konya, Turkey																																					
First Group	Terrace House 2 Ephesos, Turkey																																					
First Group	Z Building Pergamon, Turkey																																					
First Group	Archaic and late Roman remains Sardis, Turkey																																					
First Group	Citadel Wall and the Megaron Troy, Turkey																																					
First Group	Villas Dionysos and Danae Zeugma, Turkey																																					
Second Group	Fishbourne Roman Palace West Susex , UK																																					
Second Group	Roman Villa Piazza Armerina, Italy																																					
Second Group	Fortification Walls of Capo Soprano Gela, Italy																																					
Second Group	St Stephen Complex Um er-Rasas, Jordan																																					
Second Group	Roman Town House Dorchester, UK																																					
Second Group	Nile Festival Building Zippori, Israel																																					
Second Group	Great House Arizona, USA																																					
Second Group	Chedworth Roman Villa Gloucestershire, UK																																					

A: Factors causing "Very Severe" damage

B: Factors causing "Severe" damage

C: Factors causing "Moderate" damage

D: Factors causing "Slight" damage

E: Factors causing "Very Slight" damage

Table 1. 5. Assessment of deterioration factors under protective structures.

		Sources of Water			Instability of Microclimate							Activities of the Living	
		Rain penetration	Rising damp	Condensation	Solar gain	Heat built up	Fluctuations of T and RH	Wetting and drying cycles	Crystallization of solub salts	Freezing	Excessive ventilation	Inefficient ventilation	Vegetation	Animals
First Group	Neolithic Houses (South) Çatalhöyük, Turkey													
	Neolithic Houses (North) Çatalhöyük, Turkey													
	Alaeddin Kiosk Konya, Turkey													
	Terrace House 2 Ephesus, Turkey													
	Z Building Pergamon, Turkey													
	Archaic and late Roman remains Sardis, Turkey													
	Citadel Wall and the Megaron Troy, Turkey													
	Villas Dionysos and Danae Zeugma, Turkey													
Second Group	Fishbourne Roman Palace West Susex , UK													
	Roman Villa Piazza Armerina, Italy													
	Fortification Walls of Capo Soprano Gela, Italy													
	St Stephen Complex Um er-Rasas, Jordan													
	Roman Town House Dorchester, UK													
	Nile Festival Building Zippori, Israel													
	Great House Arizona, USA													
	Chedworth Roman Villa Gloucestershire, UK													

Table 1.6. Evaluation of the deterioration factors in relation to the design characteristics of protective structures.

		Sources of Water											
		Rain penetration			Rising damp							Condensation	
		Leaks in roof	Limited roof area / excessive roof height	Louvers / Segmentation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels	Surface of remains	Surface of roof material
First Group	Neolithic Houses (South) Çatalhöyük, Turkey												
	Neolithic Houses (North) Çatalhöyük, Turkey												
	Alaeddin Kiosk Konya, Turkey												
	Terrace House 2 Ephesos, Turkey												
	Z Building Pergamon, Turkey												
	Archaic and late Roman remains Sardis, Turkey												
	Citadel Wall and the Megaron Troy, Turkey												
	Villas Dionysos and Danae Zeugma, Turkey												
Second Group	Fishbourne Roman Palace West Susex , UK												
	Roman Villa Piazza Armerina, Italy												
	Fortification Walls of Capo Soprano Gela, Italy												
	St Stephen Complex Um er-Rasas, Jordan												
	Roman Town House Dorchester, UK												
	Nile Festival Building Zippori, Israel												
	Great House Arizona, USA												
	Chedworth Roman Villa Gloucestershire, UK												

		Instability of Microclimate																					
		Solar gain			Heat built up		Fluctuations of T and RH			Wetting and drying cycles				Recrystallization of soluble salts			Freezing			Excessive / insufficient ventilation			
		Absence of sides	Transparent facade / roof material	Gaps between the louvers / segments	Transparent and translucent facade / roof material	Absence of proper insulation	Absence of sides	Louvers and permeable façades	Absence of proper insulation	Absence of sides	Louvers and permeable façades	Absence of propoer insulation	Presence of water	Absence of sides	Presence of water	Absence of propoer insulation	Absence of sides	Louvers and permeable façades	Absence of propoer insulation / inefficient	Absence of sides	Permeable facade / openings / louvers	Stagnant air due to lack of louvers	Mechanical ventilation or heating
First Group	Neolithic Houses (South) Çatalhöyük, Turkey																						
	Neolithic Houses (North) Çatalhöyük, Turkey																						
	Alaeddin Kiosk Konya, Turkey																						
	Terrace House 2 Ephesos, Turkey																						
	Z Building Pergamon, Turkey																						
	Archaic and late Roman remains Sardis, Turkey																						
	Citadel Wall and the Megaron Troy, Turkey																						
	Villas Dionysos and Danae Zeugma, Turkey																						
Second Group	Fishbourne Roman Palace West Susex , UK																						
	Roman Villa Piazza Armerina, Italy																						
	Fortification Walls of Capo Soprano Gela, Italy																						
	St Stephen Complex Um er-Rasas, Jordan																						
	Roman Town House Dorchester, UK																						
	Nile Festival Building Zippori, Israel																						
	Great House Arizona, USA																						
	Chedworth Roman Villa Gloucestershire, UK																						

		Activities of the Living								
		Vegetation				Animals				
		Microbiological vegetation due to ground moisture	Microbiological vegetation due to high RH	Plant growth due to ground moisture	Plant growth due to high RH	Birds due to absence of sides	Birds due to louvers / openings	Insects and arachnoids due to absence of sides	Insects arachnoids due to louvers / openings	Rodents and reptiles
First Group	Neolithic Houses (South) Çatalhöyük, Turkey									
	Neolithic Houses (North) Çatalhöyük, Turkey									
	Alaeddin Kiosk Konya, Turkey									
	Terrace House 2 Ephesos, Turkey									
	Z Building Pergamon, Turkey									
	Archaic and late Roman remains Sardis, Turkey									
	Citadel Wall and the Megaron Troy, Turkey									
	Villas Dionysos and Danae Zeugma, Turkey									
Second Group	Fishbourne Roman Palace West Susex , UK									
	Roman Villa Piazza Armerina, Italy									
	Fortification Walls of Capo Soprano Gela, Italy									
	St Stephen Complex Um er-Rasas, Jordan									
	Roman Town House Dorchester, UK									
	Nile Festival Building Zippori, Israel									
	Great House Arizona, USA									
	Chedworth Roman Villa Gloucestershire, UK									

A: Factors causing "Very Severe" damage

B: Factors causing "Severe" damage

C: Factors causing "Moderate" damage

D: Factors causing "Slight" damage

E: Factors causing "Very Slight" damage

Table 1. 7. Relational evaluation of architectural design characteristics of protective structures and deterioration factors.

			Deterioration Factors	Design of Protective Structure: Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
				Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples																																										
Deterioration Factors	Sources of Water	Rain penetration																																								
		Rising damp																																								
		Condensation																																								
	Instability of Microclimate	Solar gain																																								
		Heat built up																																								
		Fluctuations of T and RH																																								
		Wetting and drying cycles																																								
		Recrystallization of soluble salts																																								
		Freezing																																								
		Excessive ventilation																																								
		Insufficient ventilation																																								
	Activities of the Living	Microbiological vegetation																																								
		Plants																																								
		Birds																																								
		Insects																																								
		Rodents																																								

A: Factors causing "Very Severe" damage

B: Factors causing "Severe" damage

C: Factors causing "Moderate" damage

D: Factors causing "Slight" damage

E: Factors causing "Very Slight" damage

1.4. Significance of the Study

Protective structures in Turkey have been the subject of a few studies (Weaver 1973, Krinzinger 2000a, Özgönül 2001, Tunçağ 2002, Omacan et.al. 2003, Bachman and Schwarting 2005, Krinzinger 2006, Bachman 2006, Restelli 2006, Koçu 2007, Yaka and İpekoğlu 2008, Bachman and Schwarting 2008, Dikilitaş 2010, Yaka Çetin and İpekoğlu 2010, Yaka Çetin and İpekoğlu 2011, Omacan 2011, Yaka Çetin and İpekoğlu 2013). The majority of these studies were published by the designers themselves (Weaver 1973, Krinzinger 2000a, Omacan et.al. 2003, Bachman and Schwarting 2005, Bachman 2006, Bachman and Schwarting 2008, Restelli 2006, Omacan 2011). They mainly focus on the design and the construction process, but only a few of them mention their effects on the protection of the remains. This is the first study to systematically evaluate the protective structures in Turkey in terms of their efficiency in protecting the remains.

The importance of the study lies in the relational analysis of the effects of architectural design elements of protective structures on the protection of the remains and in the association of the observed deterioration factors with their design elements. In addition, the output of the study can be a reference while designing a protective structure for architects, archaeologists and site conservationists.

1.5. Limits and Criteria

There are a great number of protective structures which could be included in this research. Limited time and budget has prevented the study of more cases, still the variety of the selected cases have been quite sufficient to get the results of the research. As stated in introduction, protective structures are built to protect various types of remains, but mosaics, wall paintings and earthen materials are the most common types due to their fragility. In this scope, these three groups of remains were selected for the case studies. Since this research started in 2009, protective structures constructed after 2010 were excluded from the research. There are eight protective structures which provide these conditions in Turkey, therefore number of the international cases are limited to eight, as well.

Other limitations in this study were imposed by the accessibility to the cases located in Turkey and abroad. All selected cases in Turkey have been visited and the survey of the deterioration factors has been carried out on site by the author. The surveys excluded experimental studies and microclimatic monitoring. However meteorological data collected from the nearest stations have been analyzed to assess the local environmental conditions. Except Terrace House 2 at Ephesus (Turkey), all cases have been surveyed in the summer period, which has limited the understanding of the wetting conditions such as condensation and rising damp. Most of the deterioration factors have been observed by the author, whereas assistance was obtained from a specialist for detailed information about the site at Neolithic Houses at Çatalhöyük -south and north enclosures- (Turkey), Terrace House 2 at Ephesus (Turkey), Building Z at Pergamon (Turkey), Villas Dionysos and Danae at Zeugma (Turkey) and Citadel Wall and the Megaron at Troy (Turkey). On the contrary, site survey studies could not be conducted for the international cases. Thus, they had to be selected among the ones which were subjected to similar surveys and have published results. Due to this limitation only the published problems have been taken into consideration.

Architectural design of protective structures is concerned with the issues of presentation, architectural statement, site interpretation, site integrity as well as protection. Since the ultimate aim of this research is to improve the architectural design process for providing better protection, the issues other than protection are not subjected to survey studies and evaluation.

1.6. Literature Review

Construction of protective structures has been experienced since the early 19th century. However, research about the subject has been emerging only since the last decades of the 20th century. There is a bulk of published studies mostly about individual case studies concerning justification for the construction, detailed description in terms of design methodology, construction and evaluation of the performance[2]. In addition, more comprehensive research on design and maintenance issues in relation with the protective efficiency has been conducted in national and international scales. The existing literature on protective structures was compiled as an annotated bibliography

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[2] Some articles written primarily from an architectural perspective, rather than conservation and presentation one are not included to the literature if the concerned cases are not located in Turkey

and updated through 2000 and 2012 (Demas 2001, Demas 2012). The study comprised key references about protective roofing and sheltering, which have started to become an issue in the publications after the 1980s. The studies about the protective structures for the preservation of archaeological objects and sites can be listed under three main groups[3]:

- Publications on Protective Structures at Archaeological Sites consist of four main groups. First group includes publications with a general overview of protective structures from a theoretical point (Stubbs 1995, Schirmer 2000, Agnew 2001, Avrami et al. 2001, Teutonica 2001, Ferroni and Laurenti 2006, Aslan 2007, Woolfitt 2007, Matero 2008, Dikilitaş 2010). Second group is descriptive studies on utilization of the project, architectural and technical details introduced in single cases (Minissi 1961, Weaver 1973, Scichilone 1986, Agnew and Coffman 1991, Paolo and Schmid. 1991, Jerome 1995, Bertaux et al. 1998, Caroll 1998, Häuselmayer 2000, Krinzinger 2000b, Wunderer 2000, Ziesel 2000, Aslan 2001, Jerome et al. 2001, Palumbo 2001, Thompson and Taylor 2001, Tunçağ 2002, Motolese 2003, Omacan et al. 2003, Bachman and Schwarting 2005, Fintikakis 2005, Bachman 2006, Krinzinger 2006, Restelli 2006, Doumas and Fintikakis 2006, Bachmann and Schwarting 2008, Ha'obsh 2008) and group of cases (Schmidt 1988, Hebbelinck et al. 2001, Pesaresi and Rizzi 2007, Yaka and İpekoğlu 2008, Accardi 2008, Omacan 2011). Third group consists of evaluation and assessment studies based on empirical as well as experimental research on the current condition of individual cases (Agnew and Wade 1986, Agnew and Lin 1991, Stanley-Price 1997, Matero 1999, Özgönül 2001, Cosh 2002, Citterio and Giani 2006a, Citterio and Giani 2006b, Koçu 2007, Bethell 2008, Gonçalves 2008) and group cases (Fitch 1982, De Silva 1986, Waane 1986, Agnew et al. 1996, Aslan 1997, Stanley-Price and Jokilehto 2001, Fiero 2001, Vozikis 2005, Maekawa 2006, Stewart et al 2006, Stewart 2008, Michaelides and Savvides 2008, Neguer and Alef 2008, Yaka Çetin and İpekoğlu 2010, Yaka Çetin and İpekoğlu 2011, Yaka Çetin and İpekoğlu 2013). Fourth group is on the improvement, replacement or removal of the existing protective structures (Doumas 1997, Schmid 1998, Pesaresi and Rizzi 2007, Michaelides and Savvides 2008, Ha'obsh 2008, Rizzi 2008, Warner 2009, National Trust 2009a, National Trust 2009b, Jeffreys 2010, Offers 2010).

[3] Publications cited in this research are limited by access to the written and digital sources in the period of this research.

- International and nation-wide research projects that have been developed for understanding the efficiency of protective structures, and for improving the design methodology (Agnew and Coffman 1991, Agnew and Lin 1991, Agnew et al. 1996, Laurenti 2001, Laurenti et al. 2003, Laurenti 2006, Stewart et al., 2006, Stewart 2008, Neguer and Alef 2008, L'Istituto Superiore per la Conservazione ed il Restauro 2008, Getty 2009).
- Academic researches on protective structures consist of dissertations (Aslan 1998, master's thesis Demas 1990, Alef 2002, Uyar 2008, Ertosun 2012) and an undergraduate thesis (Vozikis 2002).

1.6.1. Publications on Protective Structures at Archaeological Sites

Protective structures have been the subject of national and international studies and research. They cover the topics of the need of shelter for protection, the establishment of conservation, design and construction criteria, design methodology, construction techniques, description of architectural features and conservation history, evaluation of the problems associated with the protective structure, assessment methodology for understanding the protective efficiency, improvement, replacement and removal of protective structures. These studies can be examined under four main groups:

1. Studies on protective structures in the theoretical framework introduce and describe the existing knowledge about sheltering phenomena. Protective structures have been presented among the eligible conservation works at archaeological sites (Stubbs 1995, Woolfitt 2007, Matero 2008, Dikilitaş 2010) since they have been used as a conservation method for nearly two centuries. Early examples of the protective structures and emergence of various types in the last century have been summarized with the examples found in Europe (Schirmer 2000, Ferroni and Laurenti 2006, Woolfitt 2007). Past experiences on the protective structures that address the general overviews of the problems are discussed with particular attention on the design, typology and materials (Ferroni and Laurenti 2006, Woolfitt 2007). Within the light of the past examples, basic principles and considerations on the design methodology, construction, maintenance and evaluation have been developed (Agnew 2001, Avrami et al. 2001, Teutonica 2001, Aslan 2007).

2. Descriptive studies constitute the majority of the articles about protective structures with an overview of architectural planning process, design and construction of specific examples. Utilization of the project, architectural and technical details are introduced both in single cases (Minissi 1961, Weaver 1973, Scichilone 1986, Agnew and Coffman 1991, Paolo and Schmid. 1991, Jerome 1995, Bertaux et al. 1998, Caroll 1998, Häuselmayer 2000, Krinzinger 2000a, Krinzinger 2000b, Wunderer 2000, Ziesel 2000, Aslan 2001, Jerome et al. 2001, Palumbo 2001, Thompson and Taylor 2001, Tunçağ 2002, Motolese 2003, Omacan et al. 2003, Bachman and Schwarting 2005, Fintikakis 2005, Bachman 2006, Krinzinger 2006, Restelli 2006, Citterio and Giani 2006, Doumas and Fintikakis 2006, Bachmann and Schwarting 2008, Ha'obsh 2008) and groups (Schmidt 1988, Hebbelinck et al. 2001, Pesaresi and Rizzi 2007, Yaka and İpekoğlu 2008, Accardi 2008, Omacan 2011). Among them Schmidt's study (Schmidt 1988) is the earliest and the most comprehensive of this type, since it constitutes a descriptive and visual catalogue of enclosures and shelters in Europe and Middle East. The importance of this study is that it is the first to provide an overview of the types of protective structures and materials used in construction.

Descriptive articles are mostly published to promote a design concept or present the case studies from an architectural perspective (Minissi 1961, Scichilone 1986, Häuselmayer 2000, Omacan et al. 2003, Bachman and Schwarting 2005, Fintikakis 2005, Bachman 2006, Krinzinger 2006, Restelli 2006, Doumas and Fintikakis 2006, Bachmann and Schwarting 2008, Omacan 2011). They are useful to the extent that they provide information about the planning process and the design of the shelter. However, they are quite far from projecting an objective view to inquire if the design succeeds the overall aims.

Protective structures benefit from utilization of the modern techniques and materials for protecting wide excavation areas in terms of minimum touch on the ground and ability of rapid construction in order to reduce direct contact with the exposed archaeological evidence. Innovative designs developed as prototypes are subjected to the articles by the designers (Weaver 1973, Agnew and Coffman 1991, Motolese 2003). Other articles focus on the detailed description of construction techniques (Bertaux et al. 1998, Ziesel 2000, Tunçağ 2002, Yaka and İpekoğlu 2008) and materials with a brief summary of advantages and disadvantages in terms of construction (Hebbelinck et al. 2001), presentation (Accardi 2008) and protection (Yaka

Çetin and İpekoğlu 2010, Yaka Çetin and İpekoğlu 2012, Yaka Çetin and İpekoğlu 2013).

Some articles provide thorough information on the architectural planning process to help with improvement of the design methodology on protective structures with special emphasis on establishing the design, construction and preservation criteria (Jerome et al. 2001, Palumbo 2001, Thompson and Taylor 2001). Evaluation of advantages and disadvantages (Agnew and Coffman 1991, Caroll 1998) and comparison of different proposals and practices (Jerome 1995, Pesaresi and Rizzi 2007) are among the methods applied to improve the design process. In addition, architectural design methodology based on controlling the interior climate through the use of passive systems has been applied to the design of protective structures in recent years (Aslan 2001). New technologies for modeling and predicting the micro-climate has been included to the design process (Wunderer 2000, Citterio and Giani 2006a, Ha'obsh 2008).

3. Evaluation and assessment studies help to increase knowledge about the sheltering issues. A group of descriptive studies evaluate specific protective structures in terms of their efficiency. These studies, mostly based on empirical research, criticize the current condition of individual cases (Agnew and Wade 1986, Stanley-Price 1997, Özgönül 2001, Koçu 2007) or groups (Fitch 1982, De Silva 1986, Stevens 1986, Waane 1986, Aslan 1997, Stanley-Price and Jokilehto 2001, Fiero 2001, Vozikis 2005, Michaelides and Savvides 2008, Yaka Çetin and İpekoğlu 2010, Yaka Çetin and İpekoğlu 2012, Yaka Çetin and İpekoğlu 2013). There are also studies that apply systematic methods for evaluation. Methodological assessment studies aim to understand the impact of protective structures on the conservation of the archaeological remains. A range of quantitative and qualitative methods were developed and applied with this aim (Tringham and Stewart 2008). Frequently used methods are condition assessment through site surveys (Stewart et al 2006, Stewart 2008, Neguer and Alef 2008) and environmental monitoring (Agnew and Lin 1991, Agnew et al. 1996, Maekawa 2006, Bethell 2008). In addition, experimental studies such as material analysis (Matero 1999) and comparing protective structures to reburial in terms of efficiency in protection (Gonçalves 2008) are among the methodological assessment studies on protective structures.

4. Improvement, replacement or removal of the existing protective structures has been the subject of some articles. They basically state the problems of the current

protective structures to promote the need for improvement. These studies were mostly carried out in the scope of long maintenance site planning that include replacement of either the permanent and temporary protective structures in need of maintenance and enhancement of the visitation requirements of the site (Schmid 1998, Pesaresi and Rizzi 2007, Michaelides and Savvides 2008, Warner 2009, Offers 2010). In addition, critical evaluation studies in terms of current conservation problems are proceeded by replacement or recommendations for improvement of the protective structure (Doumas 1997, Michaelides and Savvides 2008, Ha'obsh 2008, Rizzi 2008, Warner 2009, National Trust 2009a, National Trust 2009b, Jeffreys 2010, Offers 2010).

To sum up, the earlier publications on protective structures started in the second half of the 20th century. These publications were mostly about the description of the architectural design and technical aspects of the construction. After 1980's, protective structures have become an important subject for preservation during and after excavations, and few publications examined the current problems and the efficiency of the protective structures. Methodological assessments of protective efficiency and development of design methodologies have become the subjects of publications after 1990's. Finally, methodologies of architectural design have been explained in publications after 2000. Although they are in a limited number, they contribute to the development of the conservation-based design methods. However, publications on the protective structures in Turkey are very few. They are mostly written to introduce the design and construction concept, lacking in a critical evaluation and assessment of the efficiency.

1.6.2. Research Projects on Development of Design Strategies of Protective Structures

The research projects that were conducted by institutions constitute the most significant sources of this thesis. They were intended to understand the impact of protective structures on the protection of the archaeological heritage to improve the design methodology. Each research developed different methods to fulfill this aim.

The first project is titled "Development and testing of modular lightweight shelters for archaeological sites". It was conducted by Getty Conservation Institute in the scope of "The Project on Mosaics Conservation" in 1988 and 1989. The aim of the project was to develop a lightweight, modular temporary shelter that can be adopted to cover different types of archaeological sites (Agnew and Coffman 1991, Agnew and Lin 1991, Agnew et al. 1996). As a result, a prototype shelter named ‘Hexashelter’ was developed and constructed over two mosaics at the House of Orpheus at Kato Paphos, Cyprus in 1989. Later on, the same type of shelter was erected in 1991 at Fort Selden, New Mexico for field testing and evaluating the effectiveness in protection. An environmental monitoring system and test walls were installed beneath and outside the shelter to provide correlative data. Mathematical and statistical methods were used in order to quantify the effectiveness of the shelter.

The second research titled “The research project on the cover of the archaeological areas” was conducted by the Department of New Technologies, Energy and the Environment in collaboration with Istituto Centrale per il Restauro, Rome between 1997 and 2002 (L'Istituto Superiore per la Conservazione ed il Restauro 2008, Laurenti 2001, Laurenti et al. 2003, Laurenti 2006). The multi-year project aimed to develop a guiding methodology for designing protective structures. In this scope, survey of archaeological sites throughout Italy, 120 of which were specified to have protective structures, was conducted to increase the understanding of the efficiency of different types of shelters. In addition, survey of microclimatic conditions and multi-disciplinary scientific investigations such as experimental tests and laboratory analysis have been conducted at selected sites. Finally, the developed design methodology was illustrated and verified by the construction of two representative samples of protective structures at Villa Arianna in Castellammare di Stabia and Bronze Age settlement in Vivara (Procida).

The third project titled “Assessing the protective function of shelters over mosaics” is a collaborative research of English Heritage, Israel Antiquities Authority and Getty Conservation Institute, conducted between 2004 and 2009 (Stewart et al., 2006, Stewart 2008, Neguer and Alef 2008, Getty 2009, Getty 2012). The project aims at a better understanding of the relationship between the condition of mosaics and protective structures. Survey of existing examples included 24 protective structures in England and 36 in Israel. The purpose of the survey and evaluation was to understand the effect created by the protective structure in protecting mosaics *in situ*. Preliminary results presented the main threats of sheltered mosaic sites as the site hydrology and the internal environment created by the protective structure.

1.6.3. Academic Research on Protective Structures at Archaeological Sites

Academic research on protective structures consists of dissertations (Aslan 1998, master's thesis Demas 1990, Alef 2002, Uyar 2008) and undergraduate thesis (Vozikis 2002). In general they consist of descriptions on design and construction based on the existing literature and practice from all over the world (Demas 1990, Aslan 1998, Uyar 2008, Ertosun 2012) and certain countries such as Israel (Alef 2002) and Greece (Vozikis 2002). The earliest research presents general overview on the practice of protective structures prior to 1990 and review of the literature (Demas 1990). Subsequent studies examine various protective structures to understand the issues related to conservation (Aslan 1998) and presentation (Alef 2002).

CHAPTER 2

INVESTIGATION OF PROTECTIVE STRUCTURES FOR CONSERVATION AND PRESENTATION OF ARCHEOLOGICAL SITES

Protective structures are built as a protective measure for exposed archaeological heritage that are fragile to destructive effects of atmosphere and intrusion of living organisms. Conservation of the archeological findings requires a wider basis of professional and scientific techniques to achieve long-term preservation against rain, wind, solar radiation and extensive plant growth and intrusive animals. Considering the "natural" damages during and after excavations, Venice Charter (1964) devoted an article pertaining to long term protection of the remains[4]. In the past, decorations such as mosaics, frescos, and other furnishings used to be removed to museums as a common protective procedure. In contrast to the practice, ICOMOS Charter for the Protection and Management of the Archaeological Heritage (1990) has emphasized preservation of the remains in-situ[5].

There are three methodologies applied to promote conservation of exposed archaeological remains *in situ*. They are reburial of the excavated material, direct material treatments (such as capping and chemical consolidants) and sheltering. The third method, sheltering is construction of a protective structure above the remains to mitigate destructive effects of the nature (Stanley Price 2003, Matero 2001).

2.1. Introduction of Protective Structures

[4]The Venice Charter 15th Article *"Ruins must be maintained and measures necessary for the permanent conservation and protection of architectural features and of objects discovered must be taken..."*. (ICOMOS 1964).

[5] Charter for the Protection and Management of the Archaeological Heritage 6th Article "*The overall objective of archaeological heritage management should be the preservation of monuments and sites in situ, including proper long-term conservation and curation of all related records and collections etc…"* (ICOMOS 1990).

Protective structure is a building which helps to protect objects and places of cultural significance through sheltering from destructive factors. Immovable heritage such as stone, brick or adobe building remains, building decorations like mosaics and wall paintings and some sculptures and inscriptions of great importance are among the cultural heritage protected under protective structures. The elements of cultural heritage vary in size from a single object, to a monument or a complete excavation site. In general, protective structures are built to provide long term protection whereas temporary protective structures are built as a preventive measure during or after excavation. Although temporary protective structures are advantageous for a short period, they are inadequate to fulfill their function over the long term (Teutonico 2001).

Architectural features of protective structures such as size and type are related to needs of the site or the object of what has to be protected. They can be grouped under the types of shelter and enclosure according to their state of covering.

- **Shelters** are in the form of a roof having one or more sides open (Figure 2. 1).
- **Enclosures** have all sides covered in addition to roof (Figure 2. 2).

Among the two types, enclosure provides better protected environment from the point of control of climate and animals than shelter.

Figure 2. 1. Protective shelter in Troy, Turkey.

Figure 2. 2. Protective enclosure over Terrace Houses 2 in Ephesus, Turkey.

2.1.1. Identification of Protective Structures

The benefits of protecting and presenting simultaneously have led to construction of numerous protective structures for more than a century. Construction of protective structures started with large scale excavations in the 19th century. The earliest protective structures were built in England (Roman villas of Bignor in West Sussex and Chedworth in Gloucestershire in 1820) (Woolfitt 2007) and Germany (baths of the Roman castellum in Hüfingen in 1821) (Schirmer 2000). The 19th century enclosures were built in the appearance of regular (typical) farm houses in the region, were comparatively small in scale and designed to enclose rooms and mosaics individually (Schirmer 2000, Woolfitt 2007) (Figure 2. 3). Similarly, simple pitched metal roof shelters constructed between 1863 and 1875 at Pompeii demonstrate the concept of sheltering individual parts of the structure. In 1880, the roofs of the houses were restored with wood and tiles in order to protect remaining wall paintings and mosaics inside (Nappo 2011). This practice is an early example of reconstruction of roof with the aim of protecting it from destructive effects of nature. Protective structure built over Throne Room of Palace of Knossos on the island of Crete (1901-1930) and the Terrace House 2 (1979) demonstrates the extremes in interpretive reconstruction (Papadopoulos 1997, Matero 2001, Demas 1997) (Figure 2. 4).

Figure 2. 3. Protective structures in Bignor, West Sussex, England. (Source: http://www.pyrrha.rtwilson.com/mbignor1.html)

Figure 2. 4. Palace of Knossos. (Source: http://www.ancient-greece.org/images/ancient-sites/knossos/images/DSC00096_jpg.jpg)

Figure 2. 5. Protective shelter over the Great House Ruins, USA.
(Source: http://www.eartharchitecture.org/index.php?/archives/747-Casa-Grande.html)

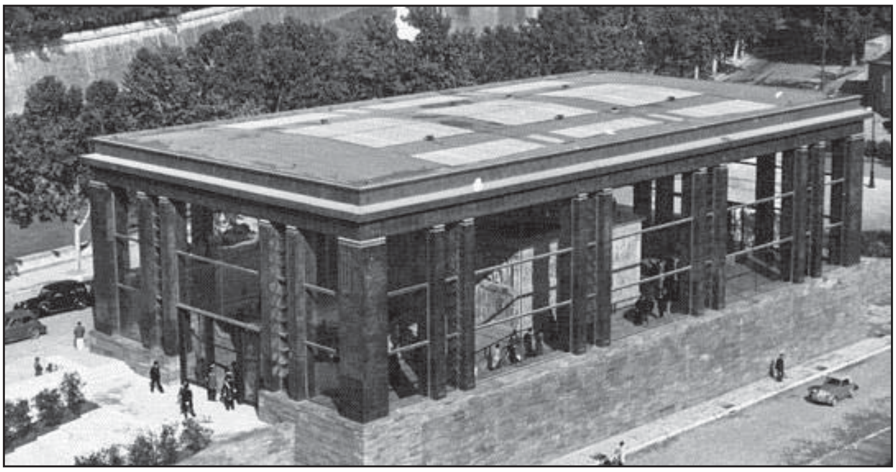

Figure 2. 6. Ara Pacis, Rome.
(Source: http://en.arapacis.it/museo/il_padiglione_novecentesco)

Developments in construction techniques have a major impact on progression of protective structures. A new type of protective structure, in the form of a hall, that covers the remains completely was developed in 20th century. The improvement of protective structures provided variety of design possibilities. At the great Hohokam site of Casa Grande (1932), the steel construction protective shelter and Ara Pacis Augustae in Rome (1938) presents advantages of modern construction techniques (Figure 2. 5, Figure 2. 6). In addition, the appearance, form, space and effect of the protective structure in the historical setting have begun to become a question with this project.

2.1.2. Design Approaches of Protective Structures in Relation to Remains

Building of a protective at an archaeological site creates a major problem itself: Its relation with the surrounding site and the remains underneath creates a question of how to insert a disparate construction into the archaeological site. Earlier practices demonstrate different approaches considering their relation to the remains that requires protection. There are two alternative ways of construction in terms of the practice. One gives an impression of original form, other forms anew.

- **Protective structures imitating the original form:** In case of standing or excavated remains, this condition may induce construction of a protective structure that alludes the original form of the building (Stanley-Price and Jokilehto 2001). When it imitates the original, it can be named as a reconstruction up to roof level rather than sheltering (Figure 2. 7). The structure bears on the walls of the remains and does not have separate foundations. This type of sheltering requires far too many interventions on the original materials. In addition, it may create a misleading effect for the visitors who cannot distinguish the original evidence of the structure.
- **Protective structures forming anew:** The alternative way of sheltering is forming anew instead of imitating the roof of the remains to be protected. Use of modern materials and techniques besides forms other than original induce to design a roof structure which do not copy the original. The roof structure may either bear on the walls of the remains or have its own supports.

Built on the remains: The roof structure is supported by the walls of the remains. This type of roofing may help to understand perception of the original space characteristics without reconstructing the remains. The structure rests on the walls of the remains and does not have separate foundations. When existing walls are not high enough, they can be constructed up to roof level with the original masonry technique (Figure 2. 8) or can be elevated with installation of modern materials (Figure 2. 9, Figure 2. 10). In this condition, it is necessary to distinguish the original materials from the new masonry work to prevent visitors from misunderstanding the original characteristics of the remains.

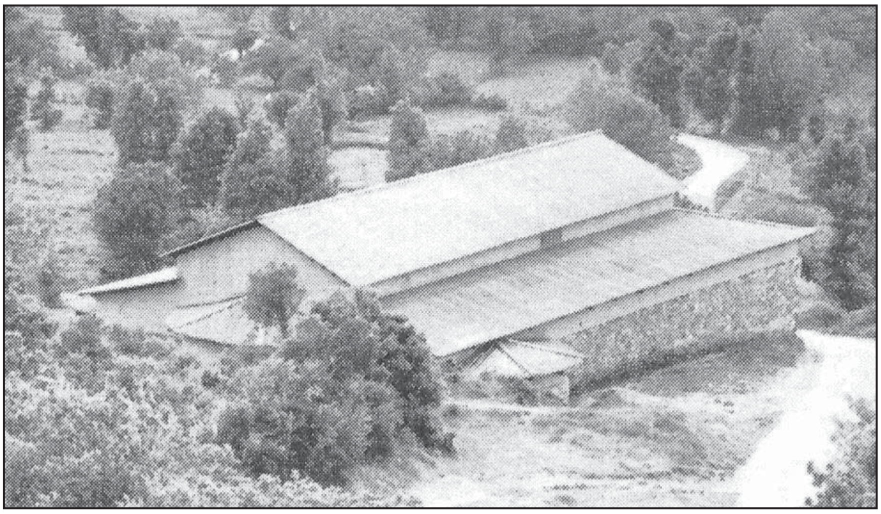

Figure 2. 7. Leonidos Basilica in Klapsi, Greece.
(Source: Schmidt 1988)

Figure 2. 8. Z Building in Pergamon, Turkey.

Table 2. 1. Classification of the protective structures

PROTECTIVE STRUCTURES

Built to protect and display objects and places of cultural significance

- **Temporary Protective Structure**

  Built for providing temporary protection during an excavation work or after excavation until a permanent one is constructed.

  - **Shelter**
    A roof structure having one or more sides open.
  - **Enclosure**
    A roof structure with all sides enclosed.

- **Permanent Protective Structure**

  Built for providing protection for a long period of time. Therefore its construction is based upon a thorough architectural design process.

  - **Shelter**
    A roof structure having one or more sides open.
    It does not protect from:
    - *Wind and wind driven rain*
    - *Invasive animals*

    Forming anew
    - **Built on remains**
    - **Built above remains**
  - **Enclosure**
    A roof structure with all sides enclosed. Provide more controlled environment than shelter.
    It protects from:
    - *rain*
    - *wind*
    - *solar radiation*
    - *plant growth*
    - *animals.*

    - **Imitating original Form**
      - **Reconstruction**
      - **Built on remains**
    - **Forming anew**
      - **Built above remains**

Built above remains: The roof structure has its own foundations which rest on ground, not onarchaeological evidences. Construction of a structure imitates neither form nor material of the original structure (Figure 2. 11). When compared with the former, this type of protective structure does not make reference to the remains and falls into disharmony with the archaeological heritage. On the other hand, it provides the advantages of using modern construction materials and technology which can span large areas, be prefabricated off site and constructed in a short time (Woolfitt 2007).

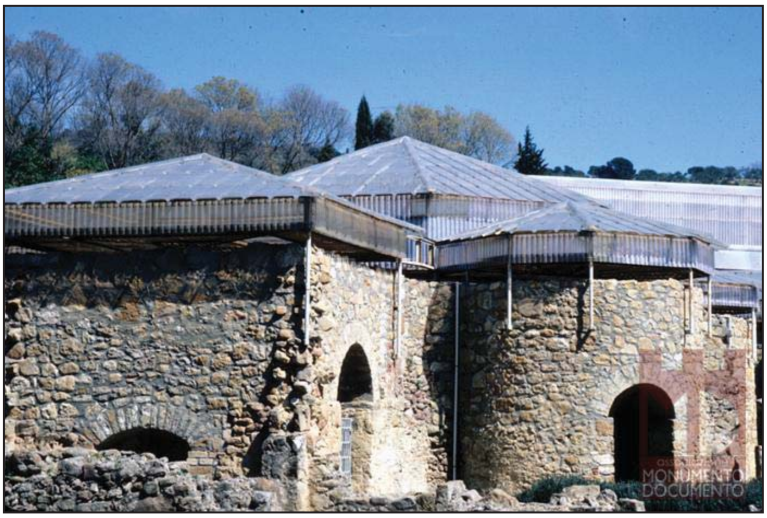

Figure 2. 9. Piazza Armerina in Sicily.
(Source: http://www.unipa.it/monumentodocumento/villadelcasale/frigidarium.html)

Figure 2. 10. Protective shelter in Sardis, Turkey.

Figure 2. 11. Protective shelter in Çatalhöyük, Turkey.

2.1.3. Function of Protective Structures

The main purpose of protective structures is to lengthen the life of the remains and mitigate the environmental factors that cause deterioration. In addition, they provide a convenient place for their presentation. It is possible to mention about protective and display function of the protective structures.

Protective function: Protective structures should provide protection against effects of climate in the atmosphere in addition to invasive flora and fauna (Agnew 2001). Sites although sheltered or enclosed still can be under the impact of deteriorative factors such as penetrating rain, wind, frost, condensation, excessive heat and fluctuating relative humidity and temperature.

When the environmental stable conditions are not provided, archaeological remains, especially porous materials, are sensitive to relative humidity values and their fluctuations (Aslan 2001, Cronyn 2002). In addition, freeze/thaw cycle cause decay when water freezes to ice, it breaks up the porous material. Another problem is related with the expansion of materials when heated. It causes disruption of the weaker when two adjacent materials which have very different coefficients of expansion. Additionally, moisture in the air and temperature are closely linked in the formation of condensation. If air with a high relative humidity near saturation point comes into contact with a cold material, heat is lost from the air, causing the relative humidity to rise until the air can hold no more water and condensation appears on the material. If the temperature doesn't decrease enough for saturation, the temperature drops and relative humidity increases (Cronyn 2002).

Display function: Protective structures enable exhibition of the remains to the researchers and visitors as well as protection. Entrance and exit, walking routes, information panels and best view points are important for the interpretation of the site (Agnew 2001).

2.2. Examination of Design and Construction Process of Protective Structures

Construction of a protective structure creates a design problem that is associated with insertion of a complete structure in the ruinous environment of an archaeological site. In addition, how to install a roof above the archaeological site is the fundamental question about the subject. The design problem is not only related with constructing a new structure in the archaeological landscape but also providing the long term protective conditions for the historic monument. There is a need for a thorough methodology for its construction due to the value of what has to be protected. The methodology requires an integrated decision making and planning process comprised of decision to shelter the site, establishing the conservation, design and construction criteria and evaluation of the protective performance.

2.2.1. Deciding to Construct Protective Structures

Construction of a protective structure should be part of a management plan which aims to preserve the values of the site. It should be limited to sites with rich artistic and decorative features, which their conservation required particular environmental conditions, to avoid from excessive use. Other potentials for protection such as reburial or consolidation should be considered before construction of a protective structure (Schmidt 1988, Avrami et al. 2001). After necessity of a protective structure is determined, it should be followed by establishing conservation, design and construction criteria (Agnew 2001).

2.2.2. Establishment of Conservation, Design and Construction Criteria for Protective Structures

Designing a protective structure requires technical investigations for understanding the cultural significance and physical condition of the site. The process includes development of design principles that are based on documentation studies, understanding the threats and factors contributing to deterioration. The principles that are developed with a comprehensive viewpoint by the site management can be investigated under the topics of protection, visual impact, construction, maintenance and display.

- ***Protection:*** Protective function of a protective structure is related with weather protection, climate control, security, stability, durability and accessibility (Schmidt 1988). It should fulfill its function against deteriorative effects of atmosphere such as precipitation, wind, solar radiation (Agnew et al. 1996, Aslan 2001, Palumbo 2001, Thompson and Taylor 2001). High and low temperatures, high relative humidity, condensation and freezing should be avoided in the environment of protective structure. It should ensure stable relative humidity and temperature in addition to ventilation inside the structure. Protective structures should also prevent from invasion of flora and fauna, as well as, the human beings.
- ***Construction:*** Construction over the valuable remains necessitates a meticulous craftsman, as well as, an accurate planning of the structure. Practicality of the construction, durability of the material and reparability are three main criteria of the construction design (Teutonico 2001). Selection of the structural system and the materials is an important issue which is directly related with conservation performance. The protective structure should have a minimum number of support points not to destroy the remains on the ground (Agnew et al. 1996, Palumbo 2001, Restelli 2006). When necessary, new construction should allow removal without causing any negative impact to the existing remains (Palumbo 2001). It should be capable of rapid construction on-site, so as to minimize disruption to the remains and investigations; in addition it should be capable of construction in such a way as not to create a risk of damage to the remains (Palumbo 2001).
- ***Maintenance:*** Archaeological sites are mostly away from today's city center which may result in inevitable neglect during certain periods of the year. Therefore

materials used for construction should have a long life span and low maintenance requirement should be ensured as much as possible (Agnew et al. 1996, Aslan 2001, Palumbo 2001). Use of natural ventilation and natural day-lighting of the site should be considered (Palumbo 2001).

- ***Visual impact:*** A protective structure is a massive intervention inserted in a historical landscape. Architectural design of a protective structure is important from the point of reference to the particular situation of the remains, distinguishability of the original materials and taking into account the topographical and architectural characteristics of the excavation site (Schmidt 1988). Its visual impact to surrounding historic fabric and significant values of the site should be considered. In addition, the relationship between protective structure and what it protects is important. The aesthetic impact of the structure should not take over from the remains (Agnew et al. 1996, Palumbo 2001). Basic design concepts which relate to the aesthetics of proportions, color, texture of materials and viewscapes should be applied (Agnew 2001).
- ***Display:*** A protective structure provides a covered space for further studies and display of remains in addition to protection. Arrangements for conservation studies and visitor circulation are necessary (Palumbo 2001). Visitor damage by walking on or touching the remains should be prevented. Entrance, routing of walkways, informative panels are of great importance for the best understanding of the site (Agnew 2001).

Above-mentioned principles include basic concerns of shelter design, but they should be assessed within the management context of the site for developing the design criteria. None of the principles should be disregarded; however a hierarchy of “protection” is advisable (Agnew 2001).

2.2.3. Evaluation of Protective Structures Performance

As all conservation treatments, evaluation is necessary for protective structure in the design process. Although protective structures have been constructed for more than a century, evaluation of the practices has come to question since last decade (Agnew et. al. 1996, Aslan 1997). This can be the result of “any shelter is better than no shelter” approach in prevention against atmospheric effects (Agnew 2001). This erroneous approach is no longer accepted in current practice. Today, evaluation is undertaken both in design process and after construction. The former is helpful to predict and minimize potential risks before construction, latter is to identify the need for remedial alterations to overcome unforeseen results (Tringham and Stewart 2008)

Aesthetics, architecture, performance of the protective structure and its relationship with existing setting can be considered among the subjects of evaluation studies (Agnew 2001). Since protective structures are built to minimize deterioration factors of the environmental conditions on remains, the main aspect can be determined as performance evaluation. Performance evaluation means determining the level of efficiency of a protective structure in fulfilling its protective function against the main threats over time (Agnew 2001, Teutonica 2001, Tringham and Stewart 2008). The method of evaluation can be undertaken by condition survey and monitoring of the deterioration phenomena over time, analytic investigations to investigate the identified risks, survey of liquid moisture sources affecting the archaeological remains, moisture monitoring in porous materials and environmental monitoring of microclimate within the protective structure and exterior environment (Tringham and Stewart 2008).

CHAPTER 3

ANALYSIS OF THE CASE STUDY EXAMPLES

Protective structures provide a great contribution for the long term protection of remains against atmospheric events. However, presence of a protective structure does not always mean that it succeeds to preserve the values of the site from main threats (Agnew 2001). The environmental conditions differing according to site, topography, region as well as the architectural design features of the protective structures specify their efficiency in protection. The selected protective structures were analyzed and evaluated in terms of the issues related with conservation of the remains under the following titles:

- Identification of the protective structures
- Analysis of architectural design characteristics of protective structures
- Assessment of deterioration factors under protective structures
- Evaluation of the deterioration factors in relation to the design characteristics of protective structures

The analysis and evaluation aims to understand the influence of protective structure on the long term protection of the fragile remains such as mosaics, wall paintings and earthen structures.

3.1. Architectural Characteristics of Selected Protective Structures

Terrace House 2 at Ephesus (Turkey) contains an insula with seven Roman houses under an enclosure (Table 3. 1). The housing units are richly decorated with wall paintings and mosaics. Inefficient drainage system, intrusion of birds and wasps are important issues to consider at the Terrace House 2 (Figure 3. 1, Figure 3. 2).

Figure 3. 1. Bird droppings on the mosaics.

Figure 3. 2. Wetting of the mosaics due to rising damp.

Table 3. 1. Identification card of Terrace House 2 at Ephesus, Turkey.

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Terrace House 2
Ephesus, Turkey</td><td rowspan="5">
Interior View

Exterior View</td></tr>
<tr><td>Characteristics of the Site
The insula contains seven housing units placed on the terraces of the hill. Peristyle houses have large areas of surviving interior decoration with fresco paintings, marble panelling and mosaics.</td></tr>
<tr><td>Identification of Remains
Ground floor levels of the houses are mostly preserved. Masonry walls up to several heights, rooms are decorated with wall paintings and mosaics.</td></tr>
<tr><td>Period
The houses are dated to 1st century BC to 3rd century AD [1].</td></tr>
<tr><td>Excavation and Preservation Work
The excavation studies started in 1960s. Construction of earlier enclosure in the form of original roofs were started in 1969/70 and continued until 1986 [1, 3].</td></tr>
<tr><td rowspan="5">Protective Structure</td><td>Type
Enclosure
Built above remains</td><td>Architect / Contractor
Project by Wolfdietrich Ziesel and Otto Hauselmayer [7].
Contractor: Metallbau Treiber KG [7].</td></tr>
<tr><td>Construction Date
October 1998 - 1999</td><td>Size
4000 m^2</td></tr>
<tr><td colspan="2">Aim
To develop a modern construction, with the predominant function of protecting the remains from damaging influences in the most natural way, involving technical means as simple as possible [4].</td></tr>
<tr><td colspan="2">Design Principles
- Protection: The interior climate with similar figures to the exterior climate can be achieved through natural ventilation [6], avoidance of condensate water [6].
- Construction: The vertical supports were not to have any negative effect on the wall and floor areas to be preserved. A complete separation from the remains, capable of being dismantled and to be erected in phases [8].
- Maintenance: Low maintenance costs and a long life span [8]. Transparent side panels and translucent roof membrane provide natural light, eliminate the need of artificial lighting [5].
- Visual Impact: The exterior form of the protective structure followed the contours of the hillside and terracing of the housing units [5].
- Display: Paths for visitors and exhibition areas should be illuminated with natural light [6].</td></tr>
<tr><td colspan="2">Structural System and Material
- Structure: Stainless steel girder structure and steel pillars.
- Roof: Translucent, light, resistant skin made of fiberglass and PTFE (polytetraflouretylene) coating (extremely light [1kg\m^2], high resistance [8000kg/m], translucent, water proof and weather proof, not easily inflammable, self-cleaning).
- Façade: Transparent façade material of the polycarbonate type was used (thickness of 8 mm, stable against damage).
- Foundation: Plain foundation and anchorage of the piles [4].</td></tr>
</table>

(cont. on next page)

Table 3.1. (cont)

	Design Characteristics for Climate Control The sides have an important climatic function that fresh air constantly penetrates in the roof and evacuates through openings in the roof [4].
	Monitoring Internal / External Environment No regular monitoring has been conducted.
	Conservation Problems and Possible Causes Color alterations at the mosaic surface [south terraces] due to wetting in rainy season, associated with inefficient drainage. Bulging of tessellatum and detached tesserae [mosaic in Unit 2] due to rising damp. Holes in the masonry structure due to large population of wasps. Deposit on the mosaic surface and wall paintings due to bird droppings. Salt efflorescence and microbiological growth such as moulds and algae [on the walls at south terrace] due to rising damp and stagnant air in the rooms with vaults. Cracks and fissures on the wall paintings may be due to fluctuations of temperature and relative humidity. Water penetration through louvers of south and southeast sides in rainstorm. Fluctuations of temperature and relative humidity, heat built up inside [40^{o}C and 70 % relative humidity during daytime in summer] and high relative humidity [90 % during daytime in winter] may be due to lack of insulation. Deficiency in the construction material: Membrane has been punctured and transparent side panels have been turned into translucent due to dust accumulation. (Conservation problems have been determined by interviewing the site restorer, Sinan İlhan)
	Modification of Protective Structure to Mitigate Problems No modification but some repair work such as patching the roof membrane to prevent leaks and re-tightening of the screws of the side panels was necessary.
Ambient Climate of the Site Ephesus is located in the Mediterranean climate region (Csa - hot and dry summers, cool and wet winters) according to Köppen climate classification. The climate statistics are based on the temperature and precipitation data recorded at a station in Selçuk between 2000 and 2010. The average annual maximum temperature is 24°C and the average minimum temperature is 11.6°C and the relative humidity averages to 57.7% annually. Hottest month of the year is August with a maximum temperature of 44°C and the coldest month is February with a minimum temperature of -5.7°C. The temperature is at or below freezing values 17 days per year, most of which occur in January and December. The rainy season is from November to February and 58.6 % of the annual rainfall is received during this rainy season. The mean precipitation is 692.35 mm per year and the average wind speed is 1.2 m/s.	
References 1- Krinzinger, Friedrich. 2000b. 2- Yurttagül, Kenan. 2000. 3- Özgönül, Nimet. 2001. 4- Ziesel, Wolfdietrich. 2000. 5- Häuselmayer, Otto. 2000. 6- Wunderer, Ekkehard. 2000. 7- Krinzinger, Friedrich. 2000c. 8- Achleitner Friedrich. 2000.	

Building Z at Pergamon (Turkey) is a peristyle house with mosaics and a limited area of wall paintings protected under an enclosure (Table 3. 2). Rain penetration through louvers and rising damp due to inefficient roof drainage are issues occasionally observed at the site (Figure 3. 3).

Figure 3. 3. Color alterations due to drainage problems.

Table 3. 2. Identification card of Building Z at Pergamon, Turkey.

Archaeological Remains	**Archaeological Site** Building Z Pergamon, Turkey	 Interior View
	Characteristics of the Site A peristyle house located near the Demeter sacred area at the Acropolis [1].	
	Identification of Remains South part is destroyed due to erosion. Only the north part is well preserved with decorations and remains of walls [1].	
	Period The early construction period is 2^{nd} century BC. Subsequently it is enlarged in the Roman period. Hellenistic pavements were removed and Roman mosaics were installed in the 1^{st} century AD [1].	 Exterior View
	Excavation and Preservation Work Head of excavation was Prof. Dr. Wolfgang Radt [1]. The first excavations started at the south side between 1908 and 1912. Mosaic pavements are found in the 1990's [2].	
Protective Structure	**Type** Enclosure Built on remains	**Architect / Contractor** Dr.-Ing. Martin Bachmann and Dipl.-Ing. Andreas Schwarting [2].
	Construction Date 1996- 2004 [1].	**Size** Approximately 45x45/ 2 m^2 [2].
	Aim Protect and display the mosaics and stucco decoration at the Building Z.	
	Design Principles - Protection*:* Principles of and conservation are taken into consideration in addition to providing good preservation, security, appropriate conditions of climate and requiring low maintenance budget [2]. - Visual Impact: The material and construction technique of the protective structure followed the tradition of the former excavated houses at the site [2].	
	Structural System and Material -Structure: Original walls elevated until height of 4 m and steel supports carry the load of the roof trusses. - Roof: Steel roof construction covered with tiles. - Façade: South side is composed of steel laminary construction of venetian blinds which provides solar control and ventilation [1, 2]. Other sides are composed of masonry walls which are constructed on the original walls with similar materials and techniques.	
	Design Characteristics for Climate Control Natural ventilation through the laminary construction at the south façade. Roof construction is elevated from the walls to provide ventilation and light [2].	
	Monitoring Internal / External Environment Comparison of current condition with historic photographs.	

(cont. on next page)

Table 3.2. (cont)

<table>
<tr><td></td><td>Conservation Problems and Possible Causes
Rain penetration through louvers at the west side in rainstorm.
Color alterations of the mosaic surface and deteriorated tesserae due to wetting in rainstorm, can be associated with inefficient site drainage which is parallel to the slope.
Deposit on the mosaic surface due to bird droppings.
(Conservation problems have been determined by interviewing the architect of the protective structure, Dr. Ing. Martin Bachmann)</td></tr>
<tr><td></td><td>Modification of Protective Structure to Mitigate Problems
Installation of polycarbonate panels west side of the gable to prevent rain infiltration through the venetian blinds in rainstorm.</td></tr>
<tr><td colspan="2">Ambient Climate of the Site
Pergamon is located in the Mediterranean climate region (Csa - hot and dry summers, cool and wet winters) according to Köppen climate classification.
The climate statistics are based on the temperature and precipitation data which were recorded at a station in Bergama between 2000 and 2010.
The average annual maximum temperature is 22.7°C and the average minimum temperature is 11.8°C and the relative humidity averages to 62.6% annually. Hottest month of the year is July with a maximum temperature of 43.9°C and the coldest month is February with a minimum temperature of -5.7°C. The temperature is at or below freezing values 17 days per year, most of which occur in January and February.
The rainy season is from November to February and 62.7 % of the annual rainfall is received during this rainy season. The mean precipitation is 651.86 mm per year and the average wind speed is 2.7 m/s.</td></tr>
<tr><td colspan="2">References
1- Bachmann, Martin and Andreas Schwarting. 2005.
2- Bachmann, Martin. 2006.
3- Bachmann, Martin and Andreas Schwarting. 2008.</td></tr>
</table>

Archaic and late Roman remains at Sardis (Turkey) consists of earthen fortification wall partially overlapping with late Roman housing units decorated with wall painting (Table 3. 3). They are protected under the same shelter. Faulty rain gutters and salt efflorescence due to instable microclimate are the main threats at the site (Figure 3. 4, Figure 3. 5).

Figure 3. 4. Rising damp due to faulty gutter system.

Figure 3. 5. Salt crystallization due to limited shelter area.

Table 3. 3. Identification card of Archaic and late Roman remains at Sardis, Turkey.

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Archaic and late Roman remains
(sectors MMS) Sardis, Turkey</td><td rowspan="5">
Interior View

Exterior View</td></tr>
<tr><td>Characteristics of the Site
Late Roman residential complex composed of two housing units and Late Roman wall paintings [1].
Archaic fortification wall (Lydian structure) [3].</td></tr>
<tr><td>Identification of Remains
Partly overlapping Archaic fortification wall and Late Roman town house with wall paintings.</td></tr>
<tr><td>Period
Lydian monumental fortification wall structure dated late 7th and 6th centuries BC.
Late Roman residential complex dated 4th – 7th AD. [1].</td></tr>
<tr><td>Excavation and Preservation Work
Uncovered in 1997 [3]. Limited reconstruction of semi-dome of the apsidal room and construction of shelter.</td></tr>
<tr><td rowspan="7">Protective Structure</td><td>Type
Shelter
Built on remains</td><td>Architect / Contractor
Troy D. Thompson and Philip Stinson [2, 3].</td></tr>
<tr><td>Construction Date
1997 -1998 [2].</td><td>Size
-</td></tr>
<tr><td colspan="2">Aim
To protect and display better preserved rooms of Late Roman and Archaic Lydian houses.</td></tr>
<tr><td colspan="2">Design Principles
Display: Overlapping Archaic and Late Roman rooms with a nucleus roof of trapezoidal outline which is culturally noncommittal parabolic form. Two adjacent Late Roman rooms received separate roofs designed to suggest the original roof forms over [2].</td></tr>
<tr><td colspan="2">Structural System and Material
Structure: Steel truss structure and steel supports.
Roof: Thermoplastic sheets.
Foundation: Anchorage of the supports on the reconstructed walls.</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
No design characteristics for climate control.</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
No monitoring.</td></tr>
</table>

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Table 3.3. (cont)

<table>
<tr><td></td><td>Conservation Problems and Possible Causes
Salt efflorescence due to rising damp associated with lack of site drainage.
Salt efflorescence and plants due to rain penetration in addition to faulty gutter system.
Rain penetration and direct solar gain due to limited shelter area.
Loss of plaster layers may be due to fluctuations of temperature and relative humidity (absence of sides).
Holes in the earthen structure due to wasps.
Condition of the mosaics could not be observed due to the protective surface covering them.</td></tr>
<tr><td></td><td>Modification of Protective Structure to Mitigate Problems
No modification.</td></tr>
<tr><td colspan="2">Ambient Climate of the Site
Sardis is located in the Mediterranean climate region (Csa - hot and dry summers, cool and wet winters) according to Köppen climate classification.
The climate statistics are based on the temperature and precipitation data which were recorded at a station in Salihli between 2000 and 2010.
The average annual maximum temperature is 25.6°C and the average minimum temperature is 11.2°C and the relative humidity averages to 60.6 % annually. Hottest months of the year are July and August with a maximum temperature of 43.7°C and the coldest month is February and October with a minimum temperature of -13.5°C. The temperature is at or below freezing values 23.5 days per year, most of which occur in January and December.
The rainy season is from November to February and 70.3 % of the annual rainfall is received during this rainy season. The mean precipitation is 501 mm per year and the average wind speed is 1.5 m/s.</td></tr>
<tr><td colspan="2">References
1- Greenewalt Crawford Hallock. 1987.
2- Greenewalt Crawford Hallock, and Marcus L. Rautman. 2000.
3- Greenewalt Crawford Hallock 1997.</td></tr>
</table>

Villas Dionysos and Danae at Zeugma (Turkey) is a Roman house complex protected under an enclosure, is composed of stone masonry walls with plasters and mosaic pavements (Table 3. 4). Disintegration and loss of plaster layers due to fluctuations of temperature and relative humidity are observed (Figure 3. 6, Figure 3. 7).

Figure 3. 6. Disintegration of plaster layers due to instable interior microclimate.

Figure 3. 7. Loss of plaster layers on the wall.

Table 3. 4. Identification card of Villas Dionysos and Danae at Zeugma, Turkey.

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Villas Dionysos and Danae
Zeugma, Turkey</td><td rowspan="5">
Interior View

Exterior View</td></tr>
<tr><td>Characteristics of the Site
Stone masonry building remains of the Roman House complexes of Danae and Dionysus.</td></tr>
<tr><td>Identification of Remains
The house located on the terraces is composed of masonry walls with plasters up to several heights. Rooms are decorated with mosaics and wall paintings.</td></tr>
<tr><td>Period
Roman Period [1].</td></tr>
<tr><td>Excavation and Preservation Work
Partially excavated by the Gaziantep Museum in 1998. The excavation of the site was resumed by Zeugma Archaeological Project in 2005, while the conservation of the previously excavated parts was undertaken [1].</td></tr>
<tr><td rowspan="7">Protective Structure</td><td>Type
Enclosure
Built above remains</td><td>Architect / Contractor
Atolye Architecture - Sinan Omacan.</td></tr>
<tr><td>Construction Date
2009-2010 [3].</td><td>Size
32x55m (2200m^2) [3].</td></tr>
<tr><td colspan="2">Aim
The protective structure was designed to enable the preservation of mosaics and frescoes in the Roman House complexes of Dionysus and Danae in their original architectural context and in a climate-controlled setting [2].</td></tr>
<tr><td colspan="2">Design Principles
Protecting the remains, proper display of findings and enabling more comfortable excavation and site visit.
Protection: Avoidance from solar radiation, provide more stable temperature and prevent from wind effects such as dust and provide air flow [3].
Maintenance: Providing light for the excavation and conservation studies [3].</td></tr>
<tr><td colspan="2">Structural System and Material
- Structure: Steel structural framework.
- Roof: Polycarbonate panels (45% transmittance and UV protection), interior surface is 18 % porosity PVC mesh textile.
- Façade: Perforated aluminum mesh, interior surface is 18 % porosity PVC mesh textile.
- Foundations: Reinforced concrete foundations [3].</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
Passive control through architectural openings. Lateral surfaces designed to prevent direct sun light and provide natural air flow [3].</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
No regular monitoring has been conducted.</td></tr>
</table>

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Table 3.4. (cont)

	Conservation Problems and Possible Causes Deposits of bird droppings and dust on the mosaic floors. Disintegration and loss of plaster layers may be due to fluctuations of temperature and relative humidity. Whitish power on the wall paintings may be due to salt efflorescence. Plants may be due to inefficient site drainage. Loss of mud mortar on masonry walls which encircle the protected site are due to inefficient site drainage. (Conservation problems have been determined by interviewing the site archaeologists, Hüseyin Yaman and Oğuz Bostancı)
	Modification of Protective Structure to Mitigate Problem Enclosing the sides of the roof pieces with PVC textile is being planned to prevent birds' nest on the roof structure.
Ambient Climate of the Site Zeugma is located in the Mediterranean climate region (Csa - hot and dry summers, cool and wet winters) according to Köppen climate classification. The climate statistics are based on the temperature and precipitation data which were recorded at a station in Gaziantep between 2000 and 2010. The average annual maximum temperature is 22.4°C and the average minimum temperature is 10.3°C and the relative humidity averages to 63.8 % annually. Hottest month of the year is July with a maximum temperature of 42.6°C and the coldest month is February with a minimum temperature of -10.2°C. The temperature is at or below freezing values 28 days per year, most of which occur in January, February and December. The rainy season is from November to February and 50.6 % of the annual rainfall is received during this rainy season. The mean precipitation is 561.1 mm per year and the average wind speed is 0.9 m/s.	
References 1- Zeugma Archaeological Project. 2012a. 2- Zeugma Archaeological Project. 2012b. 3- Sinan Omacan, personal communication.	

Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures are the remains of Neolithic houses located at two different trenches, each protected separately under an enclosure (Table 3. 5, Table 3. 6). Houses are constructed of mudbrick and walls are plastered and decorated with wall paintings. Disintegration and loss of plaster layers due to instable micro climate and salt crystallization as well as the damage of rodents are the main threats at the site (Figure 3. 8, Figure 3. 9, Figure 3. 10, Figure 3. 11).

Figure 3. 8. Plants due to lack of roof and site drainage at south shelter.

Figure 3. 9. Collapse of mudbrick walls due instable microclimate at south shelter.

Figure 3. 10. Basal erosion and presence of plants due to rising damp at north shelter.

Figure 3. 11. Loss of plaster layers at the north shelter.

Table 3. 5. Identification card of Neolithic Houses at Çatalhöyük, Turkey- south shelter.

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
South Area,
Çatalhöyük, Turkey</td><td rowspan="5">
Interior View

Exterior View</td></tr>
<tr><td>Characteristics of the Site
Sun dried mudbrick structures. There are 42 buildings identified in the south area so far [1].</td></tr>
<tr><td>Identification of Remains
Mudbrick buildings, wall paintings and plaster reliefs. Multiple layers of plaster made from marly soils coated to the walls [3].</td></tr>
<tr><td>Period
Neolithic Period.</td></tr>
<tr><td>Excavation and Preservation Work
The first excavations began in 1960s by James Mellaart [1]. New excavations are carried on between 1996 and 1998 period under the supervision of Prof. Ian Hodder [2].</td></tr>
<tr><td rowspan="7">Protective Structure</td><td>Type
Enclosure
Built above remains.</td><td>Architect / Contractor
Atolye Architecture-H.Sinan Omacan.</td></tr>
<tr><td>Construction Date
2002-2003.</td><td>Size
27x45m (1300m^2) [5].</td></tr>
<tr><td colspan="2">Aim
Protect and display of the archaeological trenches and enabling more comfortable excavation and site visit throughout the year [4, 5].</td></tr>
<tr><td colspan="2">Design Principles
Construction: Foundations, which would not hugely, impact on the archaeology, adequate load bearing on a site of variable compaction, extreme weather conditions with high wind uplift and heavy snow load, and consideration to the air flow during the hot summer months of excavation [5].</td></tr>
<tr><td colspan="2">Structural System and Material
Structure: Steel space frame.
Roof: Fiberglass paneling.
Façade: Fiberglass paneling. The paneling has 50 % light permeability and the side panels can be removed in the summer months to assist with ventilation [1, 5].
Foundations: Reinforced concrete ring structure [5] which corresponds to the topography [8].</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
Passive control through side panels. Panels on the façades are removable to provide ventilation in summer.</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
No regular monitoring has been conducted. Measurements of humidity and temperature [6].</td></tr>
</table>

(cont. on next page)

Table 3.5. (cont)

<table>
<tr><td></td><td>Conservation Problems and Possible Causes
Loss of plaster layers due to instable micro climate inside the protective structure.
Disintegration of plaster layers due to rising damp and activities of soluble salts.
Salt activities due to wetting and drying cycles, rising damp and instable microclimate. In summer period, opening sides trigger subflorescences due to excessive ventilation.
Formation of cracks on the wall paintings and plaster layers due to instable micro-climate.
Erosion of mudbrick surfaces due to excessive ventilation.
Holes in the structure due to burrowing animals. In addition birds, spiders, dogs and foxes cause damage inside the protective structure.
Rising damp is an important problem which is caused by lack of drainage system. In heavy rain, water accumulates on terraces on the slope. Then the water penetrates through the foundations.
(Conservation problems are determined by interviews with the site conservator, Duygu Çamurcuoğlu)</td></tr>
<tr><td></td><td>Modification of Protective Structure to Mitigate Problem
Some modifications are being planned by the excavation team. They are changing the cover material with double-layered polycarbonate to create more stable internal environment [7].</td></tr>
<tr><td colspan="2">Ambient Climate of the Site
Çatalhöyük is located in the Cold semi-arid climate region (Bsk- hot and dry summers, cold winters with snowfall) according to Köppen climate classification.
The climate statistics are based on the temperature and precipitation data which were recorded at a station in Çumra, between 2000 and 2010. The average annual maximum temperature is 19.2°C and the average minimum temperature is 5.5°C and the relative humidity averages to 56% annually. Hottest month of the year is August with a maximum temperature of 39.2°C and the coldest months are January and February with a minimum temperature of -22.5°C. The temperature is at or below freezing values between October and April. Average number of 91.6 days per year below freezing, most of which occur in January, February and December.
November, December and April are the most rainy months and 42.7 % of the annual rainfall is received during these months. The mean precipitation is 326.14 mm per year and the average wind speed is 0.76 m/s.</td></tr>
<tr><td colspan="2">References
1- Çatalhöyük Research Project. 2013b.
2- Farid, Shahina. 2002.
3- Matero 2000.
4- Sinan Omacan, personal communication.
5- Çatalhöyük Research Project. 2013a
6- Çatalhöyük Research Project. 2013c.
7- Çatalhöyük Research Project. 2013d.
8- Omacan, Sinan, Rıdvan Övünç, Ceren Balkır and Didem Teksöz. 2003.</td></tr>
</table>

Table 3. 6. Identification card of Neolithic Houses at Çatalhöyük, Turkey- north shelter.

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
4040 Trench
Çatalhöyük, Turkey</td><td rowspan="5">
Interior View

Exterior View</td></tr>
<tr><td>Characteristics of the Site
A group of Neolithic houses which are at the same level and separated with streets and crossroads [2]. There are 27 buildings identified in the 4040 Area so far [3].</td></tr>
<tr><td>Identification of Remains
Mudbrick houses of 9000 years and special elements such as bull horns on pilasters [1]. Geometrical wall paintings (red) and painted plasters.</td></tr>
<tr><td>Period
Neolithic Period (7000 BC).</td></tr>
<tr><td>Excavation and Preservation Work
Excavation studies started in 2000 to present. Preservation works include stabilization of mudbrick and plastered walls with chemicals and consolidation of damaged parts, filling the cracks with mortar and conservation of wall paintings and consolidation of plasters and the paintings [2].</td></tr>
<tr><td rowspan="7">Protective Structure</td><td>Type
Enclosure
Built above remains</td><td>Architect / Contractor
Atolye Architecture -H.Sinan Omacan</td></tr>
<tr><td>Construction Date
2007-2008</td><td>Size
28x45m (1300m^2)</td></tr>
<tr><td colspan="2">Aim
Protecting the mudbrick houses and enabling more comfortable excavation and site visit throughout the year [1].</td></tr>
<tr><td colspan="2">Design Principles
-</td></tr>
<tr><td colspan="2">Structural System and Material
Structure: laminated wood arch beams
Roof: 45 % transmittance, single shell polycarbonate panels
Façade: 45 % transmittance, single shell polycarbonate panels and PVC textile
Foundation: Reinforced concrete foundations</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
Lateral sides of the enclosure are removable. The sides are closed during winter to provide better protection. In summer sides are open for natural ventilation [2].</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
No regular monitoring has been conducted. Measurements of humidity and temperature [2].</td></tr>
</table>

(cont. on next page)

Table 3.6. (cont)

<table>
<tr><td rowspan="2"></td><td>Conservation Problems and Possible Causes
Loss of plaster layers due to instable micro climate inside the protective structure.
Disintegration of plaster layers due to rising damp and activities of soluble salts.
Salt activities due to wetting and drying cycles, rising damp and instable microclimate.
Subflorescences triggered by excessive ventilation is observed more severe than south shelter because it is located on the hill and expose to strong north south wind [4].
In summer period, opening sides trigger subflorescences due to excessive ventilation.
Formation of cracks on the wall paintings and plaster layers due to instable micro-climate.
Erosion of mudbrick surfaces due to excessive ventilation.
Holes in the structure due to burrowing animals. In addition birds, spiders, dogs and foxes cause damage inside the protective structure.
Rising damp is an important problem which is caused by lack of drainage system. In heavy rain, water accumulates on terraces on the slope. Then the water penetrates through the foundations, which may bring salt from the foundations.
(Conservation problems have been determined by interviewing the site conservator, Duygu Çamurcuoğlu)</td></tr>
<tr><td>Modification of Protective Structure to Mitigate Problem
Modification of the protective structure is planned by the excavation team. Adjusting the location of the vents to prevent strong winds is being planned [4].</td></tr>
<tr><td colspan="2">Ambient Climate of the Site
Konya is located in the Cold semi-arid climate region (Bsk- hot and dry summers, cold winters with snowfall) according to Köppen climate classification.
The climate statistics are based on the temperature and precipitation data which were recorded at a station in Çumra between 2000 and 2010. The average annual maximum temperature is 19.2°C and the average minimum temperature is 5.5°C and the relative humidity averages to 56% annually. Hottest month of the year is August with a maximum temperature of 39.2°C and the coldest months are January and February with a minimum temperature of -22.5°C. The temperature is at or below freezing values between October and April. Average number of 91.6 days per year below freezing, most of which occur in January, February and December.
November, December and April are the rainiest months and 42.7 % of the annual rainfall is received during these months. The mean precipitation is 326.14 mm per year and the average wind speed is 0.76 m/s.</td></tr>
<tr><td colspan="2">References
1- Sinan Omacan, personal communication.
2- Çatalhöyük Research Project. 2013c.
3- Çatalhöyük Research Project. 2013b.
4- Çatalhöyük Research Project. 2013d.</td></tr>
</table>

Alaeddin Kiosk in Konya (Turkey) constructed of mudbrick and mortar. Only the east wall survived and protected under a shelter (Table 3. 7). Basal erosion due to rising damp and surface erosion due to rain penetration and wind strong winds are the issues to consider for protection of the remains (Figure 3. 12, Figure 3. 13).

Figure 3. 12. Basal erosion due to rising damp.

Figure 3. 13. Salt crystallization on the glazed bricks.

Table 3. 7. Identification card of Alaeddin Kiosk in Konya, Turkey

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Alaeddin Kiosk (Anatolian Seljuk Mansion)
Konya, Turkey</td><td rowspan="5">
Interior View

Exterior View</td></tr>
<tr><td>Characteristics of the Site
The building is the only sample of the mansions of Anatolian Seljuks. The walls of the mansion which was built having two stories were decorated with patterns of encaustic tiles [1].</td></tr>
<tr><td>Identification of Remains
It was abandoned in 17th century and demolished due to lack of maintenance. Only the east wall survived [1,b3]. Walls are constructed of Gödene stone and mudbrick and decorated with glazed brick and mortar [1].</td></tr>
<tr><td>Period
1173 [3].</td></tr>
<tr><td>Excavation and Preservation Work
The first excavations were conducted in 1941 at the Alaeddin Hill by Remzi Oğuz Arık
The site was excavated by Mehmet Önder in 1958 [2].</td></tr>
<tr><td rowspan="9">Protective Structure</td><td>Type
Shelter
Built above remains.</td><td>Architect / Contractor
Administration of Museums.</td></tr>
<tr><td>Construction Date
1961 [1].</td><td>Size
-</td></tr>
<tr><td colspan="2">Aim
Protect the walls.</td></tr>
<tr><td colspan="2">Design Principles
-</td></tr>
<tr><td colspan="2">Structural System and Material
Structure and Roof: Reinforced concrete shell structure.
Foundations: Reinforced concrete.</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
-</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
-</td></tr>
<tr><td colspan="2">Conservation Problems and Possible Causes
Basal erosion due to rising damp.
Surface erosion due to rain penetration (leaks in roof) and exposure to strong wind.
Loss of mud mortar due to wetting and drying cycles.
Formation of cracks due to wetting and drying cycles which is triggered with cyclic contraction and expansion surface condensation, solar radiation and fluctuation of temperature and relative humidity.
Efflorescence on the brick ornaments due to rain penetration.</td></tr>
<tr><td colspan="2">Modification of Protective Structure to Mitigate Problems
Removal of the protective structure and reconstruction of the Kiosk is being planned by the Konya Municipality [4].</td></tr>
</table>

(cont. on next page)

Table 3.7. (cont)

Ambient Climate of the Site Konya is located in the Cold semi-arid climate region (Bsk - hot and dry summers, cold winters with snowfall) according to Köppen climate classification. The climate statistics are based on the temperature and precipitation data which were recorded at a station in Konya between 2000 and 2010. The average annual maximum temperature is 19.03°C and the average minimum temperature is 6.9°C and the relative humidity averages to 56.76 % annually. The hottest month of the year is August and maximum temperature is 39.8°C and the coldest months are January, February and December with a minimum temperature of -22.4°C. The temperature is at or below freezing values between October and April. Average number of 82.8 days per year below freezing, most of which occur in January, February and December. November, December and April are the rainiest months and 43.7 % of the annual rainfall is received during these months. The mean precipitation is 307.1 mm per year and the average wind speed is 1.94 m/s.
References 1- Koçu, Nazım. 2007. 2- Günlük, Seval. 2007. 3- Yıldırım, Mustafa.1997. 4- Konya Municipality. 2013.

Citadel Wall and the Megaron at Troy (Turkey) are placed adjacent to each other, protected under the same shelter (Table 3. 8). Both constructed of mudbrick walls on stone foundations. Loss of mud mortar due to rising damp, formation of cracks, detachment and loss of capping mortar due to wetting and drying cycles, excessive air flow, solar radiation are observed at the site (Figure 3. 14, Figure 3. 15).

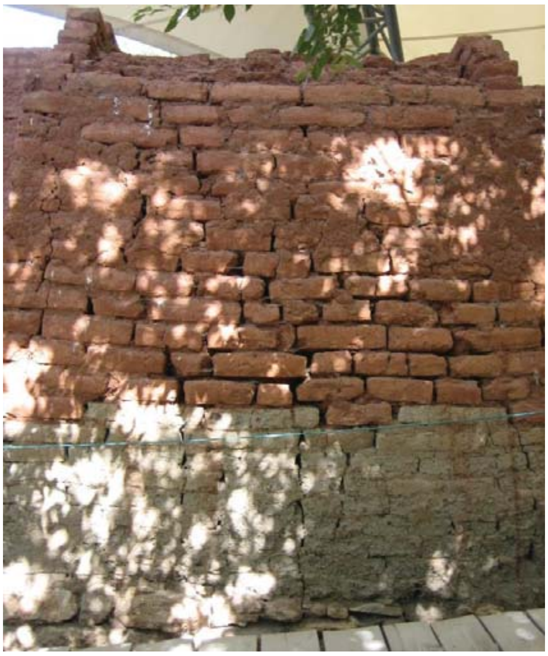

Figure 3. 14. Loss of mud mortar and structural cracks on the reconstructed fortification wall at the Citadel Wall and the Megaron at Troy (Turkey).

Figure 3. 15. Holes by wasps and arthropods at the Citadel Wall and the Megaron at Troy (Turkey).

Table 3. 8. Identification card of Citadel Wall and the Megaron at Troy, Turkey.

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Troy, Turkey</td><td rowspan="5">
Interior View

Exterior View</td></tr>
<tr><td>Characteristics of the Site
Troia II / III Citadel Wall and the Megaron</td></tr>
<tr><td>Identification of Remains
Mudbrick fortification wall and its stone foundations. Megaron, is composed of stone foundations and mudbrick walls (1.5 m high) [1].</td></tr>
<tr><td>Period
2550-2200 BC [1].</td></tr>
<tr><td>Excavation and Preservation Work
Megaron was excavated in 1998-99.
Fortification wall was reconstructed with baked red mudbrick (handmade) in 2003 [1].</td></tr>
<tr><td rowspan="8">Protective Structure</td><td>Type
Shelter
Built above remains</td><td>Architect / Contractor
Designed by Björn Rimner (student)
Prof. Wolfgang Knoll, Prof. Dr. –Ing.Werner Sobek, Prof. Peter Cheret</td></tr>
<tr><td>Construction Date
August 2003 [1].</td><td>Size
700 m^2 [2].</td></tr>
<tr><td colspan="2">Aim
Protect from sun, rain and erosion of mudbrick walls of the Megaron which are the only mudbrick walls to have been preserved at Troia [2].</td></tr>
<tr><td colspan="2">Design Principles
Form of the shelter takes the reference to the height and shape of Hisarlık hill before excavation. The sail construction of the roof recalls the wind which almost invariably blows from the north-east at Troia [2].</td></tr>
<tr><td colspan="2">Structural System and Material
Structure: Two trussed arches and two guyed masts.
Roof: Textile membrane (30x30) (PVC coated polyester)</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
No measures for climate control.</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
Megaron was partially covered due to the conservation studies during the survey (August 2011).
No regular monitoring has been conducted.</td></tr>
<tr><td colspan="2">Conservation Problems and Possible Causes
Formation of cracks due to wetting and drying cycles, surface condensation and strong wind
Loss of mud mortar due to rising damp, wetting and drying cycles, solar radiation
Detachment and loss of capping mortar due to surface condensation, wetting and drying cycles, excessive air flow, solar radiation
Lacunae caused by wasps.
Damage by birds.
(Conservation problems have been determined by interviewing the director of the excavations, Prof. Dr. Ernst Pernicka)</td></tr>
</table>

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Table 3.8. (cont)

	Modification of Protective Structure to Mitigate Problem No modification has been planned.
Ambient Climate of the Site Troy is located in the Mediterranean climate region (Csa - hot and dry summers, cool and wet winters) according to Köppen climate classification. The climate statistics are based on the temperature and precipitation data which were recorded at a station in Çanakkale between 2000 and 2010. The average annual maximum temperature is 19.8°C and the average minimum temperature is 11.7°C and the relative humidity averages to 75.2% annually. Hottest month of the year is July with a maximum temperature of 39°C and the coldest month is February with a minimum temperature of -11.2°C. The temperature is at or below freezing values 17.8 days per year, most of which occur in January and February. The rainy season is from November to February and 57.6 % of the annual rainfall is received during this rainy season. The mean precipitation is 617.11 mm per year and the average wind speed is 4.11 m/s.	
References 1- Korfmann, Manfredo O., and Dietrich Mannsperger. 2004. 2- Manfred Korfmann. 2003.	

Fishbourne Roman Palace at West Sussex (UK) is a Roman palace with well-preserved mosaic floors (Table 3. 9). High internal temperatures due to glazed south façade and mechanical ventilation encouraged evaporation of ground water with soluble salts (Figure 3. 16). The protective structure has failed to protect the remains and has been modified to create more stable environment (Stewart 2008).

Figure 3. 16. Mosaics exposed to solar gain from glazed south façade before the modification. (Source:http://commons.wikimedia.org/wiki/File: Fishbourne_roman_palace_mosaics.jpeg)

Table 3. 9. Identification card of Fishbourne Roman Palace at West Sussex (UK).

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Fishbourne Roman Palace, Chichester
West Sussex-UK</td><td rowspan="5">
Before Modification [10]

After Modification [2]</td></tr>
<tr><td>Characteristics of the Site
The palace was comprised of four large wings with colonnaded façades that surrounded a square formal garden [1].</td></tr>
<tr><td>Identification of Remains
The palace included as many as 50 mosaic floors, under-floor central heating and an integral bathhouse [1].</td></tr>
<tr><td>Period
1st century AD [1].</td></tr>
<tr><td>Excavation and Preservation Work
The excavation studies started in 1961 by Barry Cunliffe. North wing of the Palace are enclosed within a cover building for their protection [3]. There are 25 mosaic pavements presented under the structure [4]. Nine mosaics were lifted and re-laid in cement mortar and four mosaics were re-laid in lime mortar [4].</td></tr>
<tr><td rowspan="8">Protective Structure</td><td>Type
Enclosure
Built above remains</td><td>Architect / Contractor
W. Emil Godfrey [3].</td></tr>
<tr><td>Construction Date
1965 - 1968 [3].</td><td>Size
1800 m^2 [7].</td></tr>
<tr><td colspan="2">Aim
Protect and display the mosaics.</td></tr>
<tr><td colspan="2">Design Principles
-</td></tr>
<tr><td colspan="2">Structural System and Material
Structure: Wood trust construction [7] and timber.
Façade: Glass (entire south elevation) [4, 5] and aluminum [4].
Foundations: Restored subterranean foundations [6].</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
Electrical fans were installed and windows were kept open to assist ventilation for visitor comfort [4].</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
Mosaic condition survey based on observation [4, 11].</td></tr>
<tr><td colspan="2">Conservation Problems and Possible Causes
High solar gain from the glazed south elevation [4].
High water table with aggressive soluble salts [4].
Rising damp and biological growth due to ground water [6].
High international temperatures, with mechanical ventilation and fluctuating relative humidity, have probably encouraged evaporation of groundwater and the mobilization of salts [4].</td></tr>
</table>

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Table 3.9. (cont)

	Modification of Protective Structure to Mitigate Problems The structure is modified to create more stable environmental conditions. Roof insulation was installed, window area was reduced [50 %], double glazing with solar reflective glass, ventilation is improved [4]. All inside the protecting building was totally refurbished in 2005-6 [9].
Ambient Climate of the Site Fishbourne is located in the Maritime Temperate / Oceanic Climate region according to Köppen climate classification (Cfb - warm, but not hot summers and cool, but not cold winters with a narrow annual temperature range. Precipitation is evenly dispersed through the year) [8].	
References 1- Wikipedia. 2012a. 2- Wikimedia. 2011. 3- Margary, Ivan D. 1971. 4- Stewart, John. 2008. 5- Woolfitt, Catherine. 2007. 6- Aslan, Zaki. 1997. 7- Schmidt, Hartwig. 1988. 8- Wikipedia. 2012b. 9- Sussexpast. 2011. 10- Getty. 2013. 11- Rudkin, David. 2003.	

Chedworth Roman Villa at Gloucestershire (UK) consists of remains of a luxuries villa with mosaic pavements (Table 3. 10). Damage is caused by fluctuating relative humidity as repeated cycles of crystallization and hydration in addition the enclosure cannot adequately prevent freeze/thaw action (Figure 3. 17). Although the protective structure was modified before, it did not fulfill the conservation needs therefore a new one was constructed. (National Trust 2009a, National Trust 2009b).

Figure 3. 17. Mosaics at the Chedworth Roman Villa at Gloucestershire (UK). (Source: http://www.getty.edu/conservation/publications_resources/newsletters/21_1/newsletter2.html)

Table 3. 10. Identification card of Chedworth Roman Villa at Gloucestershire (UK).

Archaeological Remains	**Archaeological Site** Chedworth Roman Villa Gloucestershire, United Kingdom	 Earlier enclosure [3]
	Characteristics of the Site Luxurious fourth-century house which comprised the substantial remains of a large country house [2].	
	Identification of Remains The remains are consisted of 2 kilometers of walls, two bathhouses, several hypocaust systems, triclinium (dining room) and a water shrine with a running spring [1]. Many features of the villa including thirteen mosaic pavements have survived *in situ* [1].	 New enclosure [6]
	Period It was first occupied in the 2nd century AD and reached its maximum extent in the 4th century [2].	
	Excavation and Preservation Work The villa was excavated in 1864 [1, 2]. Three enclosures were built on some mosaics, other fragments were covered in earth and allowed to grass over [1].	
Protective Structure	**Type** Enclosure Built on remains	**Architect / Contractor** -
	Construction Date Two enclosures were built over triclinium and bath-house in 1867 [4, 3]. A shelter was built over the baths of dry heat and the last enclosure was built in 1959 [3].	**Size** -
	Aim Creating a strong and durable structure to protect the mosaics [1].	
	Design Principles The protective structures have the appearance of contemporary agricultural buildings [1].	
	Structural System and Material - Structure: Timber frame structure on low stone walls [1]. - Roof: Stone tile roof [3]. - Façade: Timber cladding with windows [3]. - Foundations: Original masonry walls were consolidated [1].	
	Design Characteristics for Climate Control Wood-burning stoves were built to prevent frost [1]. The protective structures have been repaired and modified over the years [3]. In 1960s, electric heating system, controlled thermostatically, replaced the wood-burning stoves (to eliminate dew point events and freezing episodes on the mosaic surfaces) [1]. Rigid insulation has been added to the internal walls [3].	
	Monitoring Internal / External Environment The environmental conditions within the buildings have been monitored extensively over the last twenty years [3, 7]. Wireless environmental monitoring since 1997 (surface temperature, ambient temperature, relative humidity, fabric moisture content were measured) [1, 5].	

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Table 3.10. (cont)

	Conservation Problems and Possible Causes Three enclosures do not adequately protect the remains against freeze/thaw action, which affects the stability of the mosaic floors [2, 3]. Condensation occurs in all enclosures and is particularly damaging in combination with freezing temperatures [2, 3]. Damage is caused by fluctuating moisture levels and relative humidity as repeated cycles of crystallization and hydration [2, 3]. Algae and salt efflorescence are common in both enclosures [4]. Solar radiation increases surface temperature and leads to efflorescence [2, 3]. Low relative humidity leads to the deposition of salts from ground water on archaeological surfaces. High relative humidity encourages microbiological growth [2, 3].
	Modification of Protective Structure to Mitigate Problems The protective structures do not fulfill the conservation needs of their contents. Since it was not feasible to adapt the existing protective structures (over triclinium and the bath house) a new protective structure was necessary [3]. In 2009, the Villa received Heritage Lottery funding to help conserve and protect the archaeology and artifacts by replacing the old Victorian shelters with a fabulous new climate controlled building which also provides a new accessible and flexible learning and interpretation space [9].
Ambient Climate of the Site Chedworth is located in the Maritime Temperate / Oceanic Climate region according to Köppen climate classification (Cfb - warm, but not hot summers and cool, but not cold winters with a narrow annual temperature range. Precipitation is evenly dispersed through the year) [8].	
References 1- Bethell, Philip. 2008. 2- National Trust 2009a. 3- National Trust 2009b. 4- Stewart, John. 2008. 5- Tringham, Sibylla, and John Stewart. 2008. 6- Wiltsglosstandart. 2013. 7- Thomas, C. 2000. 8- Wikipedia. 2012b. 9- National Trust 2013.	

Roman Town House at Dorchester (UK) is richly decorated with mosaics (Table 3. 11). Absence of gutters and thermal insulation resulted in dampness and algal growth in addition exposure to solar gain enhanced salt efflorescence (Stewart 2005) (Figure 3. 18). The shelter which provided unstable environment for protection of the mosaics was modified.

Figure 3. 18. The effects of water that drips down from the walls on to the mosaic floor at Roman Town House at Dorchester (UK). (Source: http://www.dorsetforyou.com/media.jsp?mediaid=168951&filetype=pdf)

Table 3. 11. Identification card of Roman Town House at Dorchester (UK).

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Dorchester Roman Town House
Dorset- UK</td><td rowspan="5">
Before modification [7]

After modification [4]</td></tr>
<tr><td>Characteristics of the Site
Roman Town House</td></tr>
<tr><td>Identification of Remains
‘L’ shaped block of 15 rooms richly adorned town house with many mosaics [2].</td></tr>
<tr><td>Period
The earliest part of the Town House dates from the first part of 4th century AD. The building was expanded and adorned with fine mosaics around AD 350 [4].</td></tr>
<tr><td>Excavation and Preservation Work
It was discovered in 1937 [4]. It was excavated in 1937-38 and subsequently reburied [1]. The excavations were carried out by Col. C. D. Drew and Mr. K. C. Collingwood Selby [2]. In 1990s the rest of the house was fully excavated and a shelter constructed over it [1].</td></tr>
<tr><td rowspan="7">Protective Structure</td><td>Type
Shelter
Built above remains</td><td>Architect / Contractor
John Stark and Crickmay Partnership [6].</td></tr>
<tr><td>Construction Date
The mosaic of Room 8 was presented under a wooden shed in 1957. Other mosaics were sheltered in 1996-99 subsequently after their excavation [1].</td><td>Size
-</td></tr>
<tr><td colspan="2">Aim
Protect and display the mosaics.</td></tr>
<tr><td colspan="2">Design Principles
- The shelters could be built to replicate antique Roman houses.</td></tr>
<tr><td colspan="2">Structural System and Material
Structure: Steel framed structure with open gables [1].
Roof: The gabled roof is covered with stone tiles which attempts to replicate the Roman design (therefore does not have gutters) [1, 3].
Façade: Fragmented glass panels below [1].
Foundations: the steel structure perched on the original foundations [3].</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
Open gables above the glass panels designed to create a high degree of ventilation [1].</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
The environmental parameters are to be monitored [1].</td></tr>
</table>

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Table 3.11. (cont)

	Conservation Problems and Possible Causes The open structure provides unstable environment, it offers negligible thermal insulation [1]. The roof that attempts to replicate the roman design does not have gutters therefore large quantity of rainwater directly goes to the perimeter of the building [1]. The mosaics are exposed to direct sun light [6]. In addition due to poor thermal insulation and drainage system mosaics show variable degrees of dampness, algal growth [6] and salt efflorescence [1]. Six mosaics on their original bedding show variable degrees of dampness, algal growth and salt efflorescence. One mosaic which is the most shaded also been colonized by moss [1].
	Modification of Protective Structure to Mitigate Problems Enclosing the gables, adding gutters and improving site drainage were decided to provide more stable environment [1].
Ambient Climate of the Site Dorchester is located in the Maritime Temperate / Oceanic Climate region according to Köppen climate classification (Cfb - warm, but not hot summers and cool, but not cold winters with a narrow annual temperature range. Precipitation is evenly dispersed through the year) [5].	
References 1- Stewart, John. 2005. 2- Corney, Mark, and Peter W. Cox. 2007. 3- Wikipedia. 2013b. 4- Dorchester Dorset. 2013. 5- Wikipedia. 2012b. 6- Edwards, C., M. Corfield, B. Knight, J. M. Teutonico, and J. Adams. 2003 7- Edwards, Carol. 2003.	

Roman Villa at Piazza Armerina (Sicily, Italy) houses wall paintings and mosaic floor of superlative quality (Table 3. 12). The main threat was solar gain from the transparent and translucent roof and façade materials caused heat built up in the enclosure (Figure 3. 19). In addition variation of temperature and relative humidity brings about continuous exchange of water vapor between the ancient structures and the environment (Laurenti et. al 2006). In order to provide better protection of the mosaics the protective structure removed and a new one was constructed.

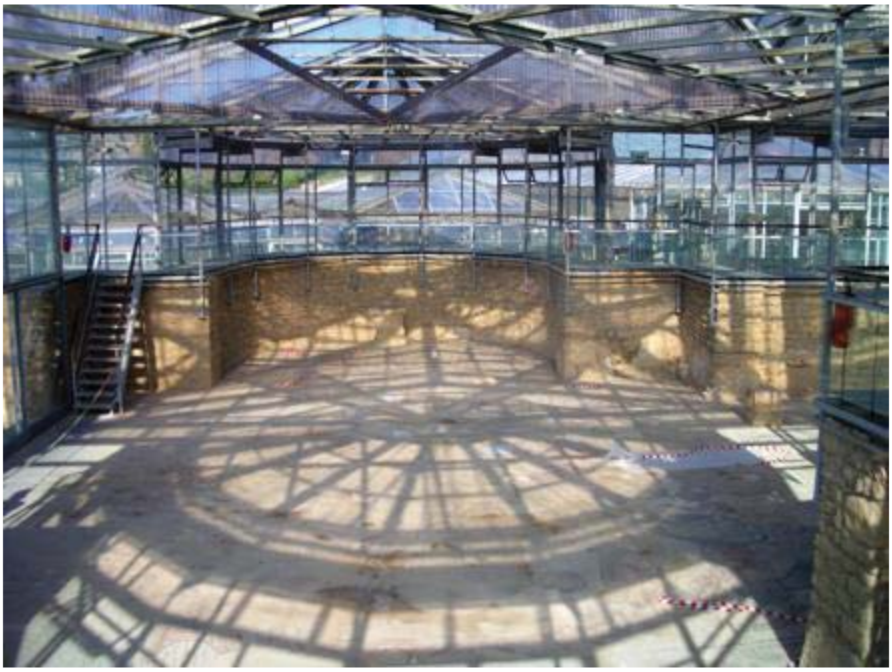


Figure 3. 19. The shading elements fail to prevent direct solar gain and heat built up in the Roman Villa at Piazza Armerina (Sicily, Italy). (Source: http://www.studiogionatarizzi.com/progetto/galleria/30/#18)

Table 3. 12. Identification card of Roman Villa at Piazza Armerina (Italy).

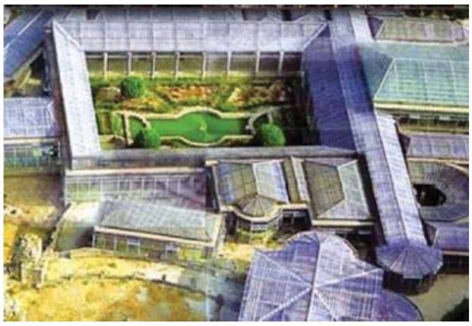
<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Roman Villa (Villa del Casele)
Piazza Armerina, Sicily</td><td rowspan="5">
Interior View [4]

Exterior View [4]</td></tr>
<tr><td>Characteristics of the Site
The building is designed in tradition of Roman Villa, but it merits title of palace due to scale and level of luxury with no parallels in the Roman Empire. It covers about $4000m^2$; all rooms are decorated with floor mosaics and wall paintings. It is one of UNESCO World Heritage Sites in Italy [2].</td></tr>
<tr><td>Identification of Remains
The Roman villa houses 3500 m^2 mosaic floors [1, 3]. Although the condition of mosaics were almost perfect, the walls were a mass of remains varying in height from 0.45 m. to 2 m. [8]. Most of the rooms had either marble facings or painted frescos on their walls [3].</td></tr>
<tr><td>Period
Most of the remains visible today dates from 300- 330 AD [1, 3, 9].</td></tr>
<tr><td>Excavation and Preservation Work
The first excavations on the site were carried out in1881, but the major part of the Villa was uncovered between 1940 and 1950’s by Cultrera and Gentili [1, 3]. Cultrera had Pierro Gazzola design and erect a roof over the three apsed halls in 1942 [3, 10]. Most sections were lifted, set on new cement bases, and fixed to the floor with numerous iron pins [3, 11].</td></tr>
<tr><td rowspan="4">Protective Structure</td><td>Type
Enclosure
Built on remains</td><td>Architect / Contractor
Translucent enclosure was designed by Minissi and Brandi (advisor) [1, 3]. Gionata Rizi is consultant for the design of the new protective structure [13].</td></tr>
<tr><td>Construction Date
1957-60 [7].</td><td>Size
The Villa is about 6385 m^2 and 3534 m^2 is protected under the structure [17].</td></tr>
<tr><td colspan="2">Aim
Protect and display of the mosaics [1, 3].</td></tr>
<tr><td colspan="2">Design Principles
Protection: Protect mosaics completely from inclemencies of the weather [6].
Construction: To add to the original structures only construction forms and materials that are obviously new and provide integrity of original masonry construction [6].
Maintenance: Roof material is resistant to possible strain [6].
Visual impact: Avoid from reconstruction and develop a new method for protection, “to form a new” without imitating the original [6, 1].
Display: Provide maximum light for best viewing and prevent visitors walking on the mosaics while viewing [13].</td></tr>
</table>

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Table 3.12. (cont)

	Structural System and Material Structure: Lightweight steel skeleton [6, 1]. Roof: Translucent plastic panels, slightly clouded Perspex laminate [6]. Façade: Sheets of plate glass and partially corrugated sheeting (slats of the Venetian blind) [6]. Foundations: the structure rests on the existing walls.
	Design Characteristics for Climate Control Level ceilings were installed under the translucent roof to reduce heat transformation. Natural ventilation was provided through windows and louvers between the framing and wall [5].
	Monitoring Internal / External Environment Mosaic condition survey and measurement of microclimate within and outside (temperature, relative humidity, wind speed and direction) [16, 18]. The microclimatic survey pointed out the protective structure creates an environment that cannot be defined “adequate” for preservation [17].
	Conservation Problems and Possible Causes Solar gain from the transparent and translucent material of the outer shell caused greenhouse effect [13, 3, and 17]. Extremes in thermal condition (in summer temperature is $6\text{-}7^{0}$ C higher than outside and relative humidity is about 10 %,) caused powdering of the material and placement of preparatory layers [17]. Salt efflorescence on plaster and masonry due to the variation of temperature and relative humidity between day and night caused continuous exchange of water vapor between the ancient structures and the environment. Percolation through cracks in the roof, seepage through the walls due to poor functioning of gutters (some gutters are occluded and downspouts drain water directly on the ground too close to the walls) cause efflorescences, degradation of the surfaces (detachment of the preparatory layers in plasters, lifting of the paint film and development of flora and micro flora)
	Modification of Protective Structure to Mitigate Problems Due to the adverse climates created by protective enclosures, removal of them came into question [3, 12, and 13]. A new protective structure which was composed of opaque envelope with ventilated roof was designed to control micro-climatic parameters [13].
Ambient Climate of the Site Piazza Armerina is located in the Mediterranean Climate region according to Köppen climate classification (Csa - hot and dry summers, cool and wet winters) [15]. Due to its location the site is coastal, oceanic and Mediterranean climate [14].	

References

1- Stanley-Price, Nicholas, and Jukka Jokilehto. 2001.
2- World Heritage Convention. 2013a.
3- Stanley-Price, Nicholas. 1997.
4- Unipa. 2008a.
5- Aslan, Zaki. 1997.
6- Minissi, Franco. 1961.
7- Woolfitt, Catherine. 2007.
9- Ampolo C., A. Carandini, G. Pucci, and P. Pensabene 1971.
10- Cultrera, Giovanni. 1936.
11- Bernabo Brea, L. 1947.
12- Scognamiglio, M. 1992.
13- Gionata Rizzi.2008.
14- Altieri, Antonella, Marco Bartolini, Elisabetta Giani, Annamaria Giovagnoli, Maria Pia Nugari, and Sandra Ricci. 2006.
15- Wikipedia. 2013a.
16- Laurenti Maria. C. 2001.
17- Maria Concetta Laurenti, Antonella Altieri, Carlo Cacace, Elisabetta Giani, Annamaria Giovagnoli, Maria Pia Nugari, and Sandra Ricci. 2006.
18- Marco Citterio, and Elisabetta Giani. 2006b.

Fortification Walls of Capo Soprano at Gela (Sicily, Italy) is the remains of mudbrick fortification wall (Table 3. 13). The shelter and the panels failed to stop wind driven rain resulted in fractures. In addition glass panels mounted on the walls caused high temperatures and humidity in the space between the glass panels and wall surface. It created an ideal microclimate for vegetation and colonization by snakes, bats and insects (Stanley- Price and Jokiletho 2001) (Figure 3. 20). Hence, the shelter and the panels were removed and a new shelter was constructed.

Figure 3. 20. Transparent sheets that were mounted on the façade to prevent rain, caused an ideal microclimate for plants and animals. (Source: http://www.unipa.it/monumentodocumento/villadelcasale/lastre_vetro.html

Table 3. 13. Identification card of Fortification Walls of Capo Soprano at Gela (Italy).

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Capo Soprano, Gela,
Sicily, Italy</td><td rowspan="5">
Earlier Protective Structure [6]

New Protective Structure [3]</td></tr>
<tr><td>Characteristics of the Site
The Greek fortification walls which used to encircle the entire ridge top were 4 km in length and constructed of stone until 3.5 m. in height, which capped by an additional 2 m. high section of mudbrick walling [1, 5].</td></tr>
<tr><td>Identification of Remains
Remains of the fortification wall are 360 m. length with the average height of 3.40 m and a thickness of 2.70-2.80 m [1].
Lower parts of the wall has an ashlar surface in calcareous tuff stone with a rubble core, upper parts are built of unfired mudbrick [1].</td></tr>
<tr><td>Period
4th century BC [5].</td></tr>
<tr><td>Excavation and Preservation Work
The excavations between 1948 and 1954 revealed the fortifications [1]. A temporary protective shelter was built over the excavated parts in 1951 and a temporary shelter was built. Afterwards a shelter was built in 1954 [1] and glass panels attached on the wall. The glass panels have been removed since 1994.</td></tr>
<tr><td rowspan="6">Protective Structure</td><td>Type
Shelter
Built above remains</td><td>Architect / Contractor
Earlier shelter: Franco Minisi [1, 7].
Prof. Federico Motta [3].</td></tr>
<tr><td>Construction Date
1952 -1954 (Earlier Shelter) [2].</td><td>Size
Length: 160 m. [7].</td></tr>
<tr><td colspan="2">Aim
Covering for maintaining the actual microclimate near the walls [4].</td></tr>
<tr><td colspan="2">Design Principles
Protection: To protect the wall with a shelter and to consolidate and enclose the fragile mudbrick structure [1].
Visual impact: Provide enclosure effect by fixing transparent panels on the surface of the wall [1].</td></tr>
<tr><td colspan="2">Structure and Material
Structure: 10 m. high light metal poles fixed to ground with steel cables supported the roof [1]. Poles were fixed only on the side of the wall; the other side of the field was column-free [7].
Roof: Translucent corrugated sheets [1]. The plastic sheets were strongly colored in the meantime [7].
Façade: The mudbrick wall was enclosed between glass panels with the dimensions of 1m x 1m and 10-11 mm thick. The panels were fixed flush to provide the enclosure effect (They were attached using aluminum bars 20mm. in diameter and placed at intervals of 500 mm.) [1].</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
-</td></tr>
</table>

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Table 3.13. (cont)

	Monitoring Internal /External Environment No regular monitoring has been conducted, but systematic condition assessment has been made [1].
	Conservation Problems and Possible Causes Large fractures due to mechanical stress corresponding to the aluminum ties of the glass panels were observed; other fractures were due to driving rain which had entered through open joints in the panels against the wall [1]. Glass panels caused high temperatures and high humidity in the space between the glass panels and wall surface resulted in ideal microclimate for vegetation and colonization by animals (snakes, bats and insects) [1]. The shelter and the panels failed to stop wind driven rain resulted in fractures [1]. The metal cables of roof had corroded due to exposure to the marine environment and wind, finally the protective structure was partially collapsed in 1980 [1].
	Modification of Protective Structure to Mitigate Problem The shelter was removed and a new shelter which offers the actual micro-climate near the walls as well as durability to corrosion, security, reversibility, weather-protection, fire resistance, U.V. resistance and easy maintenance [4].
Ambient Climate of the Site Gela is located in the Mediterranean Climate region according to Köppen climate classification (Csa - hot and dry summers, cool and wet winters) [8].	
References 1- Stanley-Price, Nicholas, and Jukka Jokilehto. 2001. 2- Unipa. 2008a. 3- Tensinet. 2009. Recent projects 4- Canobbio. 2013. 5- Perseus Digital Library. 2013. 6- Unipa. 2008b. 7- Schmidt, Hartwig. 1988.. 8- Wikipedia. 2013a.	

St. Stephen Complex at Um er-Rasas (Jordan) consists of four churches. Floors of two churches are decorated with high quality mosaic floor (Table 3. 14). The enclosure built to protect the remains was failed to mitigate water and air infiltration. Rising damp, accumulation of salts and biological deterioration were observed on the mosaics (Ferroni 2005). The protective structure was removed and a new protective structure was constructed to provide more stable environment for the protection of the mosaics (Figure 3. 21).

Figure 3. 21. Biolological deterioration that affects the mosaics at the St. Stephen Complex at Um er-Rasas (Jordan). (Source: http://whc.unesco.org/ archive/ 2005/mis1093-2005.pdf)

Table 3. 14. Identification card of St. Stephen Complex at Um er-Rasas (Jordan).

Archaeological Remains	**Archaeological Site** St. Stephen Complex Um er-Rasas, Jordan	 Earlier Protective Structure [1]
	Characteristics of the Site The site has 16 churches, some with well-preserved mosaic floors [4]. It is one of UNESCO World Heritage Sites since 2004 [1].	
	Identification of Remains Church of St. Stephen Complex consists of four churches. The floors of the churches of St. Stephen and Bishop Sergius are decorated with high quality of mosaic floor [1].	
	Period The remains of the church are dated to 8th century (Byzantium period) [2].	 New Protective Structure [3]
	Excavation and Preservation Work The archaeological work began in 1986 [1, 2].	
Protective Structure	**Type** Enclosure Enclosure built above remains	**Architect / Contractor** -
	Construction Date 1987 [1].	**Size** -
	Aim -	
	Design Principles -	
	Structural System and Material Structure: Steel frame structure. The beams are a conventional lattice truss with iron corners [1]. Roof: Pitched roof supported by columns and lattice trusses covered with thin steel plates [1]. Façade: Sides are consisted of side panels and large glass openings [1].	
	Design Characteristics for Climate Control A new protective structure will be constructed to protect the mosaics from direct solar radiation and rain. It will be ventilated naturally by two rows of windows, using the cross flow of wind to provide air movement, thus dissipating the increased humidity and temperature [1].	
	Monitoring Internal / External Environment Topographical survey to find ways to resolve the water drainage problems [1]. Geophysical surveys (gravity, resistivity ad ground penetrating radar measurements. The resistivity survey showed north of the complex has higher moisture content [1].	
	Conservation Problems and Possible Causes Problems are caused by climatic conditions, seasonal storms that deposit dust on the mosaics and ventilation [1]. The protective structure does not mitigate water and air infiltration and poor air circulation, lighting and water drainage [1]. Biological deterioration phenomena over the mosaics of the apse of St. Sergius Bishop Church because of the lack of a rain-water drainage system (on west side, in particular, water becomes stagnant under the shelter) [6]. Accumulation of salts was observed in the north side of the Church of Bishop Sergius, where the external ground is about 0.9 meter above the mosaic, and water penetrates through the wall [1]. Accumulation of salts on the mosaic along the south side of the St. Stephen (these are might have suffered from evaporation and drawing up of salts through the ground) [1].	

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Table 3.14. (cont)

<table>
<tr><td></td><td>Modification of Protective Structure to Mitigate Problems
The existing protective structure will be removed and new structure based on modeling of the internal environment will be implemented [1]. The roof will be extended to the south to prevent direct solar radiation and it will be ventilated naturally using the cross flow of wind from the south and west will change the air inside the shelter to dissipate the increased humidity and temperature resulting from the presence of visitors [1]. A proper drainage system will be installed (rainwater will be collected from the roof and discharged through rainwater down pipes to ground level, into a piped system below ground). The shelter will be built using a lightweight material placed directly onto the ancient walls.</td></tr>
<tr><td colspan="2">Ambient Climate of the Site
Um er-Rasas is located in the Mediterranean Climate region according to the Köppen Classification [5]. The site is in an arid area. It is hot and dry in summer, which usually lasts for about six months. There is no rain for four months, which means low relative e humidity and a high evaporation index. There is regular rain in winter and high relative humidity and a lower evaporating index [1].</td></tr>
<tr><td colspan="2">References
1- Ha’obsh Mervat M., 2008.
2- Franciscan Archaeological Institute. 2001.
3- Panoramia. 2010.
4- World Heritage Convention. 2013b.
5- Wikipedia. 2013a.
6- Ferroni, Angela Maria. 2005.</td></tr>
</table>

Nile Festival Building at Zippori (Israel) was originally paved with colorful mosaics (Table 3. 15). The condition assessment survey pointed out the active deterioration of the mosaics. The main threat was due to lack of insulation in the roof construction caused condensation on the fiberboard and wetting the mosaics (Figure 3. 22). Dry and wet cycles accelerated the damage to the mosaics, resulting in salt crystallization, bulging, and black- colored microorganisms (Neguer and Alef 2005).

Figure 3. 22. The Centaur panel at the Nile Festival Building at Zippori (Israel) suffered from accumulation of condensed water in summer. (Source: http://members.virtualtourist.com/m/p/m/13083c)

Table 3. 15. Identification card of Nile Festival Building at Zippori (Israel).

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Nile Festival Building
Zippori (Sepphoris) - Israel</td><td rowspan="5">
Interior View [4]

Exterior View [1]</td></tr>
<tr><td>Characteristics of the Site
It was constructed in the early Byzantine period, above the remains of Roman buildings. The buildings' central location within the city layout, its artistic richness, its size and numerous rooms indicate that it was a public building, perhaps a municipal basilica [2].</td></tr>
<tr><td>Identification of Remains
The Nile Festival Building measure approximately 50 by 35 is consisted of more than 20 rooms and corridors which are planned around a basilica hall and a courtyard [1, 2]. The building was originally paved with colorful mosaics [1]. 12 mosaic floors have been discovered in various states of preservation [1].</td></tr>
<tr><td>Period
Early 5th century AD [1, 3].</td></tr>
<tr><td>Excavation and Preservation Work
The site was excavated in 1991 and insitu conservation was undertaken during 1994-95 and a permanent shelter was erected [1].</td></tr>
<tr><td rowspan="7">Protective Structure</td><td>Type
Shelter
Shelter built on the remains</td><td>Architect / Contractor
-</td></tr>
<tr><td>Construction Date
1995.</td><td>Size
670 m2 [1].</td></tr>
<tr><td colspan="2">Aim
-</td></tr>
<tr><td colspan="2">Design Principles
-</td></tr>
<tr><td colspan="2">Structural System and Material
Structure: The shelter combines metal and timber framing. The posts are steel covered with wood [1].
Roof: The roof is composed of a complex system of pitched roof in three levels that overlap [1]. Fiberboard covered with copper sheets [1].
Foundations: Posts set in concrete footings [1].</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
Open-sided shelter with no insulation [1].</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
Rapid condition assessment survey on mosaics [1].</td></tr>
</table>

(cont. on next page)

Table 3.15. (cont)

	Conservation Problems and Possible Causes Condensation of water on the fiberboard that then water drops down on the mosaic (A difference in thermal conductivity of the copper and the wood, in addition to lack of insulation in the roof construction cause condensation on the fiberboard) [1]. The water from condensation wets the mosaic. Dry and wet cycles accelerated the damage to the mosaics, resulting in salt crystallization bulging, and black- colored microorganisms [1].
	Modification of Protective Structure to Mitigate Problems Roof insulation is necessary. Fiberboard needs to be replaced [1].
Ambient Climate of the Site Zippori is located in the Mediterranean Climate region according to Köppen climate classification (Csa - hot and dry summers, cool and wet winters) [1, 5].	
References 1- Neguer, Jacques, and Yael Alef. 2008. 2- Netzer, Ehud, and Zeev Weiss. 1992. 3- Hebrew University. 2002. 4- Panoramio. 2011.“Israel. Zippori National Park. The Nile House” Last modified June 2011. http://www.panoramio.com/photo/54311186?source=wapi&referrer=kh.google.com 5- Wikipedia. 2013a.	

Great House Ruins at Arizona (USA) is the remains of a four story structure made of earthen material (Table 3. 16). Although being protected under a shelter, site surveys pointed out the walls are subjected to active deterioration. Wind driven rain and snow in addition to the wind load caused damage to the walls (Figure 3. 23). Basal loss, salt and frost attack and voids due to variety of animals are among the deterioration phenomena at the Great House Ruins (Matero 1999).

Figure 3. 23. Remains of the Hohokam architecture at Great House Ruins at Arizona (USA), exposure to solar radiation. (Source: http://ivonyoung.blogspot.com/2011_10_01_archive.html

Table 3. 16. Identification card of Great House Ruins at Arizona (USA).

<table>
<tr><td rowspan="5">Archaeological Remains</td><td>Archaeological Site
Great House Ruins
Arizona, USA</td><td rowspan="5">
Exterior View [2]

Close up View [5]</td></tr>
<tr><td>Characteristics of the Site
The Great House is probably the most complete and best protected example of Hohokam building techniques and architecture made from caliche (a concrete-like mixture of sand, clay, and limestone) [1, 3].</td></tr>
<tr><td>Identification of Remains
The base of the structure is approximately 18m long by 12 wide and close to one meter thick [1].</td></tr>
<tr><td>Period
Great House was constructed by the Native American Hohokam between 1200AD and 1450 AD [2].</td></tr>
<tr><td>Excavation and Preservation Work
The first documentation an stabilization was performed by Cosmos Mindeleff in 1891 and continued by Jesse Walter Fewkes during his excavations in 1906 [1]. A protective shelter was built in 1903 until the new shelter was erected in 1932 [2].</td></tr>
<tr><td rowspan="7">Protective Structure</td><td>Type
Shelter
Built above remains</td><td>Architect / Contractor
Frederick Law Olmsted Jr [2].</td></tr>
<tr><td>Construction Date
December 1932.</td><td>Size
216 m^2 [1].</td></tr>
<tr><td colspan="2">Aim
Protect and allow the remains to have hierarchical presence [2].</td></tr>
<tr><td colspan="2">Design Principles
Visual impact: The structure was painted sage green to harmonize with the mountains and vegetation as well as provide contrast to the remains [2, 3].</td></tr>
<tr><td colspan="2">Structural System and Material
- Structure: The roof was supported with angled columns [3].
- Roof: The steel canopy hip roof structure incorporated glass skylights [3].</td></tr>
<tr><td colspan="2">Design Characteristics for Climate Control
-</td></tr>
<tr><td colspan="2">Monitoring Internal / External Environment
Electronic monitoring system to measure crack movement in the Great House walls was installed in 1984 [3].</td></tr>
</table>

(cont. on next page)

Table 3.16. (cont)

	Conservation Problems and Possible Causes Wind driven rain and occasionally snow reached the exterior and interior walls was evidenced by puddled water in the interior and the occasional wetting of walls after a heavy storm [3]. Basal loss in the interior walls are due to water, the agent for salt and frost attack resulting in the gradual flaking and disintegration of the wetted zone [3]. Variety of animals, birds, rodents, insects and arthropods resulted in enlargement of cracks (both structural and non-structural) and voids and associated staining [3]. Wind load have been cited as potential agents that could cause major damage to the current structural disposition of the Great House [3].
	Modification of Protective Structure to Mitigate Problems No modification but consolidation of friable surfaces was advised [3].
Ambient Climate of the Site Great House is located in the hot desert climate region (BWh - typically hot, periods of the year. During colder periods of the year, night-time temperatures can drop to freezing or below freezing) according to Köppen climate classification [4]. Annual rainfall is around 250 mm [5].	
References 1- National Park Service. 2013. 2- Earth Architecture. 2013. 3- Matero, Frank. 1999. 4- Wikipedia. 2013c. 5- Wikipedia. 2013d.	

3.2. Identification of the Studied Protective Structures

The general characteristics of the site and the protective structures of the case study examples are introduced as site characteristics, remain type, history of the protective structure, typology of the protective structure (Table 3. 17).

Site characteristics aim to describe the cases with their general characteristics with the elements climate, location, topography and proximity to the sea. They together create the environmental conditions of the sites.

Climate is one of the main components of the site that identifies the atmospheric conditions of an area. The environmental factors such as temperature, humidity, wind, precipitation, solar radiation are important in the context of understanding the new environment created by the protective structures. In this study the studied case examples are extended worldwide to a certain degree, so that Köppen Climate Classification System has been used to define the weather conditions of the selected sites. They are located in four climate regions, namely cold semi-arid climates (BSK climate region), hot desert climate (BWH climate region), hot-summer Mediterranean climate (CSA climate region) and temperate oceanic (CFB climate region).

Of the sites, Neolithic Houses at Çatalhöyük -south and north enclosure- (Turkey) and Alaeddin Kiosk in Konya (Turkey) are located at BSK climate region, Great House at Arizona (USA) is located at BWH climate region, Terrace House 2 at Ephesus (Turkey), Building Z at Pergamon (Turkey), Villas Dionysos and Danae at Zeugma (Turkey), Archaic and late Roman remains at Sardis (Turkey) and Citadel Wall and the Megaron at Troy, Roman Villa at Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Nile Festival Building at Zippori (Israel) are located in CSA Climate region and Fishbourne Roman Palace at West Sussex (UK), Chedworth Roman Villa at Gloucestershire (UK), Roman Town House at Dorchester (UK) are located in CFB climate region.

Location is the area or environment in which the selected site is found. Location of the site is important for understanding the natural environment of the site. The cultural heritage located in the urban area may be affected more by atmospheric

Table 3.17. Identification of the selected protective structures.

	SELECTED SITES	Site Characteristics					History of Protective Structure					Typology of Protective Structure				Remain Type		
		Climate region	Urban area	Rural area	Marine	Topography	Excavation date	Construction date of temporary / earlier	Construction date of the studied protective	Modificaiton of the protective structure	Replacement of a new protective structure	Shelter	Enclosure	Built on remains	Built above remains	Mosaics	Wall paintings	Earthen structures
First Group	Neolithic Houses (South) Çatalhöyük, Turkey	Bsk			far	hillside	1996 1998	-	2003	-	-	-		-		-		
	Neolithic Houses (North) Çatalhöyük, Turkey	Bsk			far	hilltop	2003 still	-	2008	-	-	-		-		-		
	Alaeddin Kiosk Konya, Turkey	Bsk			far	hillside	1941	-	1961	-	-		-	-		-	-	
	Terrace House 2 Ephesos, Turkey	Csa			close 5km	hillside	1960	1969 1986	1999	-	-	-		-				-
	Z Building Pergamon, Turkey	Csa			far	hillside	1990	-	2004	2008	-	-			-			-
	Archaic and late Roman remains Sardis, Turkey	Csa			far	flat land	1997	-	1998	-	-		-		-			
	Citadel Wall and the Megaron Troy, Turkey	Csa			close	hilltop	1999	-	2003	-	-		-	-		-	-	
	Villas Dionysos and Danae Zeugma, Turkey	Csa			close 50m	hillside	1998	-	2010	-	-	-		-				-
Second Group	Fishbourne Roman Palace West Susex , UK	Cfb			close 9km	flat land	1960	-	1968	2005 2006	-	-		-			-	-
	Roman Villa Piazza Armerina, Italy	Csa			medium	flat land	1940 1950	1942	1960	-	2007 still	-			-			-
	Fortification Walls of Capo Soprano Gela, Italy	Csa			close	flat land	1948 1954	1951	1954	-	2008		-	-		-	-	
	St Stephen Complex Um er-Rasas, Jordan	Csa			far	flat land	1986	-	1987	-	2008	-		-			-	-
	Roman Town House Dorchester, UK	Cfb			close 8km	flat land	1937 1996	1957	1999	2003 2007	-		-		-		-	-
	Nile Festival Building Zippori, Israel	Csa			medium 23	flat land	1991	-	1995	-	-		-		-		-	-
	Great House Arizona, USA	Bwh			far	flat land	1906	1903	1932	-	-		-	-		-	-	
	Chedworth Roman Villa Gloucestershire, UK	Cfb			medium 50	slope land	1864	-	1867	-	2009	-			-		-	-

pollutants than in the rural area. On the other hand, the sites located close to the sea with high relative humidity and marine aerosols are rich in sea salt particles.

Most of the studied cases are located in rural area, whereas only Alaeddin Kiosk in Konya (Turkey), Fishbourne Roman Palace at West Sussex (UK), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Great House Ruins at Arizona (USA) and Roman Town House at Dorchester (UK) are located in the urban area. Terrace House 2 at Ephesus (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Villas Dionysos and Danae at Zeugma (Turkey), Fishbourne Roman Palace at West Sussex (UK), Fortification Walls of Capo Soprano at Gela (Sicily, Italy) and Roman Town House at Dorchester (UK) are located close to the sea.

Topography of an area is used to define the surface shapes such as vertical elevation changes in a landscape in this study. Local topography effects the way rainwater moves on the ground. When the amount of the rainwater is more than the ground can absorb, the remaining rainwater flows on the ground and becomes runoff. The amount of such runoff increases with hard rainfall on inclined ground, when the water absorbing speed of the ground is slow (Bahtiyar 1978). On inclined terrain, the runoff becomes an important concern; because flowing from the slopes, it forms water puddles on parts of the ground, where the slope of the terrain relatively decreases or becomes flat.

According to topography, positions of the case study sites are varied as flat land, hillside and hilltop. Eight of the sites are located at flat land Lydian and Roman remains at Sardis (Turkey), Roman Villa Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Nile Festival Building at Zippori (Israel), Fishbourne Roman Palace at West Sussex (UK), Roman Town House at Dorchester (UK), Great House at Arizona (USA)), six of the site are located on hillside (Neolithic Houses at Çatalhöyük -south enclosure- (Turkey), Alaeddin Kiosk in Konya (Turkey), Terrace House 2 at Ephesus (Turkey), Z Building at Pergamon (Turkey), Danae and Dionysos Houses Zeugma (Turkey), Chedworth Roman Villa at Gloucestershire (UK)), two of the sites are located near the hill top (Neolithic Houses at Çatalhöyük -north enclosure- (Turkey), Citadel Wall and the Megaron at Troy (Turkey)).

History of protective structure includes a chronology of important dates starting from excavation of the remains and early sheltering practices to construction of selected cases and if examined the protective structure was modified or replaced with a new one.

Among the selected cases the earliest excavations were conducted at Chedworth Roman Villa at Gloucestershire (UK) in 1864, then Great House at Arizona (USA) in 1906. Roman Town House at Dorchester (UK), Roman Villa Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Alaeddin Kiosk in Konya (Turkey), Terrace House 2 at Ephesus (Turkey) and Fishbourne Roman Palace at West Sussex (UK) were executed between 1935 and 1960. St. Stephen Complex at Um er-Rasas (Jordan), Nile Festival Building at Zippori (Israel), Danae and Dionysos Houses Zeugma (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Lydian and Roman remains at Sardis (Turkey), Z Building at Pergamon (Turkey), Neolithic Houses at Çatalhöyük (Turkey) south were excavated in the 1985's then 2000. Neolithic Houses at Çatalhöyük (Turkey) north excavations have restarted in recent years, and still continue.

Many attempts have been made to preserve the unearthed structures. Excavations have been followed by conservation of the remains and site preservation studies. Three of the sites were protected by temporary protective structures during the excavation studies (Roman Town House at Dorchester (UK), Fortification Walls of Capo Soprano at Gela (Sicily, Italy)) or even before the excavation studies started as in the Great House at Arizona (USA) case. In the cases of Roman Villa Piazza Armerina (Sicily, Italy) and Terrace House 2 at Ephesus (Turkey) permanent protective structures were designed and constructed. However, they turned out to be inadequate and replaced with the new ones that have been studied in this research.

The studied protective structures were constructed between 19th century and 21st century. The earliest is the Chedworth Roman Villa at Gloucestershire (UK), which was built in 1867, is a significant example to 19th century protective structures. The Great House at Arizona (USA) built in 1932 follows, which is one of the earliest examples of the modern constructed protective structures as well. Most of the selected cases were constructed in the second half of the 20th century (Alaeddin Kiosk in Konya (Turkey), Fishbourne Roman Palace at West Sussex (UK), Roman Villa Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Terrace House 2 at Ephesus (Turkey), Lydian and Roman remains at Sardis (Turkey), St. Stephen Complex at Um er-Rasas (Jordan), Roman Town House at Dorchester (UK), Nile Festival Building at Zippori (Israel)). The last five examples were constructed in the early 21st

century (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Z Building at Pergamon (Turkey), Citadel Wall and the Megaron at Troy (Turkey) and Danae and Dionysos Houses Zeugma (Turkey)).

After the construction, unexpected consequences, especially related with the conservation issues have been observed at some sites. The issues about providing stable environment for the conservation of the remains under protective structures have been emerging nearly since 1990s. This subject increased the condition assessment of the protected remains, which resulted in reconsidering the design of some protective structures in the next decade, as the studied cases have illustrated. Among the studied cases design of Fishbourne Roman Palace at West Sussex (UK) and Roman Town House at Dorchester (UK) protective structures were changed to mitigate the deterioration of the mosaics and only a small scale building section of the Z Building at Pergamon (Turkey) was modified as well. In addition Roman Villa Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan) and Chedworth Roman Villa at Gloucestershire (UK) have been replaced with the new protective structures.

Typology of protective structure defines whether it is a shelter or an enclosure. Seven of the selected cases are shelter (Alaeddin Kiosk in Konya (Turkey), Lydian and Roman remains at Sardis (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Roman Town House at Dorchester (UK), Nile Festival Building at Zippori (Israel), Great House at Arizona (USA)) and nine of them are enclosure (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Terrace House 2 at Ephesus (Turkey), Z Building at Pergamon (Turkey), Danae and Dionysos Houses Zeugma (Turkey), Fishbourne Roman Palace at West Sussex (UK), Roman Villa Piazza Armerina (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Chedworth Roman Villa at Gloucestershire (UK)). In addition it defines how the structure relates with the remains interms of the foundations in touch with the site as stated under the heading 2.1.2. The Z Building at Pergamon (Turkey), Lydian and Roman remains at Sardis (Turkey), Roman Villa Piazza Armerina (Sicily, Italy), Roman Town House at Dorchester (UK), Nile Festival Building at Zippori (Israel), Chedworth Roman Villa at Gloucestershire (UK) rests on the walls of the remains without having separate foundations. Neolithic Houses at Çatalhöyük -south and north enclosure- (Turkey), Alaeddin Kiosk in Konya (Turkey), Terrace House 2 at Ephesus (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Danae and Dionysos Houses Zeugma (Turkey), Fishbourne Roman Palace at West Sussex (UK), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Great House at Arizona (USA) have their own foundations so as not to disturb the excavated remains.

Remain type refers to the fragile materials that the protective structures were built to protect. This research has been limited to the archaeological sites that are decorated with mosaics and wall paintings and earthen structures.

The Lydian and Roman remains at Sardis (Turkey) cover three of the types due to overlapping of the Roman house and archaic fortification wall. Six of the protective structures cover two types of remains. Roman housing units and shrines are decorated with mosaics as well as wall paintings (Terrace House 2 at Ephesus (Turkey), Z Building at Pergamon (Turkey), Danae and Dionysos Houses Zeugma (Turkey), Roman Villa Piazza Armerina (Sicily, Italy)). In addition five of the cases are decorated with mosaic floors (St. Stephen Complex at Um er-Rasas (Jordan), Roman Town House at Dorchester (UK)), Nile Festival Building at Zippori (Israel), Chedworth Roman Villa at Gloucestershire (UK), Fishbourne Roman Palace at West Sussex (UK)).

Six of the selected sites are constructed of earthen structures (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures and Alaeddin Kiosk in Konya (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Great House at Arizona (USA)). Among them Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures house wall paintings on plastered earthen walls as well.

3.3. Analysis of Architectural Design Characteristics of Protective Structures

Common architectural features are determined as structural system, roof system, roof material, façade system, façade material, thermal control system, drainage system and modifications to give detailed information about the selected protective structures (Table 3. 18).

Table 3.18. Analysis of architectural design characteristics of protective structures.

	SELECTED SITES	Structural System				Roof System			Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System			Modifications						
		Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Tiles	Concrete	Membrane	opaque (steel, copper plates, ..)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Roof Insulation	Facade Insulation	Natural ventilation	Heating	Mechanical ventilation	Roof drainage	Surface drainage	Site drainage	Installation of gutters / drainage system	Installation of roof insulation	Installation of shading	Installation of solar reflective glass	Minimize the window area	Minimize the louvers area	Construction of a new structure
First Group	Neolithic Houses (South) Çatalhöyük, Turkey			x			x	x					x			x						x				x		x		x								
First Group	Neolithic Houses (North) Çatalhöyük, Turkey				x		x	x					x			x						x				x		x										
First Group	Alaeddin Kiosk Konya, Turkey		x				x			x																x												
First Group	Terrace House 2 Ephesos, Turkey			x		x		x			x						x						x			x			x		x							
First Group	Z Building Pergamon, Turkey	x		x			x	x	x						x		x		x		x					x			x	x	x						x	
First Group	Archaic and late Roman remains Sardis, Turkey			x		x							x													x												
First Group	Citadel Wall and the Megaron Troy, Turkey			x			x				x															x				x								
First Group	Villas Dionysos and Danae Zeugma, Turkey			x		x		x										x		x						x			x	x	x							
Second Group	Fishbourne Roman Palace West Susex , UK				x		x					x			x								x					x	?	?	?	?	x	x	x	x		
Second Group	Roman Villa Piazza Armerina, Italy			x		x							x	x	x								x			x			x	x	?							x
Second Group	Fortification Walls of Capo Soprano Gela, Italy			x			x						x		x								x			x												x
Second Group	St Stephen Complex Um er-Rasas, Jordan			x			x					x			x						x		x			x												x
Second Group	Roman Town House Dorchester, UK			x		x			x																	x					x	x		x				
Second Group	Nile Festival Building Zippori, Israel			x		x						x														x			x	?	?		x					
Second Group	Great House Arizona, USA			x			x					x														x												
Second Group	Chedworth Roman Villa Gloucestershire, UK				x		x		x						x						x		x	x	x		x				x							x

Structural System of a protective structure is a building technique based on vertical structural members as well as the roof structure. Masonry, timber skeleton, reinforced concrete, and steel are the types of the construction systems among the cases. The majority such as Neolithic Houses at Çatalhöyük -south- (Turkey), Great House at Arizona (USA), Terrace House 2 at Ephesus (Turkey), Danae and Dionysos Houses Zeugma (Turkey), Roman Villa Piazza Armerina (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Nile Festival Building at Zippori (Israel), Citadel Wall and the Megaron at Troy (Turkey), Lydian and Roman remains at Sardis (Turkey), Roman Town House at Dorchester (UK), Z Building at Pergamon (Turkey) are steel construction. Only the last case is the combination of steel roof structure and masonry walls. Three of the cases, which are Neolithic Houses at Çatalhöyük -north- (Turkey), Fishbourne Roman Palace at West Sussex (UK) and Chedworth Roman Villa at Gloucestershire (UK) are constructed of timber skeleton system. Alaeddin Kiosk in Konya (Turkey) is the only example to use reinforced concrete protective structures in this study.

Roof system is used to define the form of the roof design, either it is consisted of a single piece or composition of single segments. Neolithic Houses at Çatalhöyük - south and north enclosures - (Turkey), Alaeddin Kiosk in Konya (Turkey), Great House at Arizona (USA), Z Building at Pergamon (Turkey), St. Stephen Complex at Um er-Rasas (Jordan), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Citadel Wall and the Megaron at Troy (Turkey), Fishbourne Roman Palace at West Sussex (UK), Chedworth Roman Villa at Gloucestershire (UK) can be listed as single piece roofs. Terrace House 2 at Ephesus (Turkey), Danae and Dionysos Houses Zeugma (Turkey), Nile Festival Building at Zippori (Israel), Lydian and Roman remains at Sardis (Turkey), Roman Town House at Dorchester (UK) have segmented roofs.

In the case of shelters, roof height and wideness is among considerable points of the roof system. Excessive roof height and limited shelter area may result in exposure to rain and solar radiation of the area underneath. Similarly, this may be the case in the existence of segmented roofs when single segments have wide open spaces between each segment. When it comes to enclosures, these voids are designed to enhance air flow with louvers. Louvers are helpful for the removal of hot air and increase of temperature. Neolithic Houses at Çatalhöyük - south and north enclosures - (Turkey), Terrace House 2 at Ephesus (Turkey), Z Building at Pergamon (Turkey) and Danae and Dionysos Houses Zeugma (Turkey) are sites with louvers on the roof.

Roof material is one of the important features that influence the thermal behavior of protective structures. Thermal properties of the building envelope have an effect on specifying the interior environment. Opacity or transparency of roofing materials may be a good example in terms of the effects of solar radiation. Types of roofing materials used to cover the case examples can be listed as tiles, concrete, membrane in addition to various types of roofing plates that can be grouped under opaque, translucent and transparent. All the cases lack roof insulation, but among them Z Building at Pergamon (Turkey), Chedworth Roman Villa at Gloucestershire (UK), Roman Town House at Dorchester (UK) have gabled roofs covered with tiles and Alaeddin Kiosk in Konya (Turkey) have concrete domed roof, which are relatively old and thick materials. On the other hand, Citadel Wall and the Megaron at Troy (Turkey) and Terrace House 2 at Ephesus (Turkey) have roof membranes that are considerably thinner and lighter than any other roofing materials. Roofing plates are the most common roofing materials for the protective structures. In this study plates are grouped under three sections to understand the effect on the inner microclimate. Great House at Arizona (USA), St. Stephen Complex at Um er-Rasas (Jordan), Nile Festival Building at Zippori (Israel) and Fishbourne Roman Palace at West Sussex (UK) have opaque plates such as steel or copper plates. Neolithic Houses at Çatalhöyük - south and north enclosures - (Turkey), Roman Villa Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Lydian and Roman remains at Sardis (Turkey) and Danae and Dionysos Houses Zeugma (Turkey) are constructed with translucent plates such as polycarbonate and fiberglass to provide good illumination. Although none of the selected cases have complete transparent roofs Roman Villa Piazza Armerina (Sicily, Italy) has particular sections with glass roof and Great House at Arizona (USA) has glass skylights.

Façade System means how the design provides the interrelation of the interior space with the exterior. The façade system is important in terms of providing stable climate, enhancing air flow, controlling excessive humidity and prevention from invasion of animals. They can be subgrouped as impermeable, adjusting sides in seasons, louvers and permeable considering the architectural design for providing air permeability. Roman Villa Piazza Armerina (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Fishbourne Roman Palace at West Sussex (UK), Chedworth Roman Villa at Gloucestershire (UK) can be listed as impermeable façades, as their façades are designed as an ordinary building with windows which control the air flow and increasing of humidity by opening the windows when needed. Çatalhöyük - south enclosure - (Turkey), was designed to be completely enclosed in winter. During the excavation period in summer façade panels are removed and it turns out to be an open shelter.

Another way is installation of louver systems for providing natural air flow as in the Z Building at Pergamon (Turkey) and Terrace House 2 at Ephesus (Turkey). However Z Building at Pergamon (Turkey) is partially, Terrace House 2 at Ephesus (Turkey) completely; have façades with louver systems, so that they can be listed under permeable façades as well. In fact, enclosures with permeable façades have little difference from the shelters from the point of obstructing invasion of uninvited animals. Danae and Dionysos Houses Zeugma (Turkey) have two layers of façades consisted of perforated aluminum mesh and PVC mesh textile is a good example to permeable façades which provide continuous air flow.

Façade Material and roof material are similar in terms of their influence on thermal mass of the protective structures. The façade materials used in the selected cases can be subgrouped as stone masonry, perforated sheets (such as aluminum mesh, PVC textile), in addition to opaque, translucent and transparent panels. Different from the roof, façades are mostly consisted of combination of two materials. For instance Z Building at Pergamon (Turkey) is the only case with stone masonry walls, however one façade is completely steel louver system and the other three are combination of stone masonry walls and approximately 1mt high steel louver panels resting on the wall up to the roof level. Danae and Dionysos Houses Zeugma (Turkey) illustrates double skin façades which are a combination of PVC textile inside and aluminum mesh outside.

Other materials consist of panels assembled on the façades, which can be subgrouped as opaque, translucent and transparent as in the roof materials. Opaque panels are steel plates (Z Building at Pergamon (Turkey) and St. Stephen Complex at Um er-Rasas (Jordan)) and timber cladding (Chedworth Roman Villa at Gloucestershire (UK)). To provide light inside, both St. Stephen Complex at Um er-Rasas (Jordan) and Chedworth Roman Villa at Gloucestershire (UK) have glass windows as well. On the other hand, Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures are enclosed with the same translucent panels on the roof and the façades. North shelter has translucent panels of single shell polycarbonate (45 % light transmittance) and South shelter has fiberglass (50 % light transmittance) on the façades as well as the roof for providing natural illumination. Terrace House 2 at Ephesus (Turkey), Roman Villa Piazza Armerina (Sicily, Italy) have transparent façades constructed of transparent plastic panels and at Fishbourne Roman Palace at West Sussex (UK), extreme use of glass windows can be observed on three façades of the protective structure while St. Stephen Complex at Um er-Rasas (Jordan) and Chedworth Roman Villa at Gloucestershire (UK) have limited glass windows.

Thermal Control System includes the design elements for providing stable microclimate for protecting the remains. Although thermal insulation is crucial for stability, none of the cases have insulated roof and façades. The thermal control systems used among the cases are enhancing natural ventilation, installation of mechanical ventilation and heating system.

The selected case shelters lack thermal control systems due to the lack of sides and insulated roof, naturally they expose to natural ventilation. On the contrary enclosures must be specially designed for enhancing natural ventilation, to prevent stagnant air. Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures have louvers at the roof ridge, Terrace House 2 at Ephesus (Turkey) and Z Building at Pergamon (Turkey) have façades with louver system, Danae and Dionysos Houses Zeugma (Turkey) has complete permeable façade system in addition Roman Villa Piazza Armerina (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Chedworth Roman Villa at Gloucestershire (UK) and Fishbourne Roman Palace at West Sussex (UK) have windows for providing natural ventilation. Since natural ventilation is not sufficient due to the increasing inner temperatures at Fishbourne Roman Palace at West Sussex (UK), mechanical ventilation system was installed. In cold climates, low temperatures can be a crucial problem, as well. Chedworth Roman Villa at Gloucestershire (UK) is an example of this issue. Initially wood-burning stoves were built to prevent frost, subsequently a heating system was added to eliminate dew point events and freeze thaw cycles.

Drainage System is an important element of a protective structure for providing basic moisture control in addition to prevent damage originating from the existence of ground moisture. In this study, drainage system refers to rainwater disposal systems such as roof drainage, surface drainage and site drainage. Rain gutter and downspouts are advantageous to collect the rainwater that falls on the roof and safely send it away from the protected area. In addition, surface drainage, type of a channel drain on the floor helps to reduce ponding of rainwater. Site drainage is an important element of archaeological site management and consists of underground channels which prevent water infiltration towards the subsoil and foundations. Among the studied cases only Building Z at Pergamon (Turkey) and Villas Dionysos and Danae at Zeugma (Turkey) have roof drainage, surface drainage and site drainage. Roman Villa at Piazza Armerina (Sicily, Italy) has roof drainage and surface drainage, Terrace House 2 at Ephesus (Turkey) has roof drainage and site drainage as well. In addition, Nile Festival Building at Zippori (Israel) has roof drainage, Neolithic Houses at Çatalhöyük -south enclosure- (Turkey) and Citadel Wall and the Megaron at Troy (Turkey) have surface drainage, Chedworth Roman Villa at Gloucestershire (UK) and Roman Town House at Dorchester (UK) have site drainage systems. Nevertheless, certain information about the presence of drainage system at Fishbourne Roman Palace at West Sussex (UK), surface and site drainage at Nile Festival Building at Zippori (Israel) and site drainage at Roman Villa at Piazza Armerina (Sicily, Italy) could not be found in the written sources.

Modifications to mitigate damage have been applied at the sites where the protective structures created adverse climates. Modifications can be named as small-scale and large-scale according to level of improvement. Small-scale modifications include alteration of architectural elements such as installation of drainage system, roof insulation, shading elements and solar reflective glass and minimize the window and louvers area on the existing building. At the Fishbourne Roman Palace at West Sussex (UK) gutters, roof insulation, shading elements and solar reflective glass have been installed and window area has been minimized; at Roman Town House at Dorchester (UK) drainage system has been improved and gutters and shading elements have been installed; at Chedworth Roman Villa at Gloucestershire (UK) roof insulation has been installed; at Building Z at Pergamon (Turkey) louvers area has been minimized. On the other hand, large-scale modifications include replacement of the studied protective structures with a new one as demonstrated in Roman Villa at Piazza Armerina (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Chedworth Roman Villa at Gloucestershire (UK).

3.4. Analysis and Evaluation of the Deterioration Factors of Remains under Protective Structures

Construction of a protective structure does not always provide long term protection of the remains they are built to preserve. Besides, some shelters and enclosures actually contribute to the deterioration process (Stewart 2008). The factors in the protected environment can be stated under three main groups as sources of water, instability of microclimate and activities of the living (Table 3. 19) Presence of water in any of its phases triggers decay of most building remains (Feilden 2001). A protective structure prevents direct rainfall on the archaeological remains; however it frequently fails to keep remains completely dry.

Sources of water in a sheltered or an enclosed site can be caused by either the site characteristics or design faults of the protective structure (Table 3. 20). One of the main important causes is *rain penetration*. In case of shelters; due to absence of sides or in the condition of limited roof area and excessive roof height causes the remains getting wet as at the Alaeddin Kiosk in Konya (Turkey), Lydian and Roman remains at Sardis (Turkey), Fortification Walls of Capo Soprano at Gela (Sicily, Italy) and Great House at Arizona (USA). In addition, infiltration of water from the leaks in the roof and guttering that allows the access of water into the protective structure as at the Alaeddin Kiosk in Konya (Turkey), Roman Villa Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy). Similarly the holes between the segments on the roof and presence of louvers on the façades can cause the rain water to enter the protective structure especially in rain storms as at the Terrace House 2 at Ephesus (Turkey), Building Z at Pergamon (Turkey) and Lydian and Roman remains at Sardis (Turkey).

Rising damp in walls and moisture drawn up from the sub-soil is another important source of water. Lack or faulty disposal of rain water is the most frequent cause of rising damp. In this study, causes of rising damp is specified as absence of roof

Table 3. 19. Assessment of deterioration factors under protective structures

		Sources of Water			Instability of Microclimate								Activities of the Living	
		Rain penetration	Rising damp	Condensation	Solar gain	Heat built up	Fluctuations of T and RH	Wetting and drying cycles	Crystallization of soluble salts	Freezing	Excessive ventilation	Inefficient ventilation	Vegetation	Animals
First Group	Neolithic Houses (South) Çatalhöyük, Turkey	-	A	C	-	A	A	A	A	C	C	-	D	C
	Neolithic Houses (North) Çatalhöyük, Turkey	-	A	C	E	A	A	A	A	C	A	-	D	C
	Alaeddin Kiosk Konya, Turkey	C	A	-	B	-	B	B	D	C	C	-	E	D
	Terrace House 2 Ephesus, Turkey	E	B	E	D	C	C	C	C	E	-	-	C	A
	Z Building Pergamon, Turkey	E	D	-	-	-	-	D	D	-	-	-	-	D
	Archaic and late Roman remains Sardis, Turkey	A	A	C	E	-	C	C	A	E	-	-	C	C
	Citadel Wall and the Megaron Troy, Turkey	-	C	C	B	-	A	C	-	E	A	-	-	C
	Villas Dionysos and Danae Zeugma, Turkey	-	-	E	-	C	C	C	-	E	C	-	E	E
Second Group	Fishbourne Roman Palace West Susex , UK	-	A	-	A	A	A	A	A	-	A	-	B	-
	Roman Villa Piazza Armerina, Italy	C	C	A	A	A	A	A	A	-	-	-	B	-
	Fortification Walls of Capo Soprano Gela, Italy	A	-	-	A	A	-	-	-	-	-	-	A	A
	St Stephen Complex Um er-Rasas, Jordan	-	A	-	-	-	-	A	A	-	-	B	B	-
	Roman Town House Dorchester, UK	-	B	-	A	-	C	C	C	-	-	-	B	-
	Nile Festival Building Zippori, Israel	-	-	C	-	-	-	C	C	-	-	-	B	-
	Great House Arizona, USA	C	C	-	B	-	-	C	C	C	A	-	-	A
	Chedworth Roman Villa Gloucestershire, UK	-	-	A	C	-	A	C	C	A	-	-	B	-

A: Factors causing "Very Severe" damage

B: Factors causing "Severe" damage

C: Factors causing "Moderate" damage

D: Factors causing "Slight" damage

E: Factors causing "Very Slight" damage

Table 3.20. Evaluation of the deterioration factors in relation to the design characteristics of protective structures.

Sources of Water

Group	Site	Rain penetration: Leaks in roof	Rain penetration: Limited roof area / excessive roof height	Rain penetration: Louvers / Segmentation	Rising damp: Absence of roof drainage	Rising damp: Absence of surface water drainage	Rising damp: Absence of site drainage	Rising damp: Inefficient roof drainage	Rising damp: Inefficient surface water drainage	Rising damp: Inefficient site drainage	Rising damp: High groundwater levels	Condensation: Surface of remains	Condensation: Surface of roof material
First Group	Neolithic Houses (South) Çatalhöyük,	-	-	-	A	-	A	-	-	-	-	C	C
	Neolithic Houses (North) Çatalhöyük,	-	-	-	A	B	A	-	-	-	-	C	-
	Alaeddin Kiosk Konya, Turkey	C	C	-	A	A	A	-	-	-	-	-	-
	Terrace House 2 Ephesos, Turkey	-	-	E	-	B	-	B	-	B	-	E	-
	Z Building Pergamon, Turkey	-	-	E	-	-	-	-	-	D	-	-	-
	Archaic and late Roman remains Sardis, Turkey	-	A	A	-	A	A	A	-	-	-	C	-
	Citadel Wall and the Megaron Troy, Turkey	-	-	-	C	-	C	-	C	-	-	C	-
	Villas Dionysos and Danae Zeugma, Turkey	-	-	-	-	-	-	-	-	-	-	E	-
Second Group	Fishbourne Roman Palace West Susex , UK	-	-	-	-	-	-	-	-	-	A	-	-
	Roman Villa Piazza Armerina, Italy	C	-	-	-	-	-	C	-	-	-	A	-
	Fortification Walls of Capo Soprano Gela,	A	A	-	-	-	-	-	-	-	-	-	-
	St Stephen Complex Um er-Rasas, Jordan	-	-	-	A	A	A	-	-	-	-	-	-
	Roman Town House Dorchester, UK	-	-	-	B	B	-	-	-	B	-	-	-
	Nile Festival Building Zippori, Israel	-	-	-	-	-	-	-	-	-	-	-	C
	Great House Arizona, USA	-	C	-	-	-	C	-	-	-	-	-	-
	Chedworth Roman Villa Gloucestershire, UK	-	-	-	-	-	-	-	-	-	-	A	-

Instability of Microclimate

Group	Site	Solar gain: Absence of sides	Solar gain: Transparent facade / roof material	Solar gain: Gaps between the louvers / segments	Heat built up: Transparent and translucent facade / roof material	Heat built up: Absence of propoer insulation	Fluctuations of T and RH: Absence of sides	Fluctuations of T and RH: Permeable facade / openings / louvers	Fluctuations of T and RH: Absence of proper insulation	Wetting and drying cycles: Absence of sides	Wetting and drying cycles: Permeable facade / openings / louvers	Wetting and drying cycles: Absence of propoer insulation	Wetting and drying cycles: Presence of water	Crystallization of soluble salts: Absence of sides	Crystallization of soluble salts: Permeable facade / openings / louvers	Crystallization of soluble salts: Absence of propoer insulation	Crystallization of soluble salts: Presence of water	Freezing: Absence of sides	Freezing: Permeable facade / openings / louvers	Freezing: Absence of propoer insulation / inefficient	Excessive / insufficient ventilation: Absence of sides	Excessive / insufficient ventilation: Permeable facade / openings / louvers	Excessive / insufficient ventilation: Stagnant air due to lack of louvers	Excessive / insufficient ventilation: Mechanical ventilation or heating
First Group	Neolithic Houses (South) Çatalhöyük,	-	-	-	A	-	A	-	A	-	-	A	-	-		A	-	-	-	C	-	C	-	-
	Neolithic Houses (North) Çatalhöyük,	-	-	E	A	-	-	-	A	-	-	A	-	-		A	-	-	-	C	-	A	-	-
	Alaeddin Kiosk Konya, Turkey	B	-	-	-	-	B	-	-	B	-	-	-	D		-	-	C	-	-	C	-	-	-
	Terrace House 2 Ephesos, Turkey	-	-	D	-	C	-	C	-	-	C	-	C	-		-	C	-	E	-	-	-	-	-
	Z Building Pergamon, Turkey	-	-	-	-	-	-	-	-	-	-	-	D	-		-	D	-	-	-	-	-	-	-
	Archaic and late Roman remains Sardis, Turkey	E	-	E	-	-	C	-	-	C	-	-	-	A		-	-	E	-	-	-	-	-	-
	Citadel Wall and the Megaron Troy, Turkey	B	-	-	-	-	A	-	-	C	-	-	-	-		-	-	E	-	-	A	-	-	-
	Villas Dionysos and Danae Zeugma, Turkey	-	-	-	C	-	-	C	-	-	C	-	-	-		-	-	-	E		-	E	-	-
Second Group	Fishbourne Roman Palace West Susex , UK	-	A	-	-	A	-	-	A	-	-	A	A	-		A	A	-	-	-	-	-	-	A
	Roman Villa Piazza Armerina, Italy	-	A	-	A	-	-	-	A	-	-	A	-	-		A	-	-	-	-	-	-	-	-
	Fortification Walls of Capo Soprano Gela,		A	-	A	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
	St Stephen Complex Um er-Rasas, Jordan	-	-	-	-	-	-	-	-	-	-	A	A	-		A	A	-	-	-	-	-	B	-
	Roman Town House Dorchester, UK	-	A	-	-	-	C	-	-	C	-	-	C	C		-	C	-	-	-	-	-	-	-
	Nile Festival Building Zippori, Israel	-	-	-	-	-	-	-	-	-	-	C		C		-	C	-	-	-	-	-	-	-
	Great House Arizona, USA	B	-	-	-	-	-	-	-	C	-	-	C	C		-	C	C	-	-	A	-	-	-
	Chedworth Roman Villa Gloucestershire, UK	-	C	-	-	-	-	-	A	-	-	-	-	-		C	-	-	-	A	-	-	-	-

Activities of the Living

Group	Site	Vegetation: Microbiological vegetation due to ground moisture	Vegetation: Microbiological vegetation due to high RH	Vegetation: Plant growth due to ground moisture	Vegetation: Plant growth due to high RH	Animals: Birds due to absence of sides	Animals: Birds due to louvers / openings	Animals: Insects and arachnoids due to absence of sides	Animals: Insects arachnoids due to louvers / openings	Animals: Rodents and reptiles
First Group	Neolithic Houses (South) Çatalhöyük,	-	-	D	-	-	E	-	E	C
	Neolithic Houses (North) Çatalhöyük,	-	-	D	-	-	E	-	E	C
	Alaeddin Kiosk Konya, Turkey	E	-	-	-	D	-	-		-
	Terrace House 2 Ephesos, Turkey	D	-	C	-	-	B	-	A	E
	Z Building Pergamon, Turkey	-	-	-	-	-	D	-	-	-
	Archaic and late Roman remains Sardis, Turkey	D	-	C	-	D	-	C	-	-
	Citadel Wall and the Megaron Troy, Turkey	-	-	-	-	D	-	C	-	-
	Villas Dionysos and Danae Zeugma, Turkey	-	-	E	-	-	E	-	-	-
Second Group	Fishbourne Roman Palace West Susex , UK	B	-	-	-	-	-	-	-	-
	Roman Villa Piazza Armerina, Italy	B	-	-	-	-	-	-	-	-
	Fortification Walls of Capo Soprano Gela,	-	A	-	A	-	-	A	-	A
	St Stephen Complex Um er-Rasas, Jordan	B	-	-	-	-	-	-	-	-
	Roman Town House Dorchester, UK	B	-	-	-	-	-	-	-	-
	Nile Festival Building Zippori, Israel	-	B	-	-	-	-	-	-	-
	Great House Arizona, USA	-	-	-	-	A	-	A	-	A
	Chedworth Roman Villa Gloucestershire, UK	-	B	-	-	-	-	-	-	-

A: Factors causing "Very Severe" damage

B: Factors causing "Severe" damage

C: Factors causing "Moderate" damage

D: Factors causing "Slight" damage

E: Factors causing "Very Slight" damage

drainage, surface water drainage, site drainage, inefficient roof drainage, surface water drainage, site drainage and presence of high groundwater levels (Table 3. 20).

Nine of the studied cases have rising damp in the absence of drainage system such as Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Alaeddin Kiosk in Konya (Turkey), Citadel Wall and the Megaron at Troy (Turkey), St. Stephen Complex at Um er-Rasas (Jordan) and Roman Town House at Dorchester (UK) due to absence of roof drainage; Neolithic Houses at Çatalhöyük -north enclosure- (Turkey), Alaeddin Kiosk in Konya (Turkey), Terrace House 2 at Ephesus (Turkey), Archaic and late Roman remains at Sardis (Turkey), St. Stephen Complex at Um er-Rasas (Jordan), Roman Town House at Dorchester (UK) due to absence of surface water drainage; Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Alaeddin Kiosk in Konya (Turkey), Archaic and late Roman remains at Sardis (Turkey), Citadel Wall and the Megaron at Troy (Turkey), St. Stephen Complex at Um er-Rasas (Jordan) and Great House Ruins at Arizona (USA) due to absence of site drainage. Seven of the studied cases have rising damp although they have a drainage system. Terrace House 2 at Ephesus (Turkey), Archaic and late Roman remains at Sardis (Turkey) and Roman Villa at Piazza Armerina (Sicily, Italy) due to inefficient roof drainage; Citadel Wall and the Megaron at Troy (Turkey) due to inefficient surface water drainage; Terrace House 2 at Ephesus (Turkey), Building Z at Pergamon (Turkey) and Roman Town House at Dorchester (UK) due to inefficient site drainage. In addition, high groundwater levels are among the sources of water rising from the ground as in Fishbourne Roman Palace at West Sussex (UK).

Water can access protected remains directly through the air by *condensation,* which is consisted of droplets of liquid water. It occurs when the air is damp and the warm air contacts a surface, colder than the dew point of the air (Feilden 2001). In the environment of a protective structure condensation occurs on the coldest surface available due to cooling at night from lack of insulation (Stewart 2008). Therefore, condensation may occur either on the surface of remains and the roof materials (Table 3. 20). At the sites of Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Terrace House 2 at Ephesus (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Archaic and late Roman remains at Sardis (Turkey), Villas Dionysos and Danae at Zeugma (Turkey), Roman Villa at Piazza Armerina (Sicily, Italy), Chedworth Roman Villa at Gloucestershire (UK) deterioration problems due to condensation on the remains have been observed. In addition, at the Neolithic Houses at

Çatalhöyük -south enclosure- (Turkey) and Nile Festival Building at Zippori (Israel) condensation on the roof material resulted in water dropping onto the remains.

Instability of microclimate is an important cause of deterioration especially in concomitant with presence of water and soluble salts. According to the design, internal environment of a protective structure which primarily consist interaction of relative humidity and temperature may be affected by solar gain, heat built up, fluctuations of temperature and relative humidity, wetting and drying cycles, crystallization of soluble salts, freezing, excessive and inefficient ventilation.

Building materials with high thermal absorptivity reach temperatures much higher than that of the ambient air (Feilden 2001). In case of protected remains, solar gain can be direct and indirect according to the type of a protective structure. Direct solar gain from external radiation may cause extremely high temperatures of remains due to the absence of façades as at the Alaeddin Kiosk in Konya (Turkey), Great House Ruins at Arizona (USA), Citadel Wall and the Megaron at Troy (Turkey), Archaic and late Roman remains at Sardis (Turkey). Gaps between the louvers and segments also cause to gain solar radiation at the Neolithic Houses at Çatalhöyük - north enclosures- (Turkey), Terrace House 2 at Ephesus (Turkey), Archaic and late Roman remains at Sardis (Turkey). In addition indirect solar gain can affect the internal temperature through transparent façade and roof elements as at the Roman Villa at Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Fishbourne Roman Palace at West Sussex (UK), Chedworth Roman Villa at Gloucestershire (UK), Roman Town House at Dorchester (UK).

Heat built up inside a protective structure can be defined as increase of internal temperature due to solar gain through transparent or translucent façade and roof elements. The Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Roman Villa at Piazza Armerina (Sicily, Italy), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Villas Dionysos and Danae at Zeugma (Turkey), Archaic and late Roman remains at Sardis (Turkey) is a good example to the condition. In addition, opaque envelope with low thermal mass in the absence of insulation may result in heat built up as at the Terrace House 2 at Ephesus (Turkey), Fishbourne Roman Palace at West Sussex (UK).

Fluctuations of temperature and relative humidity can be defined as repeating increase and decrease of temperature and relative humidity. As in the case of shelters, they mostly fail at controlling temperature and relative humidity, so that the protected remains may be exposed to daily and seasonal fluctuations. Alaeddin Kiosk in Konya (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Archaic and late Roman remains at Sardis (Turkey), Roman Town House at Dorchester (UK) are examples to the subject. Like shelters, some enclosures with louvers (Terrace House 2 at Ephesus (Turkey)) and permeable façades (Villas Dionysos and Danae at Zeugma (Turkey)) as well as removing sides in summer period (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures) created an internal environment which is dramatically affected by the outdoor climatic conditions. Whereas, at completely enclosed environments such as the Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Roman Villa at Piazza Armerina (Sicily, Italy), Fishbourne Roman Palace at West Sussex (UK), Chedworth Roman Villa at Gloucestershire (UK) lack of insulation is the most important cause of fluctuations of temperature and relative humidity.

The repeating wetting of the remains due to the presence of water such as rain penetration, rising damp and condensation in the protective structure, followed by a drying phase is named as *wetting and drying cycles.* The process is mostly triggered by the variations in temperature and relative humidity levels in addition to excessive ventilation. Absence of sides as at the Alaeddin Kiosk in Konya (Turkey), Great House Ruins at Arizona (USA), Citadel Wall and the Megaron at Troy (Turkey), Roman Town House at Dorchester (UK) and Archaic and late Roman remains at Sardis (Turkey) besides louvers and permeable façades at the Terrace House 2 at Ephesus (Turkey) and Villas Dionysos and Danae at Zeugma (Turkey) as well as lack of proper insulation as Roman Villa at Piazza Armerina (Sicily, Italy), Fishbourne Roman Palace at West Sussex (UK), St. Stephen Complex at Um er-Rasas (Jordan), Chedworth Roman Villa at Gloucestershire (UK), Nile Festival Building at Zippori (Israel) are the main causes of wetting and drying cycles under a protective structure. Existing drainage related problems also increase the cycles of wet / dry at Terrace House 2 at Ephesus (Turkey), Building Z at Pergamon (Turkey), Fishbourne Roman Palace at West Sussex (UK), St. Stephen Complex at Um er-Rasas (Jordan), Roman Town House at Dorchester (UK), Great House Ruins at Arizona (USA).

Wetting and drying cycles may be quite more destructive when accompanied with *crystallization of soluble salts.* Even when soluble salts are not a major threat at the site, wet/dry cycles may accelerate the salt damage (Neguer and Yalef 2008). In addition, accumulation of soluble salts by lateral migration from the unsheltered surroundings is a consequence of sheltering with inefficient drainage system (Agnew

2001). Temperature and relative humidity variations and excessive ventilation exacerbate the damage by accelerating the crystallization of soluble salts. Absence of sides at the Alaeddin Kiosk in Konya (Turkey), Great House Ruins at Arizona (USA), Nile Festival Building at Zippori (Israel), Archaic and late Roman remains at Sardis (Turkey), Roman Town House at Dorchester (UK) and louvers at the façades of Terrace House 2 at Ephesus (Turkey), absence of proper insulation at the Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Roman Villa at Piazza Armerina (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Fishbourne Roman Palace at West Sussex (UK), Chedworth Roman Villa at Gloucestershire (UK) are the main causes of salt crystallization at the specified sites. In addition, slight damage of salt at Building Z at Pergamon (Turkey) which provided rather stable environment can be explained by the drainage problems at heavy rains.

Freezing causes any trapped water in the pores of materials to expand and damage the perimeter of the pores. Frequency of freezing is related to the ambient climate of the site; however protected remains' exposure to the frost damage is also related to the design characteristics applied in order to prevent the risk. Absence of sides at the sheltered sites of Alaeddin Kiosk in Konya (Turkey), Great House Ruins at Arizona (USA), Citadel Wall and the Megaron at Troy (Turkey), Archaic and late Roman remains at Sardis (Turkey) in addition to louvers at Terrace House 2 at Ephesus (Turkey) and permeable façades at Villas Dionysos and Danae at Zeugma (Turkey) are the main causes of freezing. The lack of insulation resulted in freezing at most of the enclosed sites such as Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures. Nonetheless at Chedworth Roman Villa at Gloucestershire (UK), even though the protective structure is insulated and has a heating system installed, freezing still occurs due to the extreme cold climate.

Ventilation (*excessive / insufficient ventilation)* is an important challenge of the indoor climate of a protective structure. Shelters are inefficient to control and prevent excessive ventilation due to absence of sides as at the Alaeddin Kiosk in Konya (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Great House Ruins at Arizona (USA). In addition, design elements for natural ventilation can sometimes cause excessive ventilation as seen at Villas Dionysos and Danae at Zeugma (Turkey) with permeable façades. Furthermore, at the Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures openings on the façades of enclosures resulted in rapid air flow. Mechanical ventilation is another cause of excessive ventilation at Fishbourne

Roman Palace at West Sussex (UK). On the other hand, lack of louvers and other design elements may cause stagnant air as at the St. Stephen Complex at Um er-Rasas (Jordan).

Activities of the living can be defined as presence of invasive species either plants or animals which are quite destructive for the preservation of archaeological remains. In fact, protective structures sometimes provide suitable environment for living and growing of plants and animals. Vegetation can be grouped as microbiological vegetation and plants. The main cause of microbiological vegetation can be related with presence of ground moisture mostly caused by inefficient drainage systems as at the Terrace House 2 at Ephesus (Turkey), Alaeddin Kiosk in Konya (Turkey), Archaic and late Roman remains at Sardis (Turkey), Fishbourne Roman Palace at West Sussex (UK), Roman Villa at Piazza Armerina (Sicily, Italy), St. Stephen Complex at Um er-Rasas (Jordan), Roman Town House at Dorchester (UK). In addition high relative humidity inside the protective structure may cause microbiological vegetation as at the Nile Festival Building at Zippori (Israel), Walls of Capo Soprano at Gela (Sicily, Italy) and Chedworth Roman Villa at Gloucestershire (UK). Excessive ground moisture also causes plant growth as at the Terrace House 2 at Ephesus (Turkey), Villas Dionysos and Danae at Zeugma (Turkey), Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Archaic and late Roman remains at Sardis (Turkey). In addition, transparent façade panels at the Fortification Walls of Capo Soprano at Gela (Sicily, Italy) created excessive relative humidity which is an available environment for plant growth.

Protective structures provide a safe place for the animals in the wild world as much as the archaeological remains. At the selected sites birds, insects and rodents are among the damaging factors. In contrast to enclosures, shelters allow access of any kind of animals as at the Alaeddin Kiosk in Konya (Turkey), Archaic and late Roman remains at Sardis (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Great House Ruins at Arizona (USA). On the other hand, the enclosures at the Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Terrace House 2 at Ephesus (Turkey), Building Z at Pergamon (Turkey) and Villas Dionysos and Danae at Zeugma (Turkey) allow birds inside the protective structure through the louvers and façade openings. Similarly, shelters at the Archaic and late Roman remains at Sardis (Turkey), Citadel Wall and the Megaron at Troy (Turkey), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Great House Ruins at Arizona (USA) have various kinds of insects and arachnids due absence of sides. In addition, the Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Terrace House 2 at Ephesus (Turkey) are exposed to insects and arachnids through louvers and façade openings. Rodents and reptiles are also among the animals that cause damage of the selected sites such as Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Terrace House 2 at Ephesus (Turkey), Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Great House Ruins at Arizona (USA).

CHAPTER 4

EVALUATION OF THE CASE STUDY EXAMPLES IN RELATION TO THE EFFECT OF ARCHITECTURAL CHARACTERISTICS ON CONSERVATION OF REMAINS

Conservation issues observed at archeological sites protected under protective structures can be associated with the capability of protective structure in prevention from the atmospheric and environmental conditions. As the environmental conditions and the architectural design of the protective structures varies from site to site, a large number of conservation problems, as well as the factors observed in relation with these variations. In order to identify and assess the role of protective structures on creating deterioration factors, this study groups the design characteristics of protective structures under Typology, Structural System, Roof System, Roof Material, Façade System, Façade Material, Thermal Control System and Drainage System and the deterioration factors under Sources of Water, Instability of Microclimate and the Activities of the Living as explained in Chapter 3 (Table 4. 1). The relationship between each of these groups are analyzed and evaluated individually. The analysis and the evaluation is conducted at 16 selected case examples and the deterioration factors are described under 5 categories according to the qualification and the affected area of the deterioration as “very severe” (A), “severe” (B), “moderate” (C), “slight” (D) and “very slight” (E). The evaluation process is conducted under the titles of:

- The relationship between typology and sources of water, instability of microclimate and activities of the living
- The relationship between structural system and sources of water, instability of microclimate and activities of the living
- The relationship between roof system and sources of water, instability of microclimate and activities of the living
- The relationship between roof material and sources of water, instability of microclimate and activities of the living

Table 4. 1. Relational evaluation of architectural design characteristics of protective structures and deterioration factors.

Design of Protective Structure

Deterioration Factors		Deterioration Factors	Typology of Protective Structure: Shelter	Enclosure	Built on remains	Built above remains	Structural System: Masonry	Reinforced concrete	Steel	Timber skeleton	Roof System: Segmented	Single piece	Louvers	Limited shelter area / excessive roof height
	Number of Examples		7	9	6	10	1	1	12	3	6	10	5	3
Deterioration Factors	Sources of Water	Rain penetration	2A 2C								1A			2A 2C
		Rising damp	2C											1C
		Condensation	3C											
	Instability of Microclimate	Solar gain	2A 3B 1E								1E		1E	3B 1E
		Heat built up												
		Fluctuations of T and RH	1A 1B 2C											
		Wetting and drying cycles	1B 5C											1A 1B 1C
		Crystallization of soluble salts	1A 3C											1A
		Freezing	2C 2E											
		Excessive ventilation	2A 1C											
		Insufficient ventilation												
	Activities of the Living	Microbiological vegetation												
		Plants									1C			1C
		Birds	1A 3D								1E		1B	
		Insects	1A 2C										1A	
		Rodents	1A											

Deterioration Factors			Roof Material: Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates,	translucent (polycarbonate /	transparent (polycarbonate	Facade System: Impermaeble	Adjusting sides in seasons	Louvers	Permeable
	Number of Examples		3	1	2	4	5	2	6	2	3	4
Deterioration Factors	Sources of Water	Rain penetration									2E	
		Rising damp										
		Condensation					1A 2C 1E	1A			1E	1E
	Instability of Microclimate	Solar gain					1A	1A			1D	
		Heat built up			1C		3A 1C	1A				
		Fluctuations of T and RH			1C		3A 1C	1A		2A	1C	1C
		Wetting and drying cycles			1C		3A 1C	1A		2A	1C	1C
		Crystallization of soluble salts			1C		3A	1A		2A	1C	
		Freezing					2C				1E	1E
		Excessive ventilation								1A 1C		1C
		Insufficient ventilation							1B			
	Activities of the Living	Microbiological vegetation										
		Plants										
		Birds								2E	1B	
		Insects								2E	1A	
		Rodents										

Deterioration Factors			Facade Material: Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate	Thermal Control System: Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation
	Number of Examples		1	1	3	2	7	16	16	14	1	1
Deterioration Factors	Sources of Water	Rain penetration										
		Rising damp										
		Condensation		1E		2C	2A	3C 1E	2C		1A	
	Instability of Microclimate	Solar gain					3A 1C					
		Heat built up				2A	3A 1C	3A 2C	2A 1C			
		Fluctuations of T and RH		1C		2A	2A 1C	3A 3C	2A 2C			1A
		Wetting and drying cycles		1C		2A	2A 2C	4A 2C	3A 2C	2A 1B 2C	1A	1A
		Crystallization of soluble salts				2A	2A 2C	4A 2C	3A 1C	2A 1C		1A
		Freezing		1E		2C		2C	2C		1A	
		Excessive ventilation		1C						3A1C		1A
		Insufficient ventilation								1B		
	Activities of the Living	Microbiological vegetation					1A	1B				
		Plants					1A					
		Birds										
		Insects					1A					
		Rodents					1A					

Deterioration Factors			Drainage System: Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
	Number of Examples		11	9	8	5	7	8	1
Deterioration Factors	Sources of Water	Rain penetration							
		Rising damp	4A 1B 2C	4A 2B 1C	5A 2C	1A 1C 1D	1C	2B 1D	1A
		Condensation	2C	1C	2C				
	Instability of Microclimate	Solar gain							
		Heat built up							
		Fluctuations of T and RH							
		Wetting and drying cycles	3A 1B 3C	2A 1B 4C	3A 1B 3C	1C 1D	1C	2C 1D	1A
		Crystallization of soluble salts	3A 2C	3A 3C	4A 1C	2A 1D		2C 1D	1A
		Freezing							
		Excessive ventilation							
		Insufficient ventilation							
	Activities of the Living	Microbiological vegetation	2B 1E	2B 2D 1E	1B 1D 1E	1B 1D		1B 1D	1B
		Plants	2D	1C 1D	1C 2D	2C		1C	
		Birds							
		Insects							
		Rodents							

A: Factors causing "Very Severe" damage

B: Factors causing "Severe" damage

C: Factors causing "Moderate" damage

D: Factors causing "Slight" damage

E: Factors causing "Very Slight" damage

- The relationship between façade and sources of water, instability of microclimate and activities of the living
- The relationship between façade material and sources of water, instability of microclimate and activities of the living
- The relationship between thermal control and sources of water, instability of microclimate and activities of the living
- The relationship between drainage system and sources of water, instability of microclimate and activities of the living

4.1. Typology of Protective Structures

According to the architectural typology, protective structures are categorized in two groups as shelters and enclosures. Among the studied sixteen protective structures nine are classified as shelter and seven are classified as enclosure. Also six of the structures were built on remains, while the other ten were built above the remains.

4.1.1. The Relationship between Typology and Sources of Water

The analyses on the case study examples showed that the sources of water related to the typology of the protective structures were rain penetration, rising damp and condensation (Table 4. 2). Rain penetration was observed at four of the seven shelters. Among them, Archaic and late Roman remains at Sardis (Turkey) and Fortification Walls of Capo Soprano at Gela (Sicily, Italy) are very severe, Alaeddin Kiosk in Konya (Turkey) and Great House Ruins at Arizona (USA) are determined as moderate. Rising damp was observed at Great House Ruins at Arizona (USA) and Citadel Wall and the Megaron at Troy (Turkey) at moderate level. Also, at three of the seven shelters a moderate level of condensation was observed (Nile Festival Building at Zippori (Israel), Citadel Wall and the Megaron at Troy (Turkey), Archaic and late Roman remains at Sardis (Turkey)). In the case of enclosures, although condensation is formed, the factors are significantly related with the design of outer shell rather than its typology.

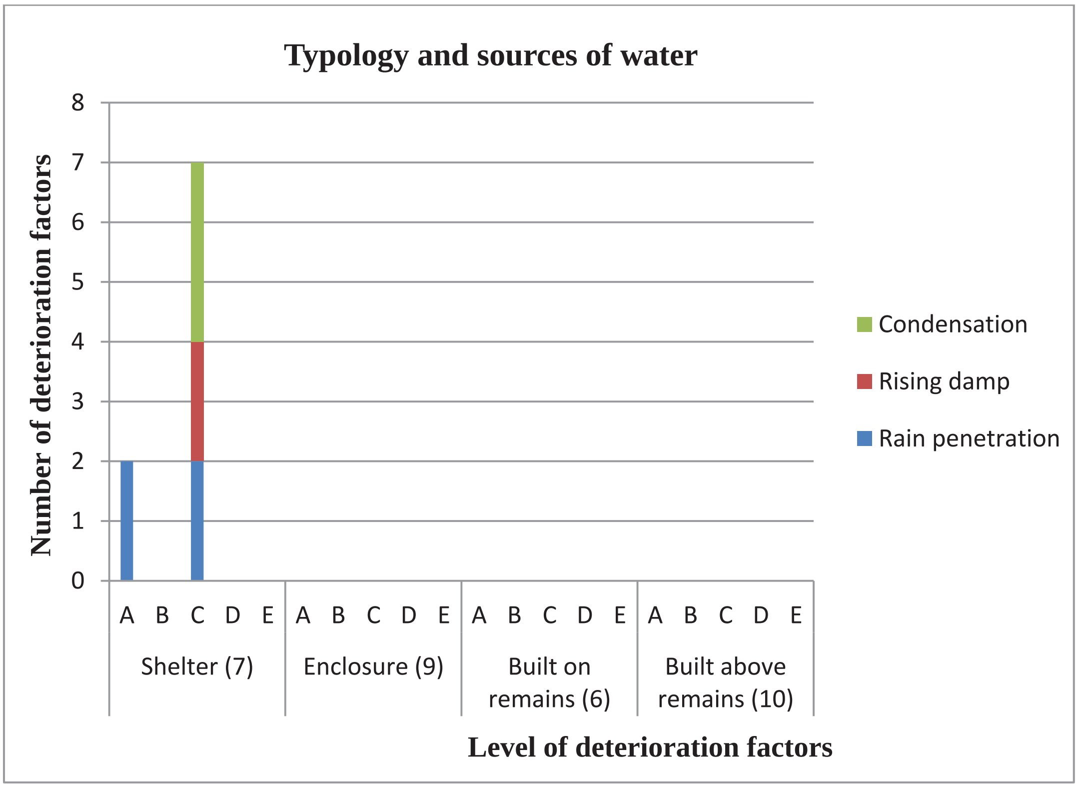
No significant evidence was found to show that there is a relation with the moisture issue and the protective structure being built on or above the remains.

The primary issue related to shelters was determined as rain penetration. The limited area of shelter not being wide enough to cover the site or excessive roof height, results in the remains getting wet by wind driven rain water (Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Archaic and late Roman remains at Sardis (Turkey), Great House Ruins at Arizona (USA)).

When the soil is soaked with rain water, dry soil under the shelter get wet through passive transport (diffusion) of water in absence of surface drainage as observed at Citadel Wall and the Megaron at Troy (Turkey). In addition, wetting of the soil under shelter is also possible in stormy rains resulted in rising damp (Great House Ruins at Arizona (USA)).

Another issue, frequently observed at shelters, was condensation. Condensation may occur when the remains are not well protected from the rapid changes in exterior temperature and humidity (Archaic and late Roman remains at Sardis (Turkey), Citadel Wall and the Megaron at Troy (Turkey)).

Table 4. 2. The relationship between typology and sources of water.



4.1.2. The Relationship between Typology and Instability of Microclimate

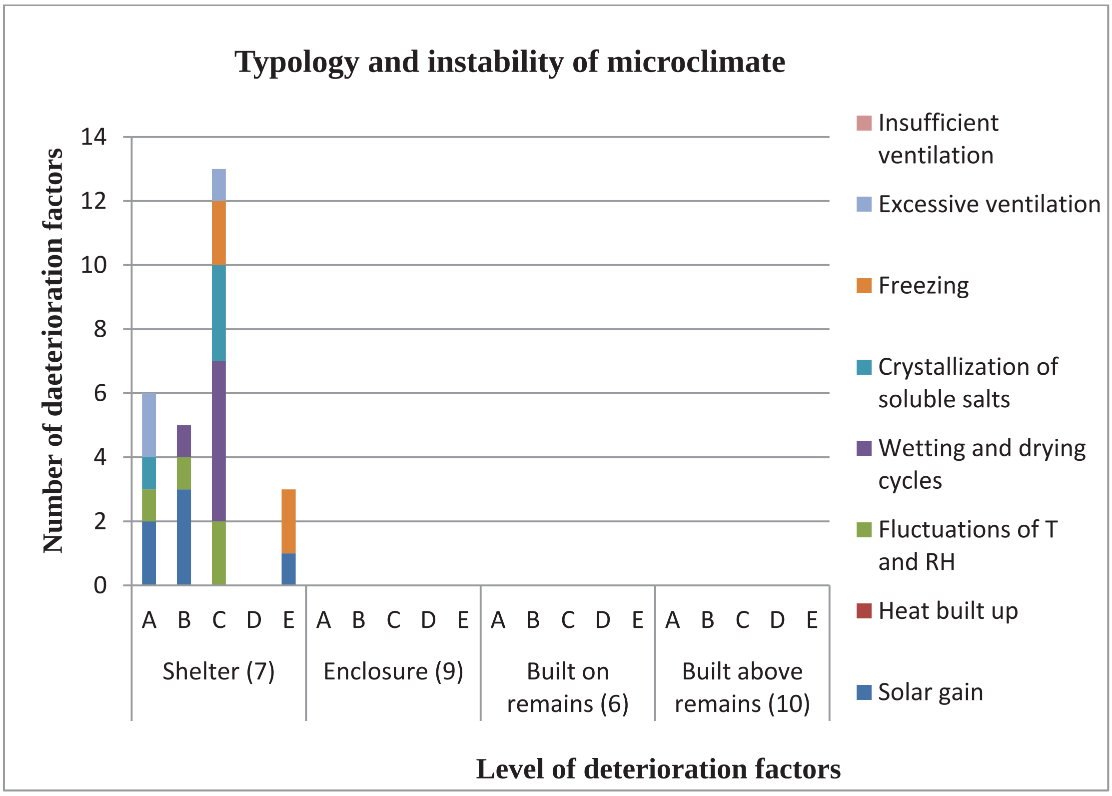
Analysis of the case study examples has shown that the conservation issues classified as instability of microclimate vary according to the typology of the protective structure. Issues observed at shelters are excessive or insufficient ventilation, crystallization of soluble salts, fluctuations of temperature and relative humidity, wetting and drying cycles, solar gain and freezing. On the other hand, the damaging factors observed at enclosures are mostly related with the design of outer shell rather than the typology.

No significance evidence was observed that the instability of microclimate is related with the protective structure being built on or above the remains.

At each of the examined seven shelters, instability of microclimate conservation issues were observed, with levels ranging from very slight to very severe (Table 4. 3). The primary issues can be stated as excessive ventilation (Great House Ruins at Arizona (USA) (A), Citadel Wall and the Megaron at Troy (Turkey) (A), Alaeddin Kiosk in Konya (Turkey) (C)) and solar gain (Fortification Walls of Capo Soprano at Gela (Sicily, Italy) (A), Roman Town House at Dorchester (UK) (A), Great House Ruins at Arizona (USA) (B), Citadel Wall and the Megaron at Troy (Turkey) (B), Alaeddin Kiosk in Konya (Turkey) (B)). Crystallization of soluble salts was observed at four sites (Archaic and late Roman remains at Sardis (Turkey) (A), The Roman Town House at Dorchester (UK) (C), Great House Ruins at Arizona (USA) (C), Nile Festival Building at Zippori (Israel) (C)), wetting and drying cycles was observed at six sites (Archaic and late Roman remains at Sardis (Turkey) (A), Alaeddin Kiosk in Konya (Turkey) (B), Citadel Wall and the Megaron at Troy (Turkey) (C), The Roman Town House at Dorchester (UK) (C), Great House Ruins at Arizona (USA) (C), Nile Festival Building at Zippori (Israel) (C)), fluctuations of temperature and relative humidity was observed at four sites (Citadel Wall and the Megaron at Troy (Turkey) (A), Alaeddin Kiosk in Konya (Turkey) (B), Archaic and late Roman remains at Sardis (Turkey) (C), Roman Town House at Dorchester (UK) (C)) and freezing was observed at two sites (Alaeddin Kiosk in Konya (Turkey) (C), Great House Ruins at Arizona (USA) (C)).

- Since shelters do not have any sides, the remains are unprotected from the winds. The effects of wind cause deterioration problems, such as surface erosion, especially on earthen structures at sites with strong wind, located on hilltops or exposed to prevailing winds (Great House Ruins at Arizona (USA), Alaeddin Kiosk in Konya (Turkey), Citadel Wall and the Megaron at Troy (Turkey)).
- While they can protect the remains from direct rays, however most of the shelters do not protect solar gain with low sun angle. Especially when the shelter lacks controlling the amount of the solar gain by design of the eaves, cracks and partial losses on earthen surfaces occur due to expansion-contraction actions (Great House Ruins at Arizona (USA), Citadel Wall and the Megaron at Troy (Turkey), Alaeddin Kiosk in Konya (Turkey)).

Table 4. 3. The relationship between typology and instability of microclimate.



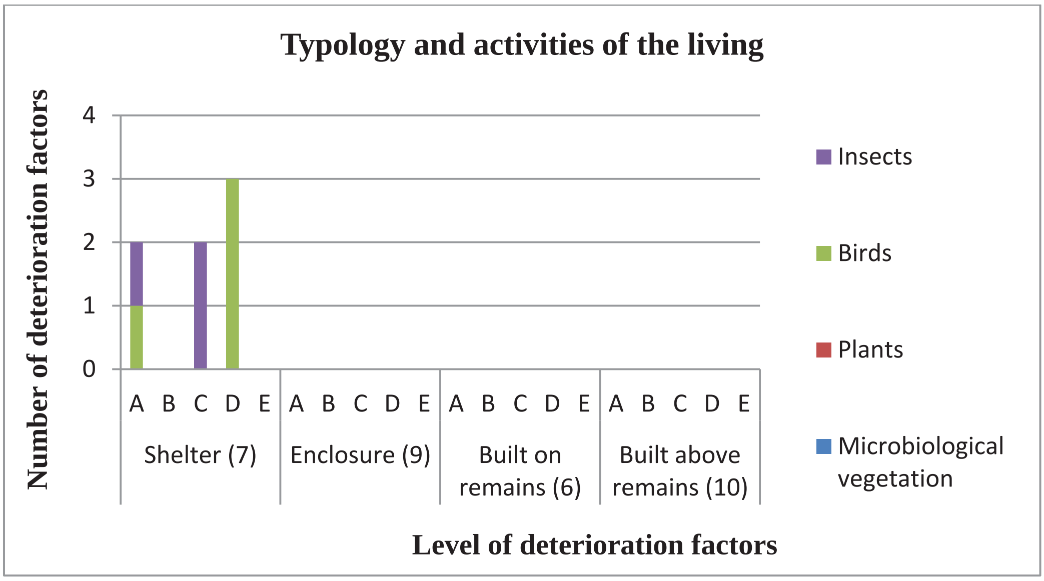
- Since the shelters do not have sides, the interior environmental conditions are almost exactly the same as the exterior environmental conditions. The daily and seasonal fluctuations of temperature and relative humidity of the atmosphere and the presence of moisture or water at the site jointly create factors of wetting and drying cycles and crystallization of soluble salts (Alaeddin Kiosk in Konya (Turkey), Archaic and late Roman remains at Sardis (Turkey), Citadel Wall and the Megaron at Troy (Turkey), The Roman Town House at Dorchester (UK), Great House Ruins at Arizona (USA) and Nile Festival Building at Zippori (Israel)). Also at climate regions with high frost action, shelters almost never can provide proper protection (Alaeddin Kiosk in Konya (Turkey), Great House Ruins at Arizona (USA)).
- Although not being observed in the studied cases, dust and salt accumulation can be an important issue for the mosaics protected by shelters at marine environments was much more common than the unprotected mosaics getting washed by pouring rain (Neguer and Alef 2008).

4.1.3. The Relationship between Typology and Activities of the Living

Examination of the case studies showed that the only issues related with typology can be named as animal-related issues and they were only observed at shelters. The problems observed about the activities of the living at enclosures were related with the design of the roof and façades, which will be explained in the following sections. Among the seven examined shelters, four of them have bird related (Great House Ruins at Arizona (USA) (A), Archaic and late Roman remains at Sardis (Turkey) (C), Alaeddin Kiosk in Konya (Turkey) (C), Citadel Wall and the Megaron at Troy (Turkey) (C)), insect related issues (Great House Ruins at Arizona (USA) (A), Archaic and late Roman remains at Sardis (Turkey) (A), Citadel Wall and the Megaron at Troy (Turkey) (A)) ((Table 4. 4).

Although damage by rodents is a critical issue at both shelters (Great House Ruins at Arizona (USA) (A) and enclosures (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C), Terrace House 2 at Ephesus (Turkey) (E)), their presence was not associated with neither typology nor other design features of the protective structures since they can access of the site either through digging underneath the ground or above the ground.

Table 4. 4. The relationship between typology and activities of the living.



- Bird related issues were more commonly observed than the other animal related issues. Since the shelters do not have sides to keep the animals away from the remains, they can easily access and damage the remains

4.2. Structural System of Protective Structures

The case study examples are classified according to the structural systems in four groups: masonry, reinforced concrete, steel construction and timber skeleton. Twelve of the structures are constructed of steel, three of them timber skeleton, one is masonry and one is reinforced concrete system. The analysis indicates that there is no significant relation between the structural system and the conservation issues.

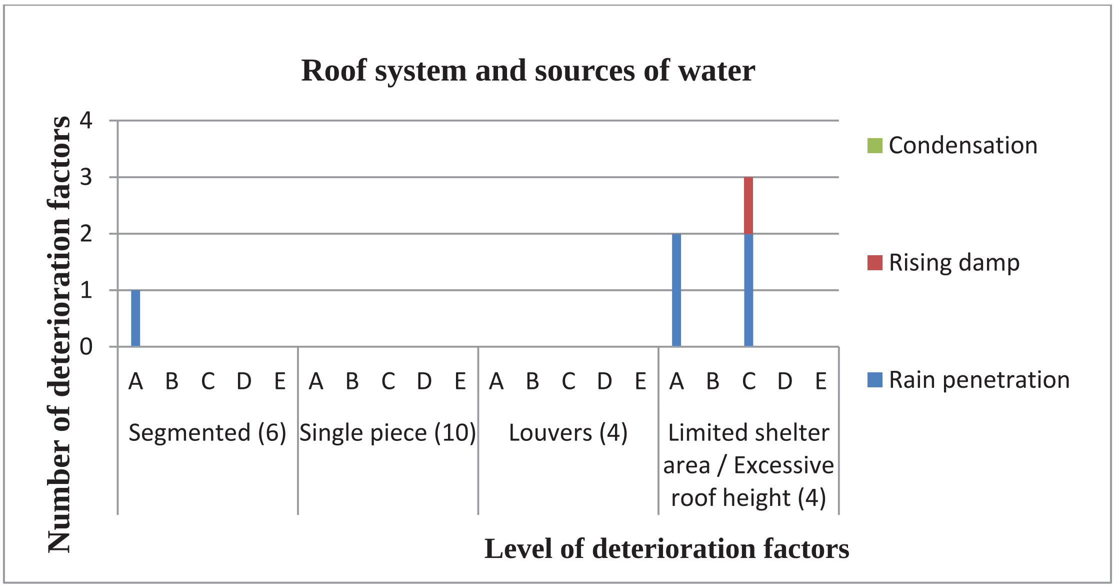
4.3. Roof System of Protective Structures

According to their design, roof systems of the examined protective structures are categorized in three groups as segmented, single piece and louvers. Six of the structures have segmented roof systems, ten of them have single piece roofs and five of them have roofs with louvers. Additionally, limited shelter area and excessive roof height subjects are also considered as design studied under this topic, since they are related with the roof design, as well.

4.3.1. The Relationship between Roof System and Sources of Water

The most commonly observed source of moisture related to the roof system of the protective structures is rain penetration; also it may rarely trigger rising damp (Table 4. 5). Primary reasons of rain penetration related to the roof system are due to limited shelter area and excessive roof height. The condition was observed at Archaic and late Roman remains at Sardis (Turkey) and Fortification Walls of Capo Soprano at Gela (Sicily, Italy) at very severe level in addition, at Great House Ruins at Arizona (USA) and Alaeddin Kiosk in Konya (Turkey) at moderate level. If not properly drained, wind-drawn rain form puddles and may cause rising damp (Great House Ruins at Arizona (USA) (C). Especially, the shelters consisted of segmented roofs may have rain penetration related issues, in order the segments have been designed separately leaving wide gaps in between (Archaic and late Roman remains at Sardis (Turkey) (A)). The conservation issues related to single piece roofs and roofs with louvers are unimportant when compared to structures with segmented roofs.

Table 4. 5. The relationship between roof system and sources of water.



- The wider the gaps between the segments are more rain water penetrates and wets the protected remains. The protective structure over the Archaic and late Roman remains at Sardis (Turkey) consists of one parabola shaped main shelter and smaller sloped shelters. The wide gaps between these different shaped segments caused the rain penetration to be a significant and critical conservation problem.
- When the shelter area is not wide enough to fully cover the remains or the roof is too high, wind driven rain can easily access to the remains, making them wet (Fortification Walls of Capo Soprano at Gela (Sicily, Italy), Archaic and late Roman remains at Sardis (Turkey) and Alaeddin Kiosk in Konya (Turkey)). In colder climate regions, wind driven snow also penetrates through the gaps between the segments, also making the remains wet (Great House Ruins at Arizona (USA)).
- Occasionally, wind driven rain especially after heavy storms result in rising damp. It was which was evidenced at Great House Ruins at Arizona (USA) by puddled water wetting the internal walls.

4.3.2. The Relationship between Roof System and Instability of Microclimate

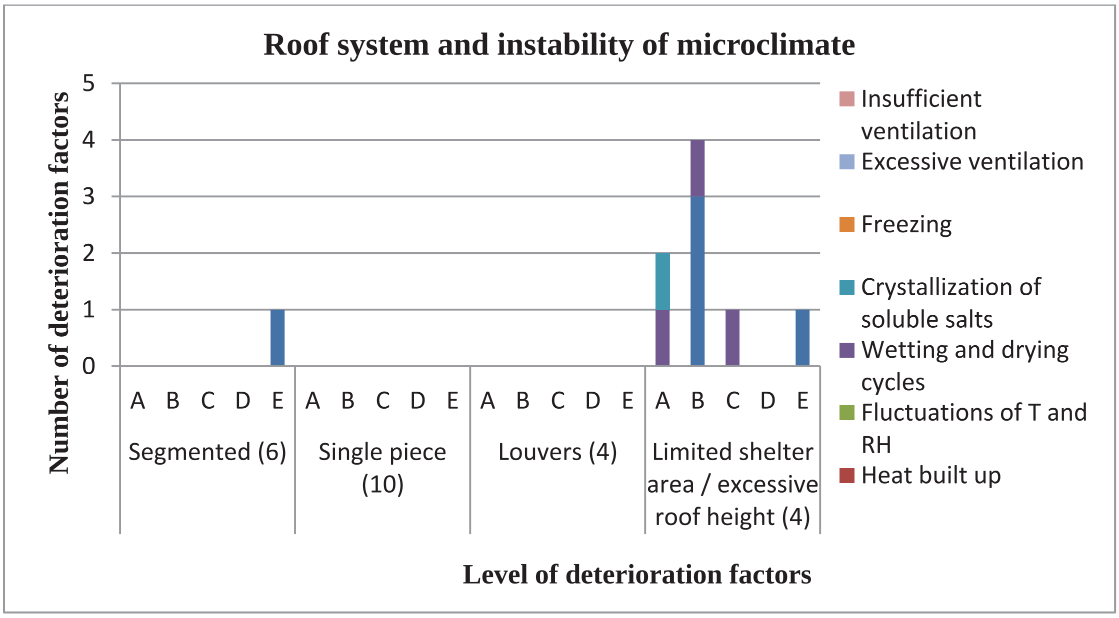
In relation with the roof system, the primary factor of deterioration is solar gain due to limited shelter area. The condition was observed at Citadel Wall and the Megaron at Troy (Turkey), Alaeddin Kiosk in Konya (Turkey) and Great House Ruins at Arizona (USA) at severe level, while to Archaic and late Roman remains at Sardis (Turkey) at very slight level. Presence of wide gaps between segmented roofs at Archaic and late Roman remains at Sardis (Turkey) and Neolithic Houses at Çatalhöyük - north enclosure- (Turkey) are at very slight level (Table 4. 6). Moreover, wetting and drying cycles ((Archaic and late Roman remains at Sardis (Turkey) (A), Alaeddin Kiosk in Konya (Turkey) (B), Great House Ruins at Arizona (USA) (C)) and crystallization of soluble salts (Archaic and late Roman remains at Sardis (Turkey) (A)) are the factors triggered by rain penetration together with solar gain under limited shelter areas.

- If the necessary precautions have not been taken, when the sun is comparatively low solar gain may affect the condition of the remains as explained in detail in the heading 4.1.2. In the case of limited shelter area and excessive roof height, the affects become more severe, causing loss of mud mortar and plaster layer (Citadel

Wall and the Megaron at Troy (Turkey), Alaeddin Kiosk in Konya (Turkey), Great House Ruins at Arizona (USA) and Archaic and late Roman remains at Sardis (Turkey)).

- Sites with limited shelter area face both rain penetration and direct solar gain. The combination of these factors triggers wetting and drying cycles which lead to higher levels of salt crystallization. Therefore, the deterioration problems caused by this chain of events can be associated with the roof system, at least in an indirect way as at Archaic and late Roman remains at Sardis (Turkey), Alaeddin Kiosk in Konya (Turkey).

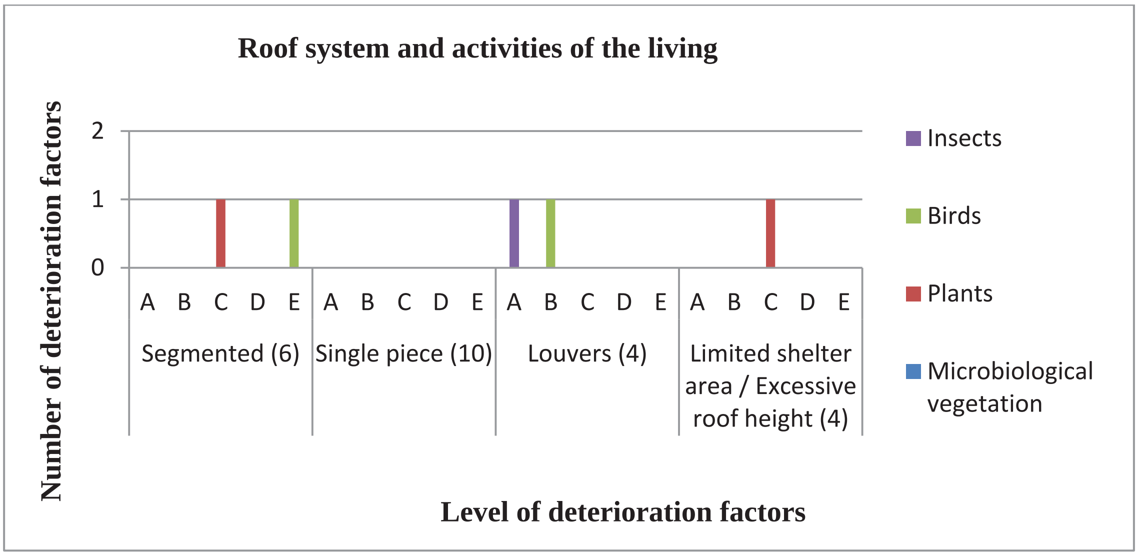
Table 4. 6. The relationship between roof system and instability of microclimate.



4.3.3. The Relationship between Roof System and Activities of the Living

Conservation problems related to the design of the roof system are caused by plants, mainly birds and insects (Table 4. 7). Among the four protective structures with louvers Terrace House 2 at Ephesus (Turkey) wasps caused were very severe damage in addition to the bird droppings at severe level. Also, at sites with segmented roofs, presence of bird droppings (Villas Dionysos and Danae at Zeugma (Turkey) (D)) and plants (Archaic and late Roman remains at Sardis (Turkey) (D)) were observed.

Table 4. 7. The relationship between the roof system and activities of the living.



- Presence of wasps caused very severe damage due to the numerous cavities in the mortar at Terrace House 2 at Ephesus (Turkey) (Figure 4. 1).
- Louvers when the distance between the louvers is not narrow enough, birds can enter easily through and nest inside, where it is much safer to live for them. Hence high amount of droppings of these birds caused deterioration on mosaics and wall paintings at the Terrace House 2 at Ephesus (Turkey) (Figure 3.1).
- Although textile canvas was stretched under the roof to prevent birds entering through the gaps between the segments at Villas Dionysos and Danae at Zeugma (Turkey), it could not prevent the bird droppings from filtering through the canvas on to the remains.
- Remains exposed to rain penetration and solar gain due to the limited shelter area resulted in plant growth at the Archaic and late Roman remains at Sardis (Turkey) (Figure 4. 2).

Figure 4. 1. Cavities in the wall structure at the Terrace House 2 at Ephesus (Turkey).

Figure 4. 2. Plant growth on the mudbrick fortification wall at the Archaic and late Roman remains at Sardis (Turkey).

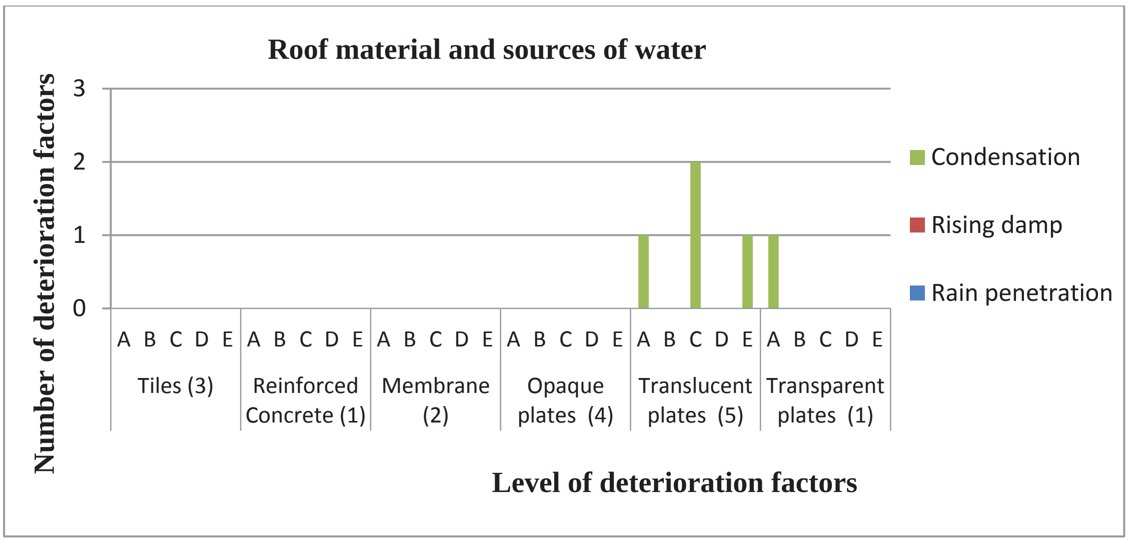
4.4. Roof Material of Protective Structures

On studied protective structures, a variety of tile, uncoated concrete, membrane and plates such as opaque (fiberboard, steel and copper plates), translucent (polycarbonate and fiberglass plates) and transparent (glass and polycarbonate plates) were used as roof materials. Among the variety of roofing materials, plates constitute the majority. Five of the sites had roofs constructed of translucent panels, four of the sites were constructed of opaque plates and only one site was constructed of transparent plates together with translucent plates. In addition, tiles were used at three sites, concrete was used at one site and membrane was used at two sites.

4.4.1. The Relationship between Roof Material and Sources of Water

Condensation is identified as the most common issue among the humidity related problems associated with the roof materials (Table 4. 8). Formation of condensation was observed mostly under roofs with transparent (Roman Villa at Piazza Armerina (Sicily, Italy) (A)) and translucent (Roman Villa at Piazza Armerina (Sicily, Italy) (A), Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C), Villas Dionysos and Danae at Zeugma (Turkey) (E)) materials. In the case of roofs constructed of opaque plates condensation was formed, as well. However, the factors are significantly related with the insulation and exposure to solar gain rather than their roof material, which will be explained in the following sections.

Table 4. 8. The relationship between roof material and sources of water.



- Outer shell of the enclosures is highly important, essentially, good insulation, thermal mass and permeability to moisture of the materials are beneficial to prevent condensation (Feilden 2001). However, translucent and transparent roof materials, lead to high temperatures inside the enclosed structures. Since warm air is able to contain many times more moisture as the inner temperature increases, relative humidity decreases (Feilden 2001). These temperature and humidity conditions favor evaporation of the ground moisture and increase the level of vapor in the internal environment (Citterio and Giani 2006b). When the temperature decreases the surplus moisture becomes liable to condensation (Feilden 2001). This recurring cycle of events, result in continuous exchange of water vapor between ground and the interior environment. Depending on the moisture levels on the ground and the thermophysical characteristics of the roof materials as well as the presence of insulation, condensation mostly occurs under the roof material (Neolithic Houses at Çatalhöyük -south enclosure- (Turkey)). Besides, it may occur on the surface of the remains which are colder than the interior atmosphere (Roman Villa at Piazza Armerina (Sicily, Italy) (A), Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C), Villas Dionysos and Danae at Zeugma (Turkey) (E).

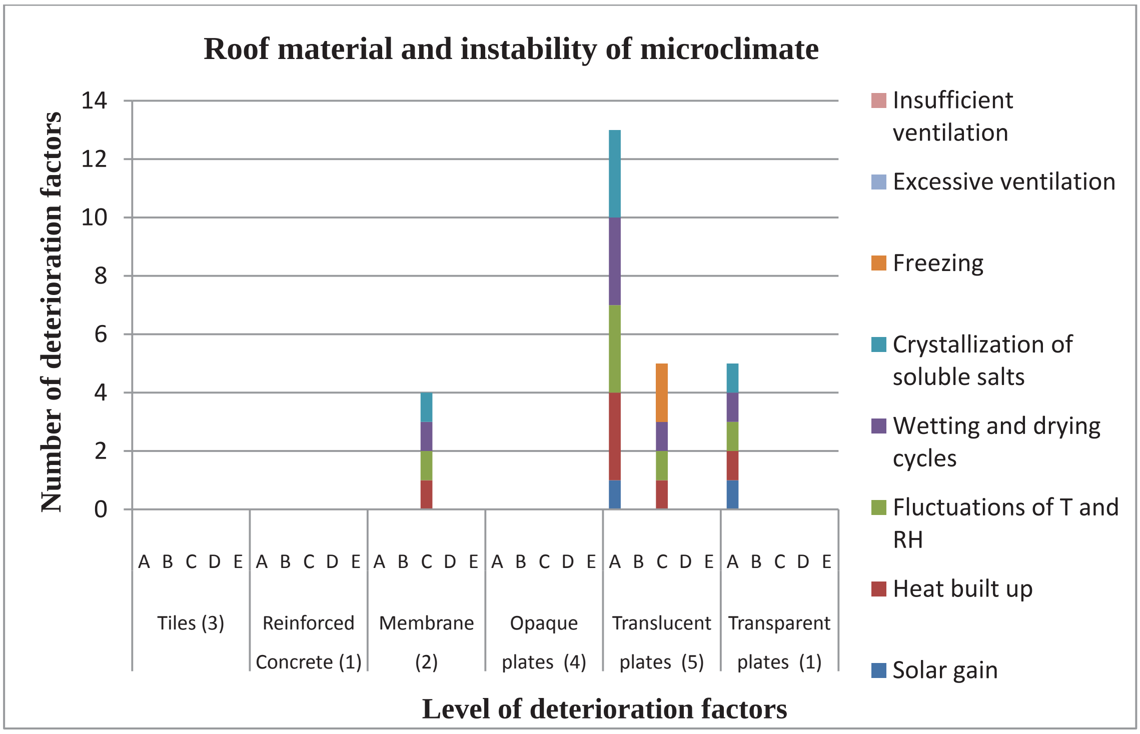
Another important issue related to the roof materials and sources of water is percolation through the cracks in the roof. Although the condition is related with roof material, it is basically associated with lack of maintenance (Figure 4. 3).

Figure 4. 3. Percolation through cracks in the roof material.

4.4.2. The Relationship between Roof Material and Instability of Microclimate

The analysis of the case study examples has shown that the roof material can directly be associated with heat built up, fluctuations of temperature and relative humidity, wetting and drying cycles, crystallization of soluble salts and freezing (Table 4. 9). Usage of panels as roof materials without insulation created less stable interior environment than tiles and reinforced concrete. Among the three categories the panels are grouped in this study, transparent panels are identified as the source for the most severe problems caused by the instability of microclimate (Roman Villa at Piazza Armerina (Sicily, Italy) (A)). Besides, as mentioned in the heading 4.4.1, translucent plates on the roof caused unstable interior environment at majority of the five sites (Roman Villa at Piazza Armerina (Sicily, Italy) (A), Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (A), Villas Dionysos and Danae at Zeugma (Turkey) (C)). Additionally, of the 2 sites with membrane roof material, unstable environment were observed on a moderate level at Terrace House 2 at Ephesus (Turkey).

Table 4. 9. The relationship between roof material and instability of microclimate.



- Since transparent and translucent panels allow high solar gain, heat builds up inside the enclosed structure. Because of the high thermal conductivity of the panels give rise to fluctuations of temperature and relative humidity. In the case of enclosures with poor air ventilation, where humid air is trapped inside, providing the conditions mentioned in the heading 4.4.1, transparent and translucent panels also trigger wetting and drying cycles which activate and accelerate salt crystallization (Roman Villa at Piazza Armerina (Sicily, Italy) (A), Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (A), Villas Dionysos and Danae at Zeugma (Turkey) (C)). When the excessive moisture condenses the level of deterioration depends on the water content of the soil as well as the concentration of salts (Ha'obsh 2008).
- At the Terrace House 2 at Ephesus (Turkey), heat builds up since membrane roof material fails in reducing the effects of solar gain. Even though almost all of the façade consists of louvers, in case of stagnant air, increase of temperature and fluctuations of temperature and relative humidity were observed.
- Especially on cold climates, if the panel components are applied without proper insulation, the interior temperature can drop below the freezing temperature generating freeze/thaw events (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C)).

4.4.3. The Relationship between Roof Material and Activities of the Living

No significant evidence was found suggesting that the roof materials are directly related to the problems caused by the activities of the living.

4.5. Façade System of Protective Structures

The relation between façade system and the factors that cause conservation problems has been examined. The protective structures in this study were grouped under four categories according to the design system to enhance the level of air flow. Among the selected cases, there is one protective structure with permeable façades, two with louvers, two partially removing sides in summer and six impermeable façades.

4.5.1. The Relationship between Façade System and Sources of Water

The façade system of the protective structures rarely causes rain penetration and condensation (Table 4. 10). At some cases, the louvers built on façade for providing enhance air ventilation, also allowed wind driven rain to penetrate from the prevailing wind direction inside during storms (Terrace House 2 at Ephesus (Turkey) (E), Building Z at Pergamon (Turkey) (E)). Louvers and permeable façade systems acting as a natural way of air ventilation also cause continuous heat and humidity transfer between inside and outside. Therefore, the interior environment is considerably no different from the external environment (Woolfitt 2007). That is, atmospheric events such as condensation events are formed inside the protective structure as well (Terrace House 2 at Ephesus (Turkey) (E), Villas Dionysos and Danae at Zeugma (Turkey) (E)).

4.5.2. The Relationship between Façade System and Instability of Microclimate

It is possible to say that the deterioration factors created by the façade systems are mainly related to the ability of the façade to enhance or reduce natural ventilation (Table 4.11). Commonly observed factors can be listed as insufficient ventilation on

Table 4. 10. The relationship between façade system and sources of water.

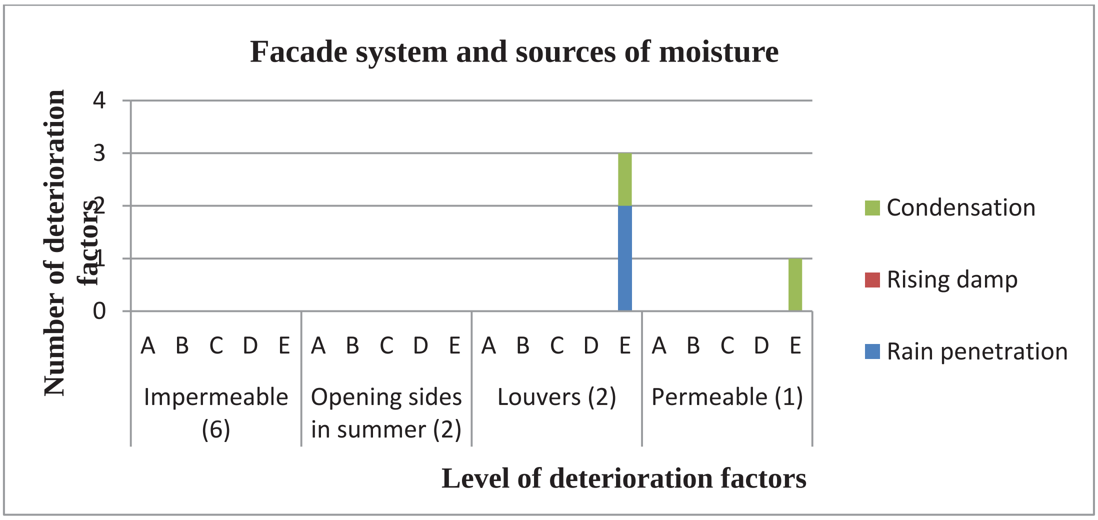
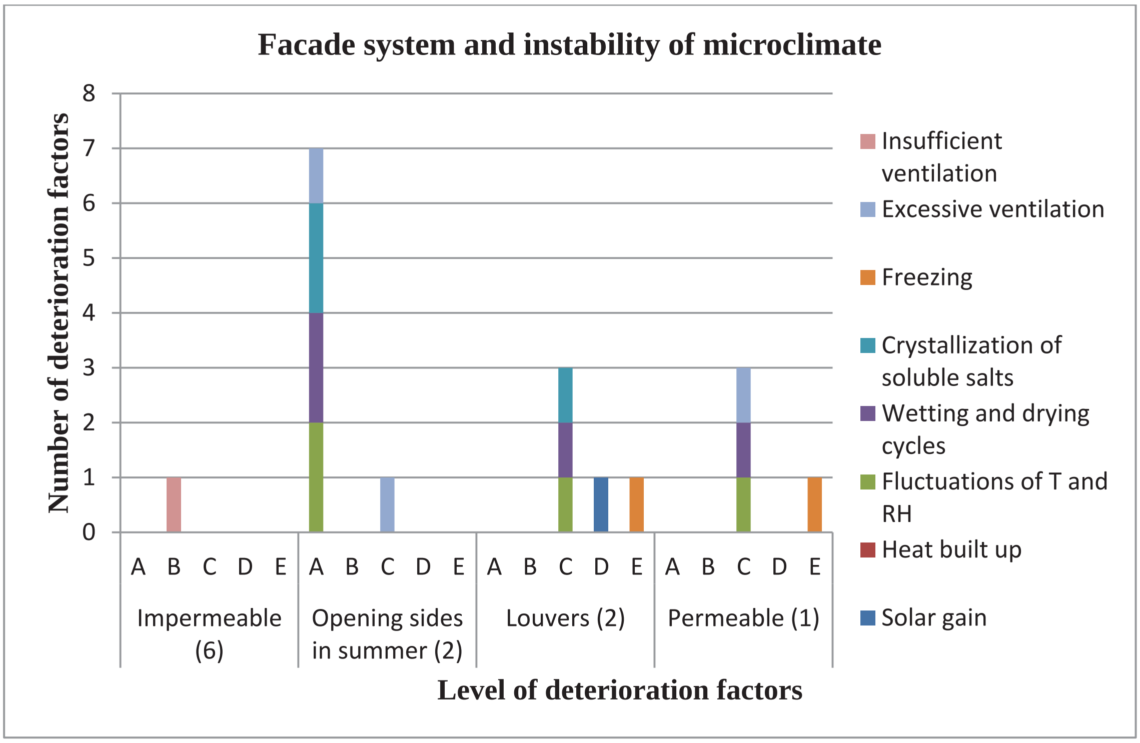


Table 4. 11. The relationship between façade system and instability of microclimate.



impermeable façade (St. Stephen Complex at Um er-Rasas (Jordan) (B)), excessive ventilation on partially removing sides (Neolithic Houses at Çatalhöyük (Turkey) -north enclosure (A), Neolithic Houses at Çatalhöyük -south enclosure- (Turkey) (C)). The problems related to these factors are fluctuations of temperature and relative humidity, wetting and drying cycles and crystallization of soluble salts (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C)). Also, since façade with louvers and permeable façade systems easily transmits the exterior environmental conditions to the interior environment, therefore fluctuations of temperature and relative humidity, wetting and drying cycles and crystallization of soluble salts were observed (Terrace House 2 at Ephesus (Turkey) (C), Villas Dionysos and Danae at Zeugma (Turkey) (C)). In addition, gaps between the louvers at the Terrace House 2 at Ephesus (Turkey) caused solar gain at slight level.

- Inside impermeable façades, if necessary precautions are not taken, air becomes stagnant due to the lack of proper air ventilation (St. Stephen Complex at Um er-Rasas (Jordan)). This eventually accelerated the deterioration process that related to high relative humidity.

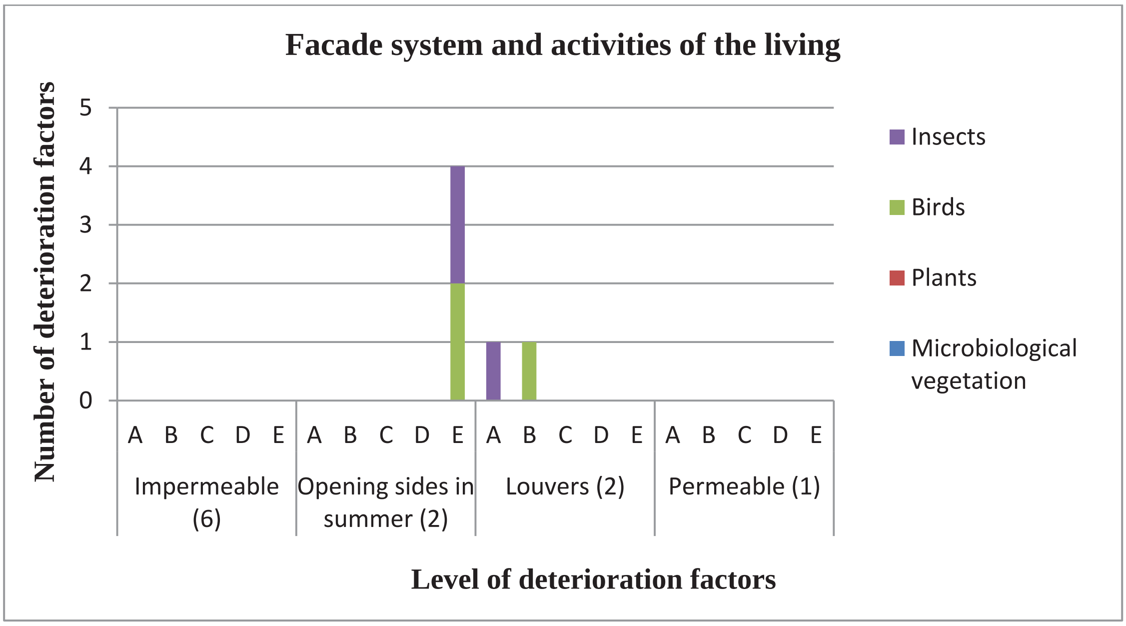
Figure 4. 4. Solar radiation on the paintings at the Terrace House 2 at Ephesus (Turkey).

- The partially or fully opening of façades of protective structures which are enclosed during wintertime may result in rapid changes of temperature and relative humidity levels in the structure. Strong air flow triggers the evaporation of the moisture content of the remains causing salt crystallization on or under their surface, depending on the evaporation speed Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures.
- Since façades with louvers and permeable façades allow the exterior atmospheric conditions directly affect the interior microclimate, fluctuations of temperature and relative humidity, wetting and drying cycles, crystallization of soluble salts (Terrace House 2 at Ephesus (Turkey) (C), Villas Dionysos and Danae at Zeugma (Turkey) (C)) and freezing Terrace House 2 at Ephesus (Turkey) (C), Villas Dionysos and Danae at Zeugma (Turkey) (C)) have been observed.
- Protective enclosures with louvers at the façades may allow the sun to pass through the gaps onto the remains at Terrace House 2 at Ephesus (Turkey) (Figure 4. 4). Exposure to solar radiation may cause fading of wall paintings in addition to the increase of the surface temperature and consequently formation of cracks on the surface depending on the thermal expansion (Feilden 2001).

4.5.3. The Relationship between Façade System and Activities of the Living

Conservation issues associated with façade systems and related to the activities of the living are primarily caused by animals, especially birds and insects (Table 4. 12). The Terrace House 2 at Ephesus (Turkey), one of the three sites with louvers on façades, problems caused by invasion of wasps (A) and birds (B) has been observed as explained in the heading 4.3.3. Birds and insects are also observed at sites with partially removing façades in summer (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (E)). On the other hand presence of rodents, which is the most critical problem at Çatalhöyük, cannot be associated with any design characteristics of the protective structure.

Table 4. 12. The relationship between façade system and activities of the living.



4.6. Façade Material of Protective Structures

At the analyzed protective structures with façades, stone masonry, perforated sheets (such as aluminum mesh and PVC textile), opaque (such as steel and fiberboard) plates, translucent plates (such as polycarbonate and fiberglass) and transparent plates (such as glass and polycarbonate) are used as façade materials. Stone masonry and perforated sheets are each used at one site. Three of the protective structures have opaque plates, two of them have translucent plates, and six of them have transparent plates as façade materials.

4.6.1. The Relationship between Façade Material and Sources of Water

Conservation problems related with sources of water, condensation is identified as the primary factor due to the façade material (Table 4. 13). The condensation problem was mostly observed at sites with transparent (Roman Villa at Piazza Armerina (Sicily, Italy) (A), Fortification Walls of Capo Soprano at Gela (Sicily,
enclosures- (Turkey) (C)) materials as described in the heading 4.4.1. Additionally, perforated façades at Italy) (A)) and translucent (Neolithic Houses at Çatalhöyük - south and north- enclosures (Turkey), the Villas Dionysos and Danae at Zeugma (Turkey) created internal environment considerably same with the external environment. Therefore, when the exterior temperature comes near dew point, formation of condensation was unavoidable (Villas Dionysos and Danae at Zeugma (Turkey) (E).

4.6.2. The Relationship between Façade Material and Instability of Microclimate

The analysis of the case studies has shown that there is a close relation between the façade materials and the deterioration factors by instability of microclimate. Such factors are heat built up, fluctuations of temperature and relative humidity, wetting and drying cycles, crystallization of soluble salts and freezing and excessive ventilation (Table 4. 14). The most critical problems were identified as being caused by the use of transparent and translucent panels. At five of the studied six structures with transparent façade materials (Fishbourne Roman Palace at West Sussex (UK) (A), Roman Villa at

Piazza Armerina (Sicily, Italy) (A), Chedworth Roman Villa at Gloucestershire (UK) (C), Terrace House 2 at Ephesus (Turkey) (C), Fortification Walls of Capo Soprano at Gela

(Sicily, Italy) (A)) and at both of the two structures with translucent façade materials (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C)) caused interior temperatures increase to extremely high temperatures combined with fluctuations of relative humidity, wetting and drying cycles and crystallization of soluble salts. In addition, these materials are also inadequate to protect the remains from freezing on cold climates with high levels of frost occurrence (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C)). While causing moderate excessive ventilation (Zeugma (C)) followed by fluctuations of temperature and relative humidity and wetting and drying cycles, perforated sheets have also caused very slight freezing because of their thermal permeable attitudes.

- Even in cold climate regions, as illustrated at Chedworth Roman Villa at Gloucestershire (UK) (C), solar radiation has a remarkable affect to increase the surface temperature which accelerates evaporation of ground moisture and activates salt crystallization on the surfaces of the remains.

Table 4. 13**.** The relationship between façade material and sources of water.

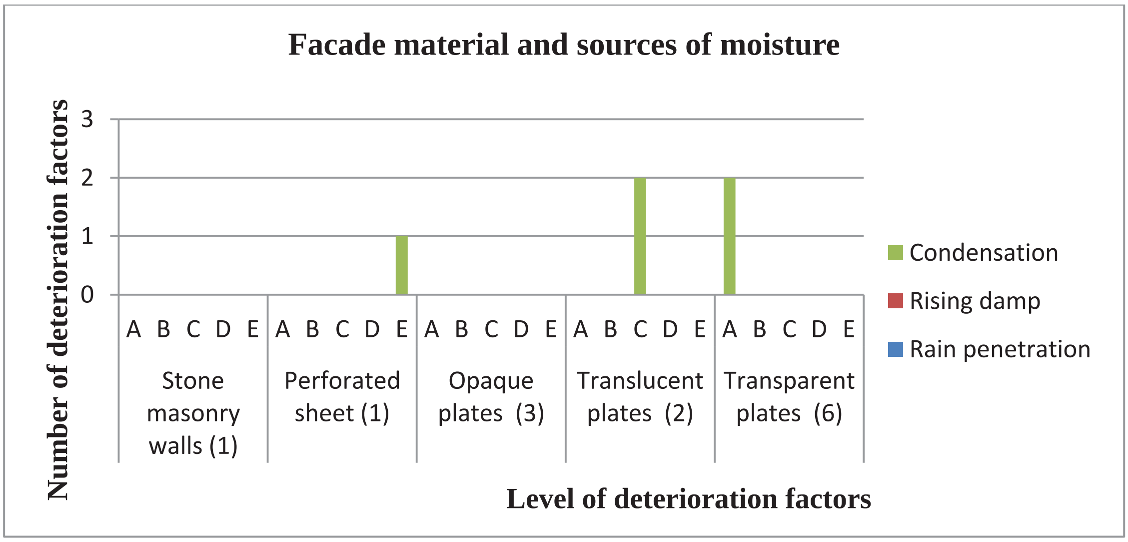
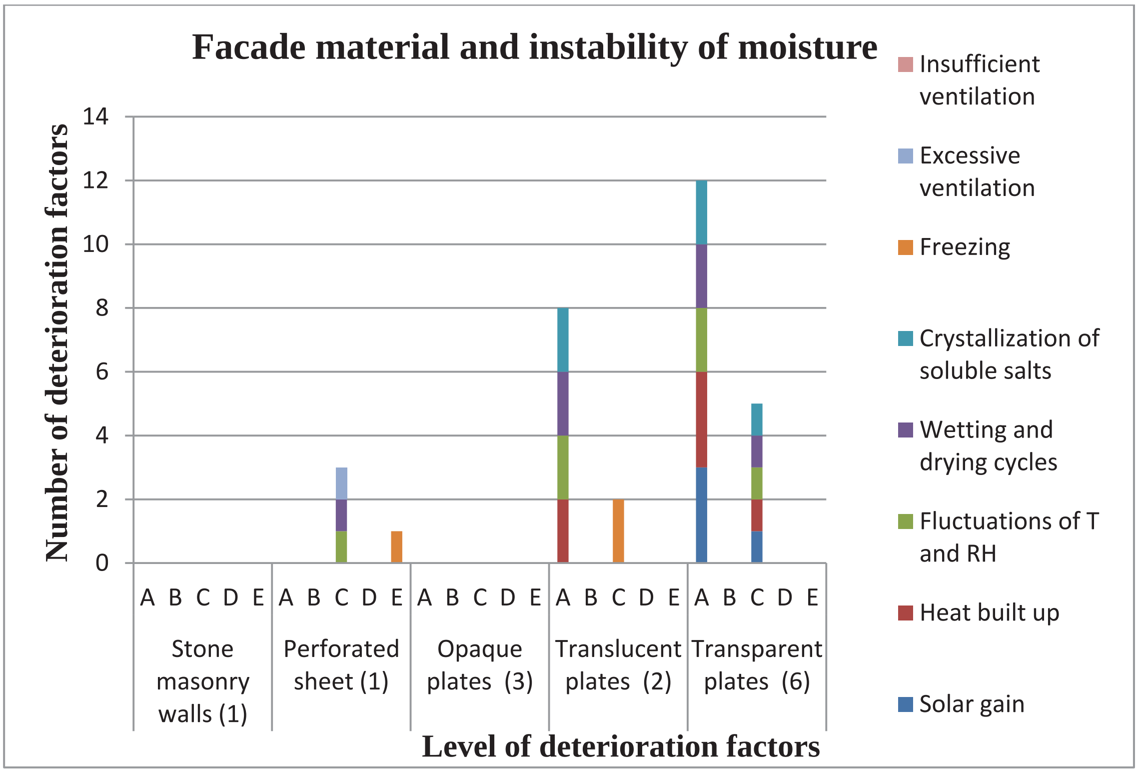


Table 4. 14. The relationship between façade material and instability of microclimate.



4.6.3. The Relationship between Façade Material and Activities of the Living

The façade material and the activities of the living are not directly related to cause damage. However, transparent glass panels mounted on the surface of the mudbrick structure to protect the remains against wind driven rain in addition to the shelter at the Fortification Walls of Capo Soprano at Gela (Sicily, Italy) caused very severe damage. The transparent panels created an environment with high in temperature and relative humidity between the panels and the wall, which was suitable for plant growth and colonization of animals such as snakes, bats and insects. Although the panels were mounted to as a component of shelter design, they are evaluated as an intervention on the walls rather than façade of the protective structure.

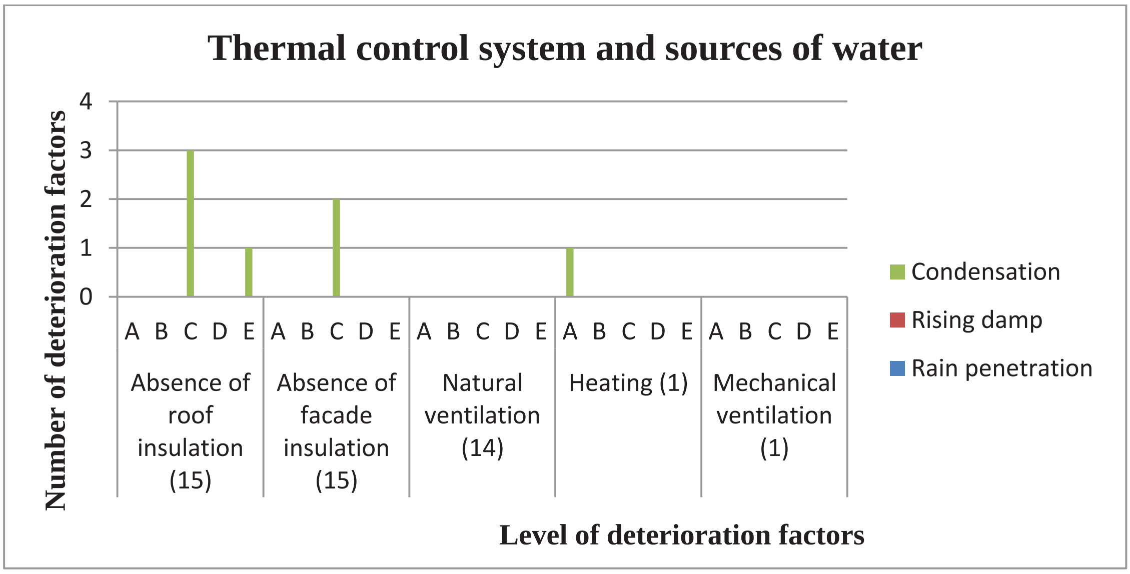
4.7. Thermal Control System of Protective Structures

The thermal control systems of the analyzed protective structures were determined as roof insulation, façade insulation, natural ventilation, mechanical ventilation and heating systems. Most of the selected cases are with no insulation except from one site with roof and façade insulation. In addition, all of the structures are ventilated naturally, only one has mechanical ventilation and another has a heating system.

4.7.1. The Relationship between Thermal Control System and Sources of Water

The main issue related to sources of water associated with the thermal control system of the protective structure is condensation (Table 4. 15). Absence of roof insulation (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C), Nile Festival Building at Zippori (Israel) (C) and Terrace House 2 at Ephesus (Turkey) (E)) and absence of façade insulation (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C)) are the main factors of condensation. In addition lack of natural ventilation and presence of heating system at Chedworth Roman Villa at Gloucestershire (UK) caused very severe damage due to formation of condensation.

Table 4. 15. The relationship between thermal control system and sources of water.

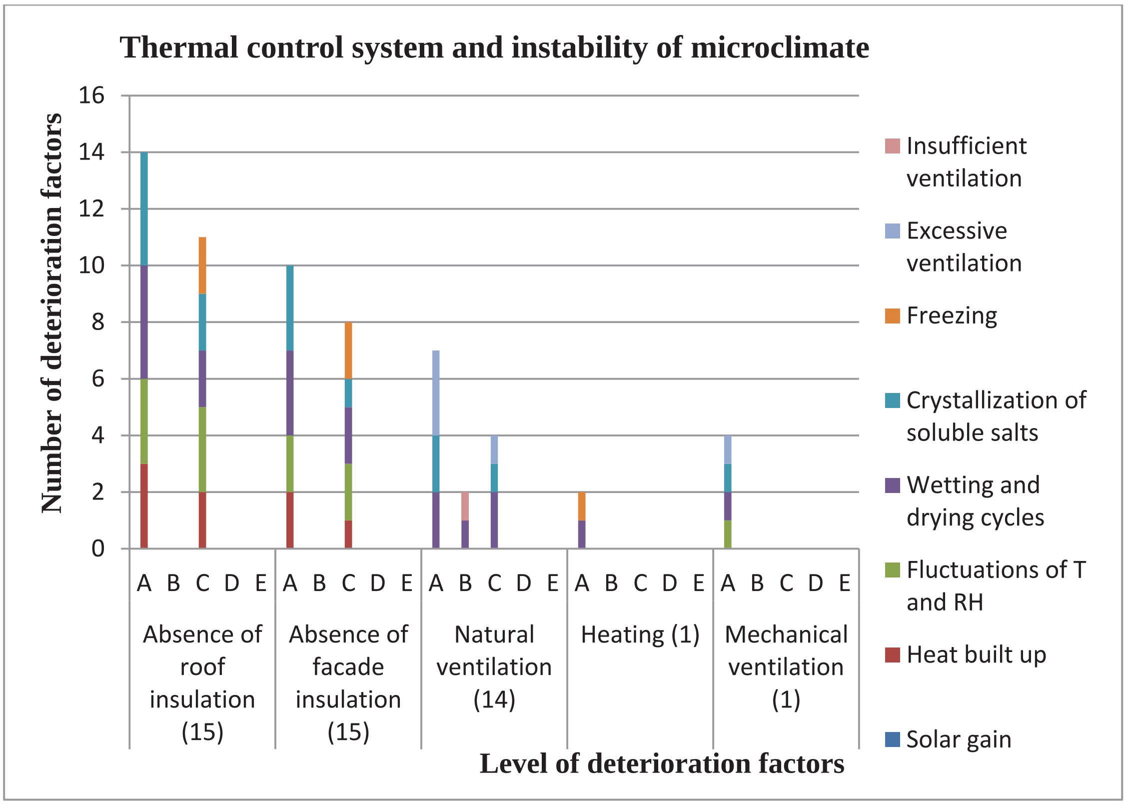


- Façade and roof panels which are mostly made of materials with high thermal conductivity, they fail to provide stable microclimate in absence of insulation. As stated in the heading 4.4.1 condensation is formed (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures).
- At the Nile Festival Building at Zippori (Israel), absence of roof insulation caused condensed water on the roof material. The reason for condensation on such sites can be explained as the difference in thermal conductivity of the materials and lack of insulation (Neguer and Alef 2008).
- In cold climates ambient temperature around the dew point of the air is critical for the formation of condensation. To prevent the damage, at the site of Chedworth Roman Villa at Gloucestershire (UK), a heating system had been installed. However, inefficient ventilation caused increase of the amount of moisture in the air, as well as the formation of condensation.

4.7.2. The Relationship between Thermal Control System and Instability of Microclimate

The analysis of the case studies has shown that the thermal control system used at the protective structure is directly related to create damage heat built up, fluctuations of temperature and relative humidity, wetting and drying cycles, crystallization of soluble salts, freezing and excessive or inefficient ventilation (Table 4. 16). Throughout the selected cases of this study, the thermal control systems applied to design of the protective structures are grouped under 5 categories: absence of roof and façade insulation, natural ventilation, mechanical ventilation and heating. Absence of roof and façade insulation, have either gave rise to increased heat built up, fluctuations of temperature and relative humidity, wetting and drying cycles which activated crystallization of soluble salts at seven of eight selected shelters (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (A), the Fishbourne Roman Palace at West Sussex (UK) (A), St. Stephen Complex at Um er-Rasas (Jordan) (A), Terrace House 2 at Ephesus (Turkey) (C), the Villas Dionysos and Danae at Zeugma (Turkey) (C), the Nile Festival Building at Zippori (Israel) (C)). They have also caused freezing ((Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C)).

Table 4. 16. The relationship between thermal control system and instability of microclimate.



Damage caused by excessive ventilation was identified as the most important issue after insulation. At seven out of thirteen protective structures, conservation problems were caused by excessive ventilation (Citadel Wall and the Megaron at Troy (Turkey) (A), (Great House Ruins at Arizona (USA) (A), Neolithic Houses at Çatalhöyük -north enclosures- (Turkey) (A), Alaeddin Kiosk in Konya (Turkey) (B), Neolithic Houses at Çatalhöyük -south enclosures- (Turkey) (C), Terrace House 2 at Ephesus (Turkey) (C), Villas Dionysos and Danae at Zeugma (Turkey) (C)), whereas at St. Stephen Complex at Um er-Rasas (Jordan) site insufficient ventilation was the cause of severe damage. Mechanical ventilation, used as the thermal control system at Fishbourne Roman Palace at West Sussex (UK), caused very severe damage due to fluctuating relative humidity and vaporization of ground waters that accelerated salt crystallization.

Heating systems, although not commonly used, can be the only way to prevent frost on cold climates. However, at Chedworth Roman Villa at Gloucestershire (UK) (A) heating system which was controlled thermostatically was inefficient to prevent wetting and frost damage to the remains. Hence, thermostatically heating system was replaced with humidistatic control to reduce condensation.

- Especially when the roof and façade elements with high thermal conductivity are not properly insulated it fails to prevent heat buildup and fluctuations of temperature and relative humidity inside the enclosed space. In addition, when it does not efficiently ventilated excessive moisture is produced indoors, which gives rise to wetting and drying cycles and salt crystallization as explained in the heading 4.4.1 (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures, Fishbourne Roman Palace at West Sussex (UK), St. Stephen Complex at Um er-Rasas (Jordan), Terrace House 2 at Ephesus (Turkey), Villas Dionysos and Danae at Zeugma (Turkey), Nile Festival Building at Zippori (Israel).
- When the exterior temperature decrease to 0^oC, if proper insulation of the roof and façade components are not applied, the protective structure does not able to prevent the interior temperature also dropping at or below freezing (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures).
- Natural and mechanical ventilation are also important causes of damage. Drying due (Citadel Wall and the Megaron at Troy (Turkey), rapid drying and salt crystallization (Neolithic Houses at Çatalhöyük - south and north enclosures- (Turkey) and surface erosion (Great House Ruins at Arizona (USA) (A)) are the issues related with excessive air flow. On the other hand, at the St. Stephen Complex at Um er-Rasas (Jordan), inefficient ventilation increased interior humidity levels and created damage depending on changing physical phases of water.
- Mechanical ventilation at the Fishbourne Roman Palace at West Sussex (UK) caused fluctuations of temperature and relative humidity which accelerated evaporation of ground waters as well as salt crystallization.

4.7.3. The Relationship between Thermal Control System and Activities of the Living

The study has shown that there is no direct relation between thermal control systems and the conservation problems caused by the activities of the living. However, it is noteworthy to mention that presence of black-colored microorganisms at the Nile

Festival Building at Zippori (Israel) (B) was formed by the droplets on the fiberboard due to absence of insulation as explained in the heading 4.7.1.

4.8. Drainage System of Protective Structures

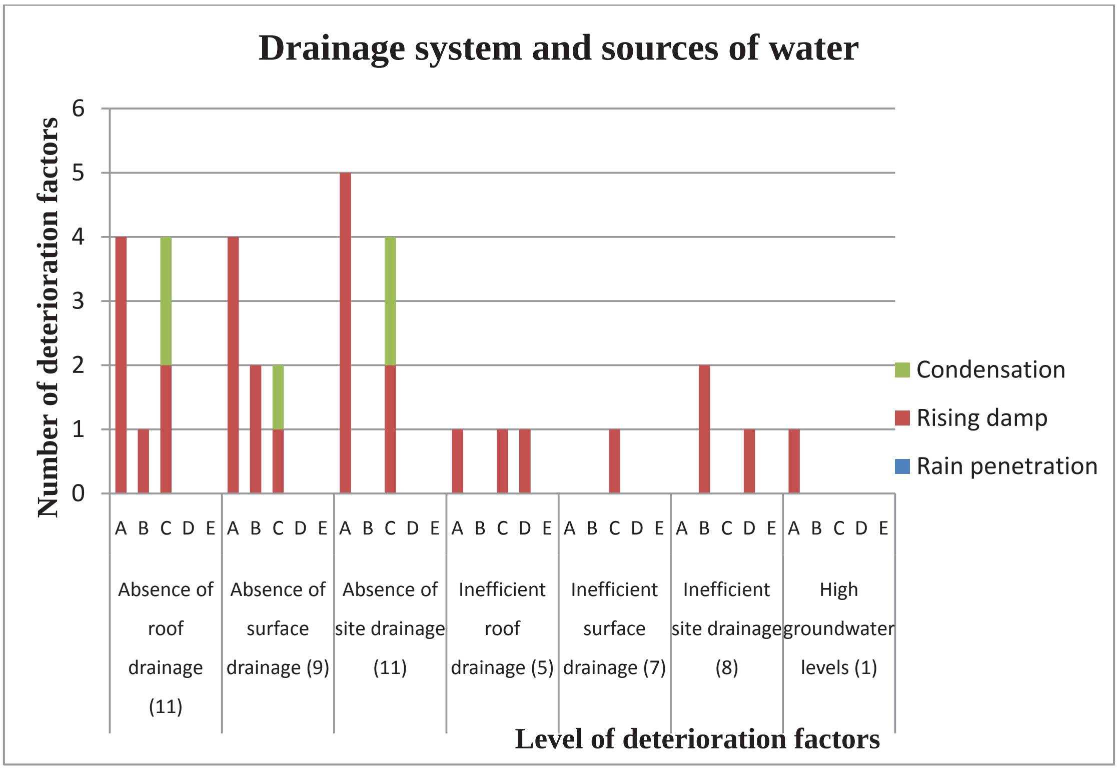
In the scope of this study, drainage systems of protective structures are categorized as roof drainage, surface drainage and site drainage. The analysis of the case studies are carried according to either presence and efficiency of the drainage systems. Only most of the protective structures do not have draniage systems and the rest which have roof, surface or site are mostly fail to divert rain water properly away from the site.

4.8.1. The Relationship between Drainage System and Sources of Water

The primary moisture related conservation problem was rising damp (Table 4. 17). The main factor of rising damp was identified as the absence of aproper drainage system at seven structures (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (A), Alaeddin Kiosk in Konya (Turkey), St. Stephen Complex at Um er-Rasas (Jordan) (A), Archaic and late Roman remains at Sardis (Turkey) (A), (Roman Town House at Dorchester (UK) (B), Terrace House 2 at Ephesus (Turkey) (B) Citadel Wall and the Megaron at Troy (Turkey) (C), Great House Ruins at Arizona (USA) (C)). Considering the one, those which had a roof, surface or site drainage, but absence of a complete water disposal system and faulty gutters were also caused rising damp (Archaic and late Roman remains at Sardis (Turkey) (A), Citadel Wall and the Megaron at Troy (Turkey) (C), Roman Town House at Dorchester (UK) (B), Terrace House 2 at Ephesus (Turkey) (B and D), Roman Villa at Piazza Armerina (Sicily, Italy) (C), Building Z at Pergamon (Turkey) (D)).

Apart from the drainage system, another reason for rising damp was the high ground level at the site (Fishbourne Roman Palace at West Sussex (UK) (A)). Similarly, undrained rainwater around the enclosure enhances the condensation events when combined with instable environment (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (C)).

Table 4. 17. The relationship between drainage system and sources of water.



- Protective structures are designed to protect the remains from the effects of atmosphere, especially from rain; but, it has been observed that the absence of roof drainage system is a common flaw in the architectural design of most of these structures. Rain water dripping from the roof puddles around the perimeter of the structure and evaporate as the interior relative humidity level is lower than the exterior. Subsequently when the relative humidity level of interior environment increases, it becomes sensitive to condensation as explained in the heading 4.4.1 (Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures).
- In the case of inefficient or non-existent site drainage, undrained water may cause rising damp by triggering water diffusion from ground to the remains (Citadel Wall and the Megaron at Troy (Turkey)). In addition, wind driven rain and snow may cause the wetting of the protected area. When not drawn away properly, the accumulated rain water may cause rising damp (Great House Ruins at Arizona (USA)).
- At sites without roof and surface drainage, rising damp can be caused by the accumulation of water on the leveled outer perimeter of the protective structure on a

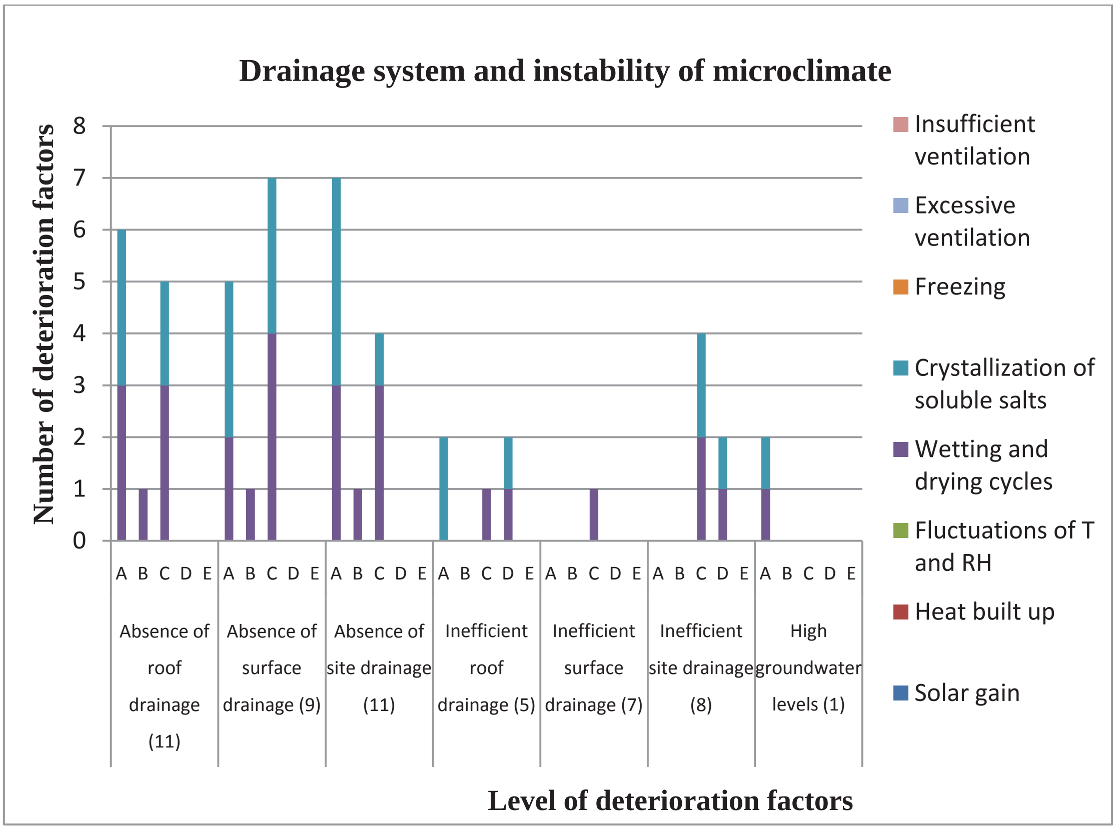
sloped terrain (Terrace House 2 at Ephesus (Turkey), Neolithic Houses at Çatalhöyük -south enclosure- (Turkey)).

- Topography and the level of the ground can address rising damp and associated damages. Even the roof, surface or site drainage systems exist at a protective structure located on a hillside, drainage of rain water still can be damaging as the water accumulate on the upper side of the structure in the direction of the slope (Building Z at Pergamon (Turkey)). In addition, rising damp can also be observed at sites which have floors with lower elevation than the surrounding terrain (St. Stephen Complex at Um er-Rasas (Jordan)).
- High groundwater level is also an important cause of rising damp. The level of damage is related with presence of a proper drainage system and stability of interior microclimate. At the Fishbourne Roman Palace at West Sussex (UK), glazed south façade and presence of mechanical ventilation triggered the damage by evaporation.
- Not to mention, faulty disposal system that does not pump away the water from the remains (Roman Villa at Piazza Armerina (Sicily, Italy)), in addition to lack of maintenance of gutters and down pipes give rise to water related damage (Archaic and late Roman remains at Sardis (Turkey)).

4.8.2. The Relationship between Drainage System and Instability of Microclimate

It seems, there is no direct relation between the drainage systems and the factors of instable microclimate. However, absence or inefficiency of drainage system is the main source of water from ground as explained in the heading 4.8.1. In presence these conditions, the environment is sensible to wetting and drying cycles, followed by the crystallization of soluble salts (Table 4. 18) (Neolithic Houses at Çatalhöyük (Turkey) -south and north enclosures (A), St. Stephen Complex at Um er-Rasas (Jordan) (A), Archaic and late Roman remains at Sardis (Turkey) (A, C), Alaeddin Kiosk in Konya (Turkey) (B), Roman Town House at Dorchester (UK) (C), Great House Ruins at Arizona (USA) (C), Roman Town House at Dorchester (UK) (C), Citadel Wall and the Megaron at Troy (Turkey) (C), Building Z at Pergamon (Turkey) (D), Fishbourne Roman Palace at West Sussex (UK) (B)).

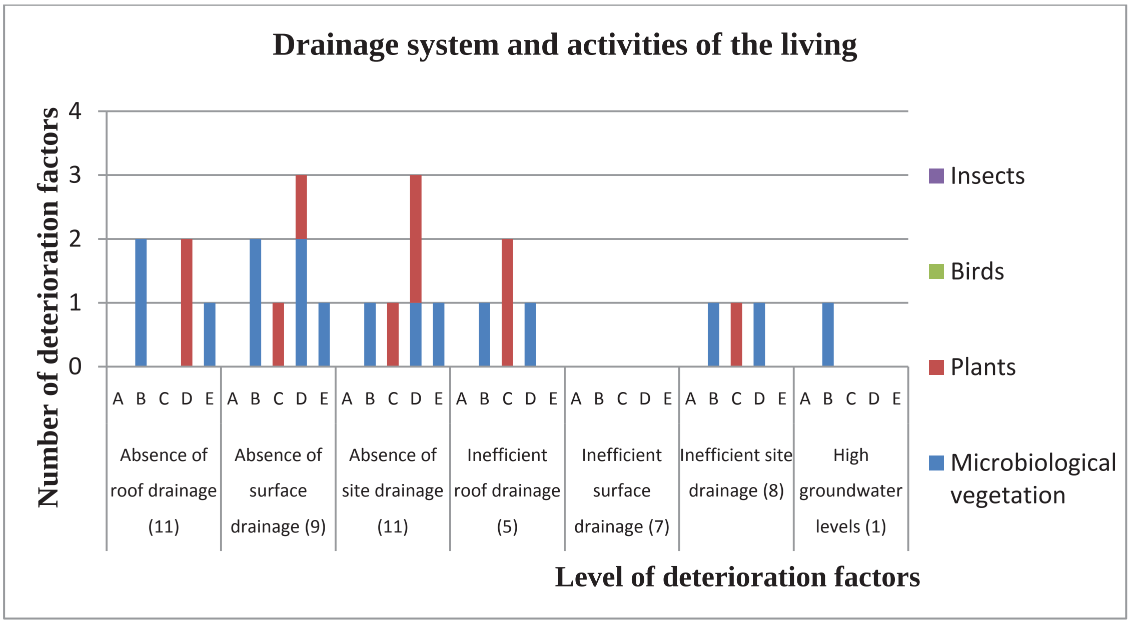
Table 4. 18. The relationship between drainage system and instability of microclimate.



4.8.3. The Relationship between Drainage System and Activities of the Living

There were no enough evidence to suggest that there is a direct relation between the drainage system and the problems caused by the activities of the animals (Table 4. 19). While most of the conservation problems were caused by the absence of drainage system (St. Stephen Complex at Um er-Rasas (Jordan) (B), Roman Town House at Dorchester (UK) (B), Neolithic Houses at Çatalhöyük (Turkey) - south and north enclosures (D), Terrace House 2 at Ephesus (Turkey) (D), Archaic and late Roman remains at Sardis (Turkey) (D), Alaeddin Kiosk in Konya (Turkey) (E)) and inefficiency of drainage system (Roman Villa at Piazza Armerina (Sicily, Italy) (B), Roman Town House at Dorchester (UK) (B) Terrace House 2 at Ephesus (Turkey) (C), Archaic and late Roman remains at Sardis (Turkey) (D)) high water tables (Fishbourne Roman Palace at West Sussex (UK) (B)) also caused of microbiological growth and plant growth.

Table 4. 19. The relationship between drainage system and activities of the living.



CHAPTER 5

CONCLUSIONS

Protective structures are built to protect the works of the past, which have cultural and historical significance, from the continuous deterioration effects of atmospheric conditions for long term survival. Although the structures that were built according to this concept have proven to play an important part to serve this purpose, a shelter or an enclosure does not guarantee full elimination of the conservation problems and long term protection. The site characteristics such as location, climate region, topographic properties and the type of remains may cause or accelerate various deterioration problems depending on the architectural design characteristics of the protective structure.

The conservation issues observed on remains protected by enclosures and shelters are commonly related to, caused by or accelerated with the presence of water. The main source of water is rising damp, either because of the absence or the inefficiency of drainage systems. Condensation, which is basically the transformation of water vapor in the air into droplets of water in instable environments due to the absence or inadequacy of insulation, is another source of water. Absence of insulation and use of transparent and translucent material at the outer shell of the protective structures give rise to extremes in temperature as well as fluctuations of temperature and relative humidity. Another issue is the damage by the living such as the growth of vegetation and uninvited animals under the protective structures. Growth of microbiological vegetation is mostly observed on the mosaic surfaces due to ground moisture in absence or inefficiency of drainage systems. Moreover, presence of acid rich bird droppings, holes by rodents, wasp and arachnids are among the critical damaging factors.

Identifying, assessing and analyzing the problems that have been observed on archeological sites under protective structures is clearly of great importance for taking necessary precautions to prevent such problems starting from the design process. The typology, structural system, roof and façade system, roofing and façade materials, application of thermal control system and application of proper drainage are amongst the most critical decisions of the design process of a protective structure which have to be considered in order to enhance the protective efficiency of the structure.

Regarding the selected case study examples in this study the conclusions may be handled for design characteristics as below:

Shelters, while providing protection against vertical rain and direct sun, may not protect the remains against the damaging effects of wind-driven rain, wind and animals. The remains under the shelter may be easily affected by the atmospheric events (high temperature and relative humidity, fluctuations in temperature and relative humidity, freeze-thaw cycles). Therefore, shelters should not be preferred as protective structures for the types of remains which are sensitive to fluctuations of temperature and relative humidity.

The most important aspect of a shelter's design is to prevent exposure to the horizontal rain and solar radiation. In order to provide such protection, the roof should cover remains and with a reasonable height. Water drainage across the site and around the shelter, is another important aspect to be considered during the design process. In the absence of a proper drainage system (rain gutters, roof drainage and site drainage), ponding water may increase the ground water table which then result in a rising damp problem.

Enclosures provide more protection than the shelters. In addition to providing protection against rain and sun, lateral sides prevent the uncontrolled invasion of animals. They also have the advantage of providing a much more controlled climatic environment compared to the shelters, creating its own micro climate. These advantages can turn into instable conditions if the architectural elements of the enclosure, such as the roof and the lateral façades, are not properly designed. The types of materials used for the roof and the lateral façades, the application of thermal control methods and the organization of the openings can be listed as the most important architectural design elements which affect the protection of the remains. On the other hand, the existence of proper drainage system is the primary factor which impacts the efficiency of the structure's performance.

Roof system: The main three roofs types are single-piece roof, segmented roof and roof with louvers. Segmented roofs generally consist of pieces with different height or shapes. Depending on the horizontal and vertical gaps between the pieces, these type of roofs may cause the remains to be exposed to solar radiation and rain. For this reason, single-piece roofs are more advantageous than segmented roofs.

Important aspects to be taken into consideration when designing multi-piece roofs are that the heights of the pieces should not be too much different, pieces should mostly cover each other, and the pieces should not allow rain penetration on the remains. Also, the gaps between the pieces should be covered with a material that does not let the birds in.

Façade systems**:** In terms of façade systems, protective structures can be divided into four subgroups: Impermeable façades, opening sides in seasons, louvers, permeable façades. A distinctive microclimate does not exist inside a structure with façades built of permeable materials. Climatically, they are affected by the fluctuations of exterior temperature, humidity and wind, but they have the advantage of keeping the animals outside.

Opening all or some parts of façade elements during summer season is a design concept applied to some protective structures. Removal of the lateral façades causes a rapid change of temperature and relative humidity values of the internal environment due to a sudden air flow from outside. Being exposed to excessive air flow may trigger subflorescences due to instant drying.

Façades with louvers may cause the interior conditions be close to the exterior climatic conditions, depending on the size and distribution. Being affected by the fluctuations in temperature, humidity and wind just like shelters, the inlets may allow rainfall as well. In addition, depending on the width and height of the inlets, various kinds of animals, such as bees, birds, cats and dogs can also find a way in.

Roof and façade materials: Using transparent and translucent materials such as glass or thermoplastic sheets for the roof and the façade surfaces leaves the remains exposed to solar radiation and may cause problems such as expansion and cracking due to overheating, in addition to color change due to UV. Also, on closed structures such as enclosures, a greenhouse effect associated with solar radiation from transparent surfaces, is inevitable. Extreme and fluctuating values of temperature and relative humidity inside the structure may trigger activities of soluble salts. Solar shading elements and eaves can be added to the architectural design in order to prevent exposure to solar radiation. To keep the interior climate as stable as possible, roof and façade materials should be carefully selected, according to their thermophysical properties such as low thermal conductivity and solar emissivity.

Thermal control systems**:** Various thermal control systems can be used in the design of a protective structure in order to create and maintain a stable internal microclimate. Some of these methods are roof and façade isolation, interior heating, natural and mechanical ventilation.

Even though importance of creating a stable interior microclimate is well known issue for the protection of remains, insulation is being ignored in the design process of protective structures. In some cases, even if insulation is added to the design, it cannot be applied due to its cost.

Unstable interior microclimate is generally the primary reason of deterioration in most of the protective structures. Inside structures without insulation, especially on cold regions, condensation is most likely to occur, causing the remains to get wet. Interior heating is a method generally used where frost is a problem. The method and the degree of heating are extremely important and should be applied carefully.

Inadequacy or nonexistence of ventilation can cause high humidity and also can lead to the creation of microbiological life forms; so proper ventilation is important. As discussed above, mechanical ventilation can cause problems such as uncontrolled temperature, relative humidity and air flow; so natural ventilation is preferred. By louvers on roof and façades, natural ventilation can be achieved inside the structure.

Site and roof drainage: The problems of most of the protective structures over archaeological sites can be directly associated with the lack or inefficiency of water drainage systems. Drainage can be examined in three subcategories: Site drainage, surface water drainage and roof drainage. If the drainage system is not properly designed or applied, ponding water may leak inside the protective structure, causing rising damp, wet-dry cycle and salt problems. Especially on a sloping terrain, water ponding on a relatively flat surface or on a slope facing the façade of the structure may cause the same problems described above. Even on protective structures with site and roof drainage, rising damp problem may still be observed under heavy rain.

As a result, the type of the protective structure as a shelter or an enclosure, selection of the design elements such as roof and façade systems as well as the materials, proper application of thermal control systems and drainage systems are the main characteristics of the design that determine the efficiency of the protective structures.

Being the first to evaluate the efficiency of most of the well known protective structures in Turkey, the study can be a starting point for further studies.

- This study is conducted on protective structures built to protect wall paintings and mudbrick structures due their fragile nature. In further studies, the number of the case study examples can be increased and protective structures built over stone and brick remains can be included to identify problems specific to those types of remains.
- With the help of microclimatic measurements to be conducted on protective structures in Turkey, the efficiency of the protective structure can be quantitatively evaluated. The results of the research can be used to determine the necessary improvements to be made on the design of current protective structures in order to increase their efficiency.
- Use of materials in existing protective structures can be analyzed in terms of their construction and maintenance capabilities such as practicality, durability, maintainability and reparability.
- The effects of the site characteristics such as location, climate region and topographic properties on the efficiency of the protective structures can be analyzed and evaluated.

REFERENCES

Accardi, Aldo R. D. 2008. "Architectures 'on Ruins" and Ambiguous Transparency: The Glass in Preservation and Communication of Archaeology." *Journal of Cultural Heritage* 9(2008):e107-e112.

Achleitner, Friedrich. 2000. "A Mine of Memories Coming to the Surface." In *A Roof for Ephesos: The Shelter for the Terrace House 2,* edited by Friedrich Krinzinger, 44-58. Wien: Österreichisches Archaologisches Institut.

Agnew, Neville, and Mary Wade. 1986. "A Case Study of a Palaeontological Site – The Need for Planning and Protection." In *Preventive Measures during Excavation and Site Protection,* 257-269. Rome: ICCROM.

Agnew, Neville, and Po-Ming Lin. 1991. "Environmental Monitoring of the Pophos Mosaics." In *The Conservation of the Orpheus Mosaic at Paphos, Cyprus,* edited by Jacki Gallagher, 42-45. California: Getty Conservation Institute.

Agnew, Neville, and Richard Coffman. 1991. "Development and Evaluation of Hexashelter." In *The Conservation of the Orpheus Mosaic at Paphos, Cyprus,* edited by Jacki Gallagher, 36-41. California: Getty Conservation Institute.

Agnew, Neville, Shin Maekawa, Richard Coffman, and Jeff Meyer. 1996. "Evaluation of the Performance of a Lightweight Modular Site Shelter. Quantitative Meteorological Data and Protective Indices for the Hexashelter." *Conservation and Management of Archaeological Sites* 1(3):139-150.

Agnew, Neville. 2001. "Methodology, Conservation Criteria and Performance Evaluation for Archaeological Site Shelters." *Conservation and Management of Archaeological Sites* 5(1&2):7-18.

Alef, Yael. 2002. *"Evaluation of Shelters over Mosaics in Israel."* Master diss., Katholieke Universiteit Leuven.

Altieri, Antonella, Marco Bartolini, Elisabetta Giani, Annamaria Giovagnoli, Maria Pia Nugari, Sandra Ricci 2006. "I Siti Campione: Collocazione Geografica e Caratteristiche." In *Le Coperture delle Aree Archeologiche*, edited by Maria Concetta Laurenti, 139-158. Roma: Gangemi.

Ampolo C., A. Carandini, G. Pucci, and P. Pensabene. 1971. "La Villa del Casale a Piazza Armerina: Problemi, Saggi Stratigrafici ed Altre Ricerche." *Mélanges de l'Ecole Française de Rome, Antiquité* 83:141-281.

Aslan, Zaki. 1997. "Protective Structures for the Conservation and Presention of Archaeological Sites." *Journal of Conservation and Museum Studies* 3. Accessed May 10, 2012. doi:http://dx.doi.org/10.5334/jcms.3974.

Aslan, Zaki. 1998. "*Archaeological Site Preservation and Environmental Conservation."* PhD diss., University College London.

Aslan, Zaki. 2001. "Designing Protective Structures at Archaeological Sites: Criteria and Environmental Design Methodology for a Proposed Structure at Lot's Basilica, Jordan." *Conservation and Management of Archaeological Sites* 5(1&2):73-85.

Aslan, Zaki. 2007. "The Design of Protective Structures for the Conservation and Presentation of Archaeological Sites in the Mediterranean" *ICCROM Newsletter* 33:14-15.

Avrami, Erica, Jake Barrow, Pamela Jerome, and Michael R. Taylor. 2001. "Protective Shelters for Archaeological Sites in the Southwest USA. A Colloquium Held at Tumacacori, Arizona 9-12 January, 2001." *Conservation and Management of Archaeological Sites* 5(1&2):3-6.

Bachmann, Martin, and Andreas Schwarting. 2005. *Pergamon Building Z: Protective Shelter for Roman Mosaics*. Dresden: Thelem.

Bachmann, Martin. 2006. "The Shelter over Bau Z in Pergamon." In *Management and Preservation of Archaeological Sites*, edited by Zeynep Ahunbay and Ülkü İzmirligil, 40-44. İstanbul: Yapı Yayın.

Bachmann, Martin, and Andreas Schwarting. 2008. "Conservation Projects in Pergamon. Building Z and the Shelter Constructed Above It." *Conservation and Management of Archaeological Sites* 10(2):157–173.

Bahtiyar, Metin. 1978. "Toprak Suyu, Toprakta Su Tutulması ve Rutubet Tansiyonu." *Atatürk Üniversitesi Ziraat Fakültesi Dergisi* 9(4):105-119.

Bernabo Brea, L. 1947. "Piazza Armerina: Restauri dei mosaici romani del Casale." *Notizie degli Scavi di Antichita*, 252-53.

Bertaux, Jean-Paul, Michel Goutal, Jean-Michel Mechling, Patrick Meistersheim, and Jean-Pierre Crevoisier. 1998. "The Gallo-Roman Sanctuary at Grand, France II: The Protection and Development of the Amphitheatre." *Conservation and Management of Archaeological Sites* 2(4):217-228.

Bethell, Philip. 2008. "140 Years of Mosaic Conservation at Chedworth Roman Villa, United Kingdom." In *Lessons Learned: Reflecting on the Theory and Practice of*

Mosaic Conservation, edited by Aicha Ben Abed, Martha Demas, and Thomas Roby, 230-237. Los Angeles, California: J. Paul Getty Trust.

Canobbio. 2013. “Capo Soprano” Accessed July 27. http://www.canobbio.com/architettura_tessile_eng.php.

Carroll, Scott. 1998. “Temporary Protection of a *Tel* Site Excavation in Central Turkey.” *Conservation and Management of Archaeological Sites* 2(3):155-162.

Çatalhöyük Research Project 2013a. “Site Management Plan.” Accessed February 17. http://www.catalhoyuk.com/smp/index.html.

Çatalhöyük Research Project. 2013b. “Buildings.” Accessed February 17. http://www.catalhoyuk.com/database/catal/buildings.asp?ListBy=Area.

Çatalhöyük Research Project. 2013c. “Çatalhöyük 2008 Raporu” Accessed February 17. http://www.catalhoyuk.com/downloads/RAPOR_Catalhoyuk_2008.pdf.

Çatalhöyük Research Project. 2013d. “Çatalhöyük Archive Report 2011” Accessed February 17. http://www.catalhoyuk.com/downloads/Archive_Report_2011.pdf.

Citterio, Marco, Elisabetta Giani. 2006a. “A Microclimatic Study for the Design of New Shelters for the Archaeological Site of Castellammare di Stabia-Naples.” In *Heritage, Weathering and Conservation,* edited by Rafael Fort, Monica Alvarez de Buergo, Miquel Gomez-Heras, and CarmenVazquez-Calvo, 403-408. London: Taylor&Francis Group.

Citterio, Marco, Elisabetta Giani. 2006b. “Clima e Microclima.” In *Le Coperture delle Aree Archeologiche. Museo Aperto,* edited by Maria C. Laurenti, 159-163. Roma: Gangemi.

Corney, Mark, and Peter W. Cox. 2007. “Colliton Park Roman Town House. A Preliminary Description of the Building, Archaeology, Setting and Reconstruction.” Accessed March 10, 2013. http://www.dorsetforyou.com/media.jsp?mediaid=168947&filetype= pdf.

Cosh, Stephen R. 2002. “Cover Buildings over Romano-British Mosaics.” *Mosaic: Bulletin of the Association for the Study and Preservation of Roman Mosaics* 29:4-8.

Cronyn, Janet M. 2002. *The Elements of Archaeological Conservation*. New York: Routledge.

Cultrera, Giovanni. 1936. “Sicilia, Piazza Armerina: Notiziario di scavi, scoperte, studi relativi all’Impero Romana.” *Bollettino Comunale di Roma* 68:129-30.

De Silva, T.K.P. 1986. Roof over a Monument Sri Lankan Experience. In *Preventive Measures during Excavation and Site Protection,* 271-279. Rome: ICCROM.

Demas, Martha. 1990. “*Preserving the Archaeological Record: Post Excavation Site Conservation.”* Master diss., Cornell University.

Demas, Martha. 1997. “Ephesus.” In *The Conservation of Archaeological Sites in the Mediterranean Region,* edited by Marta de la Torre, 127-149. Los Angeles: The J. Paul Getty Trust.

Demas, Martha. 2001. “Annotated Bibliography on Protective Shelters for Archaeological Sites.” *Conservation and Management of Archaeological Sites* 5(1&2):91-105.

Demas, Martha 2012. “Protective Shelters for Archaeological Sites.” In *Mosaic in situ. An Overview of the literature on conservation of mosaics in situ,* edited by Thomas Roby and Martha Demas, 1-75. Los Angeles: J. Paul Getty Trust.

Dikilitaş, Gülseren. 2010. “Arkeolojik Alanda Koruma.” *Restorasyon Konservasyon* 6:43-51.

Dorchester Dorset. 2013. “Roman Town House Dorchester.” Accessed March 10. http://www.dorchesterdorset.com/blog/general/roman-town-house-dorchester/.

Doumas, Christos. 1997. “Management Considerations at a Mediterranean Site: Akrotiri, Thera. In *The Conservation of Archaeological Sites in the Mediterranean Region,* edited by Marta de la Torre, 27-40. Los Angeles: The J. Paul Getty Trust.

Doumas, Christos and Nikos Fintikakis. 2006. “ Replacement of the Shelter – Conservation, Arrangement and Enhancement of the Archaeological Site at Akrotiri Thera.” Accessed September 10, 2006. http://www.santorini.net/94.html.

Earth Architecture. 2013. “Pre-History Meets Modernity: Casa Grande Ruins National Monument.” Accessed March 17. http://eartharchitecture.org/index.php?/archives/679-Pre-History-Meets Modernity-Casa-Grande-Ruins-National-Monument.html.

Edwards, Carol. 2003. “Roman Town House, Mosaics Conservation Study, Colliton Park, Dorchester.” Accessed March 10, 2013. http://www.dorsetforyou.com/media.jsp?mediaid= 168951&filetype=pdf.

Ertosun, Atiye Işıl. 2012. "Evaluation of Protective Structures in Archaeological Sites for In Situ Conservation of Architectural Remains and Artifacts." Master diss., Middle East Technical University.

Farid, Shahina. 2002 "South Area Shelter", Accessed March 10, 2013. www.catalhoyuk.com/ archive_reports/2002/ar02_08.html.

Feilden, Bernard M. 2001. *Conservation of Historic Buildings*. Oxford: Architectural Press.

Fentress, Elizabeth. 2001. "Protective Shelters for Archaeological Areas and Buildings: A One-day Conference Held at the Museo Civico Archeologico di Bologna, October 2000." *Conservation and Management of Archaeological Sites* 5(1&2):106-108.

Ferroni, Angela Maria. 2005. "Report on the Icomos Reactive Monitoring Mission to World Heritage Site Um Er-Rasas (Jordan)." Accessed March 19, http://whc.unesco.org/archive/2005/ mis1093-2005.pdf.

Ferroni, Angela Maria, and Maria C. Laurenti. 2006. "Coperture di Protezione. Studi Pregressi e Ricerche in Corso." In *Le Coperture delle Aree Archeologiche. Museo Aperto*, edited by Maria C. Laurenti, 77-109. Roma: Gangemi.

Fiero, Kathleen. 2001. "Preserving Dirt-walled Structures in Mesa Verde National Park." *Conservation and Management of Archaeological Sites* 5(1&2):55-62.

Fintikakis, Nikos. 2005. "Aristotle's Theory as a Tool for Inspiration in Architecture. The Shelter of the Archaeological Site at Akrotiri." *Proceedings of the 1st International Conference on Passive and Low Energy Cooling for the Built Environment*, 901-903. Santorini.

Fitch, James M. 1982. "Protection and Interpretation of Sites and Ruins." In *Historic Preservation: Curatorial Management of the Built World*, 293-306. Charlottesville: University Press of Virginia.

Franciscan Archaeological Institute. 2001. "Kastron Mefa'a - Umm al-Rasas" Last modified July 27.
http://198.62.75.1/www1/ofm/fai/FAIrasas.html.

Getty. 2009. "Conservation of Mosaics in Situ" Last modified November. http://www.getty.edu/conservation/our_projects/field_projects/mosaics/mosaics_component1.html.

Getty. 2012. "Conservation of Mosaics in Situ." Last modified January.

http://www.getty.edu/conservation/our_projects/field_projects/mosaics/mosaics_ publications.html#asm.

Getty. 2013. “Assessing the Protective Function of Shelters over Mosaics.” Accessed May 24. http://www.getty.edu/conservation/publications_resources/newsletters/21_1/newsletter5.html.

Gonçalves, Jose L. 2008. “Reburial Versus Sheltering: Experiments in Preventive Conservation of the Mosaics in the Roman Villa of Rabaçal, Penela, Portugal.” In *Lessons Learned: Reflecting on the Theory and Practice of Mosaic Conservation*, edited by Aicha Ben Abed, Martha Demas, and Thomas Roby, 281-288. Los Angeles, California: J. Paul Getty Trust.

Greenewalt, Crawford Hallock. 1991. “The Sardis Campaign of 1987.” *Bulletin of the American Schools of Oriental Research* 27:1-28.

Greenewalt, Crawford Hallock. 1997. “Sardis Archaeological Research in 1997.” *Kazı Sonuçları Toplantısı* 20(2):1-14.

Greenewalt, Crawford Hallock, and Marcus L. Rautman. 2000. “The Sardis Campaigns of 1996, 1997, and 1998.” *American Journal of Archaeology* 104(4):643-681.

Günlük, Seval. 2007. *“Konya İç Kalesine Ait Ortaçağ Buluntuları.*” Master diss., Selçuk University.

Ha’obsh, Mervat M. 2008. “Um Er-Rasas (Um Al-Rasas): Preservation of the Mosaics at a New World Heritage Site in Jordan.” In *Lessons Learned: Reflecting on the Theory and Practice of Mosaic Conservation*, edited by Aicha Ben Abed, Martha Demas, and Thomas Roby, 144-150. Los Angeles, California: J. Paul Getty Trust.

Häuselmayer, Otto. 2000. “Architecture and Project Development.” In A *Roof for Ephesos: The Shelter for the Terrace House 2*, edited by Friedrich Krinzinger, 201-114. Wien: Österreichisches Archaologisches Institut.

Hebbelinck, S., A.H. Hendrickx, M. Mollaert, and J. Haase. 2001. “New Ideas on the Use of Systematically Constructed Tension Structures to Cover Historical and Archaeological Sites.” In *Structural Studies, Repairs and Maintenance of Historical Buildings VII*, edited by C.A. Brebbia, 29-38. Boston: WIT Press.

Hebrew University. 2002. “The Mosaic Pavements of Roman and Byzantine Zippori.” Last modified February 26. http://archaeology.huji.ac.il/Zippori/mosaic.htm#The Nile Building.

ICOMOS. 1990. Charter for the Protection and Management of the Archaeological Heritage. http://www.icomos.org/charters/arch_e.pdf.

ICOMOS. 1964. Venice Charter. http://www.international.icomos.org/charters/venice_e.pdf.

Jeffreys, Rosemary. 2010. "The Shelter on the Temple Apollo Epikourios." Accessed September 18. http://www.iiconservation.org/node/2751.

Jerome, Pamela. 1995. "Proposed Permanent Shelter for Building 5 at the Bronze Age Site of Palaikastro, Crete." *Conservation and Management of Archaeological Sites* 1:35-42.

Jerome, Pamela, Michael R. Taylor, and John Montgomery. 2001. "Evaluation of the Protective Shelter at Blackwater Draw Archaeological Site, New Mexico." *Conservation and Management of Archaeological Sites* 5(1&2):63-72.

Koçu, Nazım. 2007. "Konya'da Selçuklu Dönemi Yapılarından Alaeddin Köşkü'nün Durumu ve Korunmasının Önemi." In *Tarihi Eserlerin Güçlendirilmesi ve Geleceğe Güvenle Devredilmesi Sempozyumu Bildiri Kitabı,* 531-541. Ankara:Kardelen Ofset Ltd. Şti.

Konya Municipality. 2013. "Kılıçarslan Köşkü Restorasyonu ve Yeni İl Halk Kütüphanesi Yapımı İşbirliği Protokolü İmzalandı." Accessed May 31. http://www.konya.bel.tr/haberayrinti.php?haberID=2368 (31 Mayıs 2013).

Korfmann, Manfred O., and Dietrich Mannsperger. 2004. *Troia / Wilusa Gezi Rehberi*. İstanbul: Ege Yayınları.

Korfmann, Manfred. 2003. "Die Arbeiten in Troia/Wilusa in 2003." *Studia Troica* 14(2004):5. http://www.uni-tuebingen.de/troia/st/fourteen/sttr14-Korfmann.pdf.

Krinzinger, Friedrich. 2000a. *A Roof for Ephesos: The Shelter for the Terrace House 2.* Wien: Österreichisches Archaologisches Institut.

Krinzinger, Friedrich. 2000b. "Terrace House 2 as an Archaeological Challenge." In *A Roof for Ephesos: The Shelter for the Terrace House 2,* edited by Friedrich Krinzinger, 7-32. Wien: Österreichisches Archaologisches Institut.

Krinzinger, Friedrich. 2000c. "The Erection of a Protective Structure over Terrace House 2." In *A Roof for Ephesos: The Shelter for the Terrace House 2,* edited by Friedrich Krinzinger, 59-70. Wien: Österreichisches Archaologisches Institut.

Krinzinger, Friedrich. 2006. The Terrace House in Ephesos: The new shelter. In *Management and Preservation of Archaeological Sites,* edited by Zeynep Ahunbay and Ülkü İzmirligil, 36-39. İstanbul: Side Foundation for Education Culture and Art.

Laurenti, Maria. C. 2001. "Research Project on Protective Shelters for Archaeological Areas in Italy. A Status Report. *Conservation and Management of Archaeological Sites* 5(1&2):109-115.

Laurenti, Maria C., ed. 2006. *Le Coperture delle Aree Archeologiche. Museo Aperto.* Roma: Gangemi.

Laurenti, Maria C., Antonella Altieri, Marco Bartolini, Carlo Cacace, G. Fazio, Elisabetta Giani, Annamaria Giovagnoli, Maria Pia Nugari, Sandra Ricci, Claudio Prosperi Porta, and Marco Citterio. 2003. "Conserving Archaeological Areas: the Study Case of Arianna's Villa in Castellamare di Stabia in the Framework of a Research Program on Protecting Shelters for Archaeological Sites." In *Summary of the Proceedings and Papers Presented at the Symposium: Conservation in the shadow of Vesuvius: A Review of Best Practices.* New York: World Monuments Fund.

Laurenti, Maria C., Antonella Altieri, Carlo Cacace, Elisabetta Giani, Annamaria Giovagnoli, Maria Pia Nugari, and Sandra Ricci. 2006. "Sintesi delle informarmazioni. I siti Campione: Analisi Integrata della Informazioni." In *Le Coperture delle Aree Archeologiche. Museo Aperto,* edited by Maria C. Laurenti, 231-236. Roma: Gangemi.

L'Istituto Superiore per la Conservazione ed il Restauro. 2008. "Copertura delle Archeologici di Dati di Base dei Materiali / Prodotti i Componenti Che il Rilevamento Carte" Last modified September 3. http://iscr.beniculturali.it/index2.php?option=com_content&do_pdf=1&id=112.

Maekawa, Shin. 2006. "Comparison of Shelters' Performance at Joya de Cerén, El Salvador." In *Heritage, Weathering and Conservation,* edited by R, Fort, de Buergo, Gomez-Heras, and Vazquez-Calvo, 469-477. London: Taylor&Francis Group.

Margary, Ivan D. 1971. "The Fishbourne Story*" Britannia* 2:117-121. Accessed April 15, 2012. doi: http://dx.doi.org/10.2307/525802.

Matero, Frank. 1999. "Lessons from the Great House: Condition and Treatment History as Prologue to Site Conservation and Management at Casa Grande Ruins National Monument." *Conservation and Management of Archaeological Sites* 3:203-224.

Matero, Frank. 2000. "The conservation of an Excavated Past." In *Towards Reflexive Method in Archaeology: the Example at Çatalhöyük*, edited by Ian Hodder, 71-88. Cambridge: McDonald Institute for Archaeological Research.

Matero, Frank. 2001. "Editorial." *Conservation and Management of Archaeological Sites* 5(1&2):1-2.

Matero, Frank G. 2008. "Heritage, Conservation, and Archaeology: An Introduction." *Heritage, Conservation, and Archaeology.* Accessed September 12, 2012. http://www.archaeological.org/pdfs/Matero.pdf.

Michaelides, Demetrios, and Nikki Savvides. 2008. "Lessons not Learned: The Shelters at Kourion, Cyprus." In *Lessons Learned: Reflecting on the Theory and Practice of Mosaic Conservation*, edited by Aicha Ben Abed, Martha Demas, and Thomas Roby, 215-223. Los Angeles, California: J. Paul Getty Trust.

Minissi, Franco. 1961. "Protection of the Mosaic Pavements of the Roman Villa at Piazza Armerina (Sicily)." *Museum* 14:2.

Motolese, Maria Rosaria. 2003. "A Lightweight Covering System for Protection of Archaeological Sites and Remains: Testing a Prototype for a Newly Excavated Area in Pompeii." *Summary of the Proceedings and Papers Presented at the Symposium: Conservation in the Shadow of Vesuvius: A Review of Best Practices.* New York: World Monuments Fund.

Nappo, Salvatore Ciro. 2011. "Pompeii: Its Discovery and Preservation." Last modified February 17. http://www.bbc.co.uk/history/ancient/romans/pompeii_rediscovery_01.shtml.

National Park Service. 2013. "Casa Grande Ruins National Monument, Arizona." Last modified July 27. http://www.nps.gov/archeology/sites/antiquities/profileCasa Grande.htm.

National Trust. 2009a. "Chedworth Roman Villa, Supporting Statement for Chedworth Roman Villa Improvements." Accessed September 12, 2012. http://www.idox.cotswold.gov.uk/WAM14/doc/Report270815.pdf?extension=.pdf&id=270815&appid=&location=volume1&contentType=application/pdf&pageCount=1.

National Trust. 2009b. "Chedworth Roman Villa Improvements: Assessment of Impact on Historic Fabric and Proposed Mitigation Strategy." Accessed September 12, 2012. http://www.idox.cotswold.gov.uk/WAM14/doc/Report270729.pdf?extension=.pdf&id=270729&appid=&location=volume1&contentType=application/pdf&pageCount=1.

National Trust. 2013. “Chedworth Roman Villa Teachers’ Quick Reference Guide.” Accessed March 17. http://www.nationaltrust.org.uk/document-1355775121073/.

Neguer, Jacques, and Yael Alef. 2008. “Rapid Assessment of Shelters over Mosaics: Initial Results from Israel.” In *Lessons Learned: Reflecting on the Theory and Practice of Mosaic Conservation*, edited by Aicha Ben Abed, Martha Demas, and Thomas Roby, 193-203. Los Angeles, California: J. Paul Getty Trust.

Netzer, Ehud, and Zeev Weiss. 1992. “Byzantine Mosaics at Sepphoris: New Finds.” *Israel Museum Journal* 10:75-80.

Offers, Donald F. 2010. The Roman City of Augusta Raurica (Canton of Basel – Landschaft, Switzerland) Accessed September 18. http://www.monuments-nationaux.fr/fichier/editions_ebook_chapitre/662/2_5_B.pdf.

Omacan, Sinan, Rıdvan Övünç, Ceren Balkır and Didem Teksöz. 2003. “Çatalhöyük Güney Kazı Alanı Üzerine Korugan Örtü.” *Yapı* 260:89-92.

Omacan, H. Sinan. 2011. “Genç Olmak” *Arredamento Mimarlık* 249: 51-69.

Özgönül, Nimet. 2001. “Efeste Bir Yapı, Yamaç Ev Koruma Projesi.” *Mimarlık,* 297:35-38.

Palumbo, Gaetano. 2001. “Sheltering an Archaeological Structure in Petra: A Case-study of Criteria, Concepts, and Implementation.” *Conservation and Management of Archaeological Sites* 5(1&2): 35-44.

Panoramio. 2010. “Um er-Rasas, Überdachter Bereich” Last modified February 15. http://www.panoramio.com/photo/32204922.

Panoramio. 2011.“Israel. Zippori National Park. The Nile House” Last modified June 2011. http://www.panoramio.com/photo/54311186?source=wapi&referrer=kh.google.com.

Pastorello, Paolo, and Werner Schmid. 1991. “Installation of a Provisional Shelter for the Mosaic.” In *The Conservation of the Orpheus Mosaic at Paphos, Cyprus,* edited by Jacki Gallagher, 26-28. California: Getty Conservation Institute.

Papadopoulos, John K. 1997. “Knossos.” In *The Conservation of Archaeological Sites in the Mediterranean Region,* edited by Marta de la Torre, 93-125. Los Angeles: The J. Paul Getty Trust.

Perseus Digital Library. 2013. “Gela (Site)” Accessed May 31. http://www.perseus.tufts.edu/hopper/artifact?name=Gela&object=Site.

Pesaresi, Paola and Gionata Rizzi. 2007. “New and Existing Forms of Protective Shelter at Herculaneum: Towards Improving the Continuous Care of the Site.” *Conservation and Management of Archaeological Sites* 8(4):237-252.

Restelli, Francesca B. 2006. “A Protective Shelter at the Archaeological site of Arslantepe - Malatya.” In *Management and Preservation of Archaeological Sites,* edited by Zeynep Ahunbay and Ülkü İzmirligil, 45-49. İstanbul: Side Foundation for Education Culture and Art.

Rizzi, Gionata. 2008. Sheltering the Mosaics of Piazza Armerina: Issues of Conservation and Presentation. *Heritage, Conservation, and Archaeology.* Accessed May 31, 2013. http://archaeological.org/news/hca/71.

Rudkin, David. 2003. “Fishbourne Roman Palace Museum: Mosaics Condition Survey.” Unpublished report, Sussex Archaeological Society.

Schirmer, Wulf. 2000. “The Protective Structure in its Time.” In *A roof for Ephesos: The Shelter for the Terrace House 2,* edited by Friedrich Krinzinger, 34-41. Wien: Sonderschiften des Österreichishen Archaologishen Institutes.

Schmid, Martin. 1998. Protective Shelters at Archaeological Sites of Malia (Crete) and Kalavasos- Tenta (Cyprus). *Conservation and Management of Archaeological Sites* 2(3):143-153.

Schmidt, Hartwig. 1988. *Schutzbauten.* Stuttgart: Theiss.

Scichilone, Giovanni. 1986. “The Site of the Cathedral At Atri: A Case Study of In Situ Conservation of Archaeological Remains.” In *Preventive Measures during Excavation and Site Protection,* 309-314. Rome: ICCROM.

Scognamiglio, Matteo. 1992. Emergency Intervention on Flooded Mosaics at Piazza Armerina. *International Committee for the Conservation of Mosaics Newsletter* 9:17-18.

Stanley-Price, Nicholas. 1997. “The Roman Villa at Piazza Armerina, Scily. In *The Conservation of Archaeological Sites in the Mediterranean Region,* edited by Marta de la Torre, 65-92. Los Angeles: The J. Paul Getty Trust.

Stanley-Price, Nicholas, and Jukka Jokilehto. 2001. “The Decision to Shelter Archaeological Sites: Three Case-studies from Scily.” *Conservation and Management of Archaeological Sites* 5(1&2):19-34.

Stanley-Price, Nicholas. 2003. "Site Preservation and Archaeology in the Mediterranean Region." In *Theory and Practice in Mediterranean Archaeology: Old World and New World Perspectives,* edited by John K. Papadopoulas, and Richard M. Leventhal, 269-283. Los Angeles: University of California.

Stevens, André. 1986. "Structures Nouvelles de Protection des Sites Archeologiques du Tiers Monde." In *Preventive Measures during Excavation and Site Protection,* 225-244. Rome: ICCROM.

Stewart, John. 2008. "Rapid Assessment of Shelters over Mosaic: Methodology and Initial Results from England." In *Lessons Learned: Reflecting on the Theory and Practice of Mosaic Conservation,* edited by Aicha Ben Abed, Martha Demas, and Thomas Roby, 181-192. Los Angeles: J. Paul Getty Trust.

Stewart, John D., Jacques Neguer, and Martha Demas. 2006. "Assessing the Protective Function of Shelters over Mosaics." *Getty Newsletter* 21(1):17-19.

Stubbs, John H. 1995. "Protection and Presentation of Excavated Structures." In *Conservation on Archaeological Excavations with Particular Reference to the Mediterranean Area,* edited by N.P.Stanley Price, 73-89. Rome: ICCROM.

Sussexpast. 2011. "Fishbourne Roman Palace" Accessed March 12, 2013. http://sussexpast.co.uk/wp-content/uploads/2011/10/Fishbourne.pdf.

Tensinet. 2009. "Recent projects." Last modified September 30. http://www.tensinet.com/files/General_information/RECENT_PROJECTS_MEMBERS_AGM_2009-09-30_Valencia.pdf.

Teutonico, J. M. 2001. "Protective Shelters for Archaeological Sites in the Southwest USA: Conclusions and Recommendations." *Conservation and Management of Archaeological Sites 5*(1&2):87-90.

Thomas, C. 2000. "Historical Protection of Archaeological Remains in the United Kingdom:cover buildings constructed before World War II." Unpublished report, Research for the National Trust.

Thompson, Troy D., and Michael R. Taylor. 2001. "Establishment of Conservation, Design and Construction Criteria for Protective Shelters at Fort Selden State Monument New Mexico." *Conservation and Management of Archaeological Sites* 5(1&2): 45-54.

Tringham, Sibylla, and John Stewart. 2008. "Protective Shelters over Archaeological Sites: A Review of Assessment Initiatives." In *Lessons Learned: Reflecting on the Theory and Practice of Mosaic Conservation,* edited by Aicha Ben Abed, Martha Demas, and Thomas Roby, 204-214. Los Angeles, California: J. Paul Getty Trust.

Tunçağ, Muzaffer. 2002. “Efes Yamaç Evlerini Koruyan Çağdaş Bir Yapı” *İzmir Kent Kültürü Dergisi* 5:114-116.

Unipa. 2008a. “Conservazione della Villa Romana del Casale di Piazza Armerina” Accessed April 2. http://www.unipa.it/monumentodocumento/villadelcasale/conservazione_minissi_en.html.

Unipa. 2008b. “1952. Mura di Capo Soprano (Gela), Opere di Protezione Progettate da Minissi” Accessed April 2. http://www.unipa.it/monumentodocumento/villadelcasale/mura_capo_soprano.html.

Uyar, Oğuz. 2008. *“Arkeolojik Alanlarda Koruma Çatıları ve Gezi Platformlarının Düzenlenmesi: Apollon Klarios Bilicilik Merkezi Örneği.”* Master diss., Dokuz Eylül University.

Vozikis, Konstantina T. 2002. “Shutzbauten über Archaologischen Statten in Griechenland” Diplomarbeit, TU Wien.

Vozikis, Konstantina T. 2005. “Protective Structures on Archaeological Sites in Greece.” *2005 WSEAS International Conference on Environment Ecosystems and Development, Venice Italy, November 2-4, 2005*,120-125.

Waane, S. A. C. 1986. “Roofs and Shelters: the Tanzanian Experience.” In *Preventive Measures during Excavation and Site Protection*, 245-256. Rome: ICCROM.

Warner, Nicholas. 2009. “Protecting a Cemetery in Saqqara Site Works 1975-2009.” *Conservation and Management of Archaeological Sites* 11(2):98-132.

Weaver, Martin E. 1973. “The Use of Inflatable “Air-dome” to Produce Controlled Conditions for an Archaeological Site.” *Studies in Conservation* 18(1973):88-93.

World Heritage Convention. 2013a. “Villa Romana del Casale.” Accessed May 15. http://whc.unesco.org/en/list/832/.

World Heritage Convention. 2013b. “Um er-Rasas (Kastrom Mefa'a).” Accessed May 31.
http://whc.unesco.org/en/list/1093.

Wiltsglosstandart. 2013. “Chedworth Roman Villa” Accessed March 12. http://www.wiltsglosstandard.co.uk/picturegalleryphotos/chedworth_roman_villa/view/gallery_250959.Chedworth_Roman_Villa_has_reopened_to_the_public_after_a___3m_revamp/.

Wikimedia. 2011. “Fishbourne Roman Palace.” Last modified August 12. http://commons.wikimedia.org/wiki/Category:Fishbourne_Roman_Palace.

Wikipedia. 2012a. “Fishbourne Roman Palace.” Last modified May 14. http://en.wikipedia.org/wiki/Fishbourne_Roman_Palace.

Wikipedia. 2012b. “Oceanic climate.” Last modified May 9, 2012. http://en.wikipedia.org/wiki/Oceanic_climate.

Wikipedia. 2013a. “Mediterranean Climate.” Accessed July 17. http://en.wikipedia.org/wiki/Mediterranean_climate.

Wikipedia. 2013b. Roman Town House, Dorchester.” Accessed March 10. http://en.wikipedia.org/wiki/Roman_Town_House,_Dorchester.

Wikipedia. 2013c. “Desert climate.” Last modified July 17. http://en.wikipedia.org/wiki/Desert_climate.

Wikipedia. 2013d. “File:Casagrande2.jpg.” Accessed March 13. http://en.wikipedia.org/wiki/File:Casagrande2.jpg

Woolfitt, Catherine. 2007. “Preventive Conservation of Ruins: Reconstruction, Reburial and Enclosure.” In *Conservation of Ruins*, edited by John Ashurst, 177-194. Oxford: Butterworth-Heinemann.

Wunderer, Ekkehard. 2000. “Climatologic Considerations for the Shelter Construction.” In *A Roof for Ephesos: The Shelter for the Terrace House 2*, edited by Friedrich Krinzinger, 116-122. Wien: Österreichisches Archaologisches Institut.

Yaka, Funda, and Başak İpekoğlu. 2008. “Arkeolojik Alanlarda Koruma Amaçlı Üst Örtü Tasarımında Malzeme Kullanımı.” In *Proceedings of the Ulusal Yapı Malzemesi Kongresi ve Sergisi*, 217-228, İstanbul.

Yaka Çetin, Funda, and Başak İpekoğlu. 2010. “Saydam Malzemelerin Arkeolojik Alanlardaki Koruyucu Üst Örtülerde Kullanımı.” In *Proceedings of the Ulusal Yapı Malzemesi Kongresi ve Sergisi*, 44-54, İstanbul.

Yaka Çetin, Funda, and Başak İpekoğlu. 2012. “Protective Structures for Conservation and Presentation of Archaeological Sites: Use of Transparent Material”, *Proceedings of 5th International Congress Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basin*, İstanbul, Turkey, 22-25 November 2011, Vol. I, 237-243 Roma: Valmar.

Yaka Çetin, Funda, and Başak İpekoğlu. 2013. "Impact of Transparency in the Design of Protective Structures for Conservation of Archaeological Remains." *Journal of Cultural Heritage* 14(2013) e-21-24.

Yıldırım, Mustafa. 1997. "*Konya'da Son Asırda Kaybolan Bazı Türk Yapıları.*" PhD diss., Selçuk University.

Yurttagül, Kenan. 2000. "The Protection of Archaeological Zones and Terrace House 2 in Ephesos." In *A Roof for Ephesos: The Shelter for the Terrace House 2,* edited by Friedrich Krinzinger, 124-132. Wien: Österreichisches Archaologisches Institut.

Zeugma Archaeological Project. 2012a. "The Roman House." Accessed May 5. http://www.zeugmaarchproject.com/index.php?option=com_content&view=article&id=2&Itemid=8.

Zeugma Archaeological Project. 2012b. "Protective Shelter for Roman Houses." Accessed May 5. http://www.zeugmaarchproject.com/index.php?option=com_content&view=article&id=14&Itemid=16.

Ziesel, Wolfdietrich. 2000. "Construction Engineering Art for the Third Millenium." In *A Roof for Ephesos: The Shelter for the Terrace House 2,* edited by Friedrich Krinzinger, 72-99. Wien: Österreichisches Archaologisches Institut.

APPENDIX A

SITE SURVEY QUESTIONNAIRE

Name of the Site …………………………. **Survey Date /Time**………………

A. IDENTIFICATION OF THE PROTECTIVE STRUCTURE

1. What is the type of Protective Structure
   - ☐ Temporary
   - ☐ Permanent
   - ☐ Shelter
   - ☐ Enclosure

2. What is the typology of Protective Structure in relation to the remains
   - ☐ Imitating the original
   - ☐ Forming a new
   - ☐ Built on remains
   - ☐ Built above remains
   - ☐ Reburied / Buried
   - ☐ Under a removable cover

3. What is the construction date of the protective structure? ……….

4. What is the size of the protective structure? ……..

5. What is the structural system of the protective structure? ……..

6. What are the materials of the protective structure?	
Structure	
Foundations	
Roof covering	
Façade 1	
Façade 2	
Façade 3	
Façade 4	

7. What is the condition of the shelter materials?			
	In good condition	Moderate	Suffer from aging
Structure			
Foundations			
Roof covering			
Façade 1			
Façade 2			
Façade 3			
Façade 4			

8. Is there a drainage system? Does it work efficiently?			
	Yes, it is efficient	Yes, but it is not efficient	No
Roof Drainage			
Surface Drainage			
Site Drainage			

9. Does the shelter have thermal insulation?			
	Yes, it is efficient	Yes, but it is not efficient	No
Roof			
Façade 1			
Façade 2			
Façade 3			
Façade 4			

10. What is the type of the ventilation system? Does it functioning properly?			
	Proper	Improper	Excessive
Natural ventilation due to absence of lateral sides			
Natural ventilation through inlet and outlet			
Natural ventilation controlled by adjusting sides in seasons			
Mechanical ventilation or heating			
No ventilation system			

11. Is there any moisture in the protective structure? What are the sources?					
	Never	Rarely	Sometimes	Very Often	Always
Rain penetration (Leaks in roof, inadequate lateral surfaces)					
Rising damp (inadequate site drainage)					
Moisture resulting from damp air raising from ground					
Surface condensation (cooling at night due to lack of insulation)					
Absorption of moisture by hygroscopic materials					
Swelling of subsoil (expansion of subsurface with expansive clay possibly as a result of removal of trees for construction)					

12. Is the climate stable in the protective structure?					
	Never	Rarely	Sometimes	Very Often	Always
Solar radiation (Transparent façades or absence of lateral surfaces)					
Heat built up in shelter, lack of insulation					
Fluctuations of temperature and relative humidity					
Wetting and drying cycles					
Freezing (no or poor insulation)					
Crystallization of soluble salts					
Excessive/ strong air flow (Immediate evaporation)					
Insufficient ventilation/stagnant air					
Active mechanical ventilation					

13. Does the protective structure suffer from intrusion of living things?					
	Never	Rarely	Sometimes	Very Often	Always
Birds					
Insects (Wasp, spider)					
Rodents (Mice, badger)					
Man					
Microbiological vegetation (algae, lichens, mosses)					
Vegetation (Grass and Plants)					

14. Is there an assessment method for protective performance of protective structures?	
Internal environment	
External environment	
Condition survey of the remains	
Comparison of current condition with historic photographs	
Soil moisture content/ temp	

15. What is the effectiveness of the protective structure in protecting the remains/ mitigating the environmental risks?

☐ 0 % ☐ 1-30 % ☐ 31-60 % ☐ 61-79 % ☐ 80-100 %

B. CONDITION OF THE SHELTERED REMAINS

16. What are the remains protected under shelter/enclosure and their frequency?					
	No 0 %	Very Rare 1-30 %	Rare 31-60 %	Frequent 61-80 %	Very Frequent 1-100 %
Mosaics					
Wall paintings					
Plaster					
Stone structure					
Rubble stone structure					
Mudbrick structure					

17. What is the condition of the sheltered remains?			
	In good condition	Relatively stable	Actively deteriorating
Mosaics			
Wall paintings			
Stone structure			
Rubble stone structure			
Earthen structure			

18 a. What is the deterioration phenomenon and its severity?					
Mosaics	**Very Severe (A)**	**Severe (B)**	**Moderate (C)**	**Slight (D)**	**Very Slight (E)**
Detachment or bulging of tessellatum					
Depressions					
Cracks					
Detached tesserae					
Deteriorated tesserae (disaggregation, fracturing, flaking)					
Salt florescence (efflorescence or subflorescence)					
Vegetation					
Microbiological organisms					
Color alteration					
Deposit					

18 b. What is the deterioration phenomenon and its severity?					
Wall Paintings	**Very Severe (A)**	**Severe (B)**	**Moderate (C)**	**Slight (D)**	**Very Slight (E)**
Loss of plaster layers					
Disintegration of plaster layers					
Cracks/Fissures					
Loss of paint layers Blistering and peeling (Incrustations)					
Efflorescence					
Subflorescence					
Disfigurement or color loss					
Fungal growth as moulds					
Calcareous deposition					
Surface erosion					
Presence of lacunae					

18 c. What is the deterioration phenomenon and its severity?					
Earthen Structures	**Very Severe (A)**	**Severe (B)**	**Moderate (C)**	**Slight (D)**	**Very Slight (E)**
Basal erosion					
Surface erosion					
Loss of mud mortar					
Formation of structural cracks					
Formation of cracks					
Efflorescence					
Subflorescence					
Presence of lacunae					
Fungal growth as moulds					
Formation of crust of clay					
Detachment of plaster layer					
Loss of plaster layer					

19 a. Which of the possible factors may accelerate the deterioration?											
DETERIORATION TYPES Of MOSAICS		Detachment/bulging of tesellatum	Depressions	Cracks	Detached tesserae	Deteriorated tesserae	Salt florescence	Color alteration	Deposit	Vegetation	Microbiological organisms
POSSIBLE FACTORS OF DETERIORATION IN RELATION TO PROTECTIVE STRUCTURES	Rain penetration (leaks in roof, inadequate lateral sides)										
	Rising damp (inadequate site drainage)										
	Moisture resulting from damp air raising from ground										
	Surface condensation (cooling at night/lack of insulation)										
	Swelling of subsoil (expansion of subsurface with expansive clay)										
	Solar radiation (transparency or absence sides)										
	Heat built up in shelter, lack of insulation (expansion/contraction)										
	Immediate evaporation (due to wind)										
	Wetting and drying cycles										
	Freezing (no or poor insulation)										
	Crystallization of soluble salts										
	Insufficient ventilation										
	Passive ventilation via open sides or fenestration pattern										
	Active mechanical ventilation										
	Strong wind										
	Microbiological (algae, lichens, mosses)										
	Vegetation (grass and plants)										
	Birds										
	Insects										
	Rodents										
	Man										

19b. Which of the possible factors may accelerate the deterioration under the protective structure?

	DETERIORATION TYPES Of WALL PAINTINGS	Loss of plaster layers	Disintegration of plaster layers	Cracks/ Fissures	Loss of paint layers Blistering and peeling	Efflorescence	Subflorescence	Disfigurement or color loss	Calcareous deposition	Fungal growth as moulds	Surface erosion	Presence of lacunae
POSSIBLE FACTORS OF DETERIORATION IN RELATION TO PROTECTIVE STRUCTURES	Rain penetration (Leaks in roof, inadequate lateral sides)											
	Rising damp (inadequate site drainage)											
	Moisture resulting from damp air raising from ground											
	Surface condensation (cooling at night due to lack of insulation)											
	Swelling of subsoil (expansion of subsurface with expansive clay possibly as a result of removal of trees for construction)											
	Solar radiation (transparent façades or absence of lateral surfaces											
	Heat built up in shelter, lack of insulation											
	Fluctuating Temperature and RH											
	Wetting and drying cycles											
	Freezing (no or poor insulation)											
	Crystallization of soluble salts											
	Insufficient ventilation/stagnant air											
	Passive ventilation via open sides or fenestration pattern											
	Immediate evaporation (due to wind)											
	Strong wind											
	Microbiological (algae, lichens, mosses)											
	Vegetation (grass and plants)											
	Birds											
	Insects											
	Rodents											
	Man											

19 c. Which of the possible factors may accelerate the deterioration under the protective structure?

DETERIORATION TYPES Of EARTHEN STRUCTURES		Basal erosion	Surface erosion	Loss of mud mortar	Formation of structural cracks	Formation of cracks	Efflorescence	Subflorescence	Presence of lacunae	Fungal growth as moulds	Formation of crust of clay	Detachment of loose parts / plaster layer	Loss of plaster layer
POSSIBLE FACTORS OF DETERIORATION IN RELATION TO PROTECTIVE STRUCTURES	Rain penetration (Leaks in roof, inadequate lateral sides)												
	Rising damp (inadequate site drainage)												
	Moisture resulting from damp air raising from ground												
	Surface condensation (cooling at night due to lack of insulation)												
	Swelling of subsoil (expansion of subsurface)												
	Solar radiation (transparent façades or absence of lateral surfaces												
	Heat built up in shelter/enclosure, lack of insulation												
	Fluctuating Temperature and relative humidity												
	Wetting and drying cycles												
	Freezing (no or poor insulation)												
	Crystallization of soluble salts												
	Insufficient ventilation/stagnant air												
	Immediate evaporation (due to excessive air flow)												
	Strong wind												
	Microbiological (algae, lichens, mosses)												
	Vegetation (grass and plants)												
	Birds												
	Insects												
	Rodents												
	Man												

C. INVESTIGATION OF NATURAL FEATURES OF THE SITE

20. What is the location of the site?
21. What is the ambient climate of the site?
22. What is the hydrology of the site?
23. What is the topography of the site?

APPENDIX B

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS

Table B.1. Evaluation of architectural design characteristics of protective structures and deterioration factors at Terrace House 2, Ephesus (Turkey).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT TERRACE HOUSE 2, EPHESUS (TURKEY)																																									
			Design of Protective Structure																																						
			Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural Ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples				1		1			1		1		1				1						1						1	1	1	1				1		1		1	
Deterioration Factors: Sources of Water	Rain penetration	E																					E																		
	Rising damp	B																																		B		D		B	
	Condensation	E																					E							E											
Instability of Microclimate	Solar gain	D																					D																		
	Heat built up	C															C												C	C	C										
	Fluctuations of T and RH	C															C						C						C	C	C										
	Wetting and drying cycles	C															C						C						C	C	C	C				C				C	
	Crystallization of soluble salts	C															C						C						C	C	C	C				C				C	
	Freezing	E																					E																		
	Excessive / insufficient	-																																							
Activities of the Living	Microbiological vegetation	D																																		D				D	
	Plants	C																																				C		C	
	Birds	B											B										B																		
	Insects	A											A										A																		
	Rodents	E																																							

Table B.2. Evaluation of architectural design characteristics of protective structures and deterioration factors at Building Z, Pergamon (Turkey).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT BUILDING Z, PERGAMON (TURKEY)

				Design of Protective Structure: Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
			Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples					1	1		1		1			1	1		1						1		1		1		1			1	1	1						1	1	1	
Deterioration Factors	**Sources of Water**	Rain penetration	E																					E																		
		Rising damp	D																																						D	
		Condensation	-																																							
	Instability of Microclimate	Solar gain	-																																							
		Heat built up	-																																							
		Fluctuations of T and RH	-																																							
		Wetting and drying cycles	D																																			D		D	
		Crystallization of soluble salts	D																																			D		D	
		Freezing	-																																							
		Excessive / insufficient	-																																							
	Activities of the Living	Microbiological vegetation	-																																							
		Plants	-																																							
		Birds	D																																							
		Insects	-																																							
		Rodents	-																																							

Table B.3. Evaluation of architectural design characteristics of protective structures and deterioration factors at Archaic and Late Roman Remains, Sardis (Turkey).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT ARCHAIC AND LATE ROMAN REMAINS, SARDIS (TURKEY)

Design of Protective Structure

		Deterioration Factors	Typology of Protective Structure				Structural System				Roof System				Roof Material					
			Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)
Number of Examples			1		1				1		1			1					1	
Deterioration Factors: Sources of Water	Rain penetration	A	A								A			A						
	Rising damp	A																		
	Condensation	C	C																	
Instability of Microclimate	Solar gain	E	E								E			E						
	Heat built up	-																		
	Fluctuations of T and RH	C	C																	
	Wetting and drying cycles	C	C											A						
	Crystallization of soluble salts	A	A											A						
	Freezing	E	E																	
	Excessive / insufficient	-																		
Activities of the Living	Microbiological vegetation	D																		
	Plants	C									C			C						
	Birds	D	D																	
	Insects	C	C																	
	Rodents	-																		

		Deterioration Factors	Facade System				Facade Material					Thermal Control System					Drainage System						
			Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples												1		1				1	1	1			
Deterioration Factors: Sources of Water	Rain penetration	A																					
	Rising damp	A																A	A	A			
	Condensation	C																					
Instability of Microclimate	Solar gain	E																					
	Heat built up	-																					
	Fluctuations of T and RH	C																					
	Wetting and drying cycles	C																C	C	C			
	Crystallization of soluble salts	A																A	A	A			
	Freezing	E																					
	Excessive / insufficient	-																					
Activities of the Living	Microbiological vegetation	D																D	D	D			
	Plants	C																C	C	C			
	Birds	D																					
	Insects	C																					
	Rodents	-																					

Table B.4. Evaluation of architectural design characteristics of protective structures and deterioration factors at Villas Dionysos and Danae, Zeugma (Turkey).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT VILLAS DIONYSOS AND DANAE, ZEUGMA (TURKEY)

			Design of Protective Structure																																						
			Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples				1		1			1		1		1						1					1		1				1	1	1									
Deterioration Factors – Sources of Water	Rain penetration																																								
	Rising damp																																								
	Condensation	E																	E					E		E															
Instability of Microclimate	Solar gain																																								
	Heat built up	C																	C											C											
	Fluctuations of T and RH	C																	C					C		C				C	C										
	Wetting and drying cycles	C																	C					C		C				C	C	C									
	Crystallization of soluble salts																																								
	Freezing	E																						E		E															
	Excessive / insufficient	C																						C		C															
Activities of the Living	Microbiological vegetation																																								
	Plants																																								
	Birds	E									E																														
	Insects																																								
	Rodents																																								

Table B.5. Evaluation of architectural design characteristics of protective structures and deterioration factors at Neolithic Houses, Çatalhöyük -south enclosure- (Turkey).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT NEOLITHIC HOUSES, ÇATALHOYUK -SOUTH ENCLOSURE- (TURKEY)

Design of Protective Structure

		Deterioration Factors	Typology of Protective Structure: Shelter	Enclosure	Built on remains	Built above remains	Structural System: Masonry	Reinforced concrete	Steel	Timber skeleton	Roof System: Segmented	Single piece	Louvers	Limited shelter area / excessive roof height
Number of Examples				1		1			1			1	1	
Deterioration Factors – Sources of Water	Rain penetration	-												
	Rising damp	A												
	Condensation	C												
Instability of Microclimate	Solar gain	-												
	Heat built up	A												
	Fluctuations of T and RH	A												
	Wetting and drying cycles	A												
	Crystallization of soluble salts	A												
	Freezing	C												
	Excessive / insufficient	C												
Activities of the Living	Microbiological vegetation	-												
	Plants	D												
	Birds	E												
	Insects	E												
	Rodents	C												

		Deterioration Factors	Roof Material: Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Facade System: Impermaeble	Adjusting sides in seasons	Louvers	Permeable
Number of Examples							1			1		
Deterioration Factors – Sources of Water	Rain penetration	-										
	Rising damp	A										
	Condensation	C					C					
Instability of Microclimate	Solar gain	-										
	Heat built up	A					A					
	Fluctuations of T and RH	A					A			A		
	Wetting and drying cycles	A					A			A		
	Crystallization of soluble salts	A					A			A		
	Freezing	C					C					
	Excessive / insufficient	C								C		
Activities of the Living	Microbiological vegetation	-										
	Plants	D										
	Birds	E								E		
	Insects	E								E		
	Rodents	C										

		Deterioration Factors	Facade Material: Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Thermal Control System: Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation
Number of Examples						1		1	1	1		
Deterioration Factors – Sources of Water	Rain penetration	-										
	Rising damp	A										
	Condensation	C				C		C	C			
Instability of Microclimate	Solar gain	-										
	Heat built up	A				A		A	A			
	Fluctuations of T and RH	A				A		A	A			
	Wetting and drying cycles	A				A		A	A	A		
	Crystallization of soluble salts	A				A		A	A	A		
	Freezing	C				C		C	C			
	Excessive / insufficient	C								C		
Activities of the Living	Microbiological vegetation	-										
	Plants	D										
	Birds	E										
	Insects	E										
	Rodents	C										

		Deterioration Factors	Drainage System: Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples			1		1				
Deterioration Factors – Sources of Water	Rain penetration	-							
	Rising damp	A	A		A				
	Condensation	C	C		C				
Instability of Microclimate	Solar gain	-							
	Heat built up	A							
	Fluctuations of T and RH	A							
	Wetting and drying cycles	A	A		A				
	Crystallization of soluble salts	A	A		A				
	Freezing	C							
	Excessive / insufficient	C							
Activities of the Living	Microbiological vegetation	-							
	Plants	D	D		D				
	Birds	E							
	Insects	E							
	Rodents	C							

Table B.6. Evaluation of architectural design characteristics of protective structures and deterioration factors at Neolithic Houses, Çatalhöyük -north enclosure- (Turkey).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT NEOLITHIC HOUSES, ÇATALHOYUK -NORTH ENCLOSURE- (TURKEY)																																									
			Design of Protective Structure																																						
			Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples				1		1			1			1	1						1			1						1		1	1	1			1	1	1				
Deterioration Factors / Sources of Water	Rain penetration	-																																							
Deterioration Factors / Sources of Water	Rising damp	A																																	A	A	A				
Deterioration Factors / Sources of Water	Condensation	C																	C									C		C	C				C	C	C				
Deterioration Factors / Instability of Microclimate	Solar gain	E											E																												
Deterioration Factors / Instability of Microclimate	Heat built up	A																	A									A		A	A										
Deterioration Factors / Instability of Microclimate	Fluctuations of T and RH	A																	A			A						A		A	A										
Deterioration Factors / Instability of Microclimate	Wetting and drying cycles	A																	A			A						A		A	A	A			A	A	A				
Deterioration Factors / Instability of Microclimate	Crystallization of soluble salts	A																	A			A						A		A	A	A			A	A	A				
Deterioration Factors / Instability of Microclimate	Freezing	C																	C									C		C	C										
Deterioration Factors / Instability of Microclimate	Excessive / insufficient	A																				A										A									
Deterioration Factors / Activities of the Living	Microbiological vegetation	-																																							
Deterioration Factors / Activities of the Living	Plants	D																																	D	D	D				
Deterioration Factors / Activities of the Living	Birds	E																				E																			
Deterioration Factors / Activities of the Living	Insects	E																				E																			
Deterioration Factors / Activities of the Living	Rodents	C																																							

Table B.7. Evaluation of architectural design characteristics of protective structures and deterioration factors at Alaeddin Kiosk, Konya (Turkey).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT ALAEDDIN KIOSK, KONYA (TURKEY)

		Deterioration Factors	Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
			Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples			1			1		1				1		1		1														1		1			1	1	1				
Deterioration Factors – Sources of Water	Rain penetration	C	C											C																											
	Rising damp	A																																		A	A	A				
	Condensation	-																																							
Deterioration Factors – Instability of Microclimate	Solar gain	B	B											B																											
	Heat built up	-																																							
	Fluctuations of T and RH	B	B																																						
	Wetting and drying cycles	B	B											B																		B			B	B	B				
	Crystallization of soluble salts	D																																							
	Freezing	C	C																																						
	Excessive / insufficient	C	C																																						
Deterioration Factors – Activities of the Living	Microbiological vegetation	E																																		E	E	E				
	Plants	-																																							
	Birds	D	D																																						
	Insects	-																																							
	Rodents	-																																							

Table B.8. Evaluation of architectural design characteristics of protective structures and deterioration factors at Citadel Wall and the Megaron, Troy (Turkey).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT CITADEL WALL AND THE MEGARON, TROY (TURKEY)

Design of Protective Structure

		Deterioration Factors	Typology of Protective Structure				Structural System				Roof System				Roof Material					
			Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)
Number of Examples			1			1			1			1					1			
Deterioration Factors – Sources of Water	Rain penetration	-																		
	Rising damp	C	C																	
	Condensation	C	C																	
Deterioration Factors – Instability of Microclimate	Solar gain	B	B											B						
	Heat built up	-																		
	Fluctuations of T and RH	A	A																	
	Wetting and drying cycles	C	C																	
	Crystallization of soluble salts	-																		
	Freezing	E	E																	
	Excessive / insufficient	A	A																	
Deterioration Factors – Activities of the Living	Microbiological vegetation	-																		
	Plants	-																		
	Birds	D	D																	
	Insects	C	C																	
	Rodents	-																		

		Deterioration Factors	Facade System				Facade Material					Thermal Control System					Drainage System						
			Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples														1			1		1		1		
Deterioration Factors – Sources of Water	Rain penetration	-																					
	Rising damp	C															C		C		C		
	Condensation	C																					
Deterioration Factors – Instability of Microclimate	Solar gain	B																					
	Heat built up	-																					
	Fluctuations of T and RH	A																					
	Wetting and drying cycles	C															C		C		C		
	Crystallization of soluble salts	-																					
	Freezing	E																					
	Excessive / insufficient	A												A									
Deterioration Factors – Activities of the Living	Microbiological vegetation	-																					
	Plants	-																					
	Birds	D																					
	Insects	C																					
	Rodents	-																					

Table B.9. Evaluation of architectural design characteristics of protective structures and deterioration factors at Fishbourne Roman Palace, West Sussex (UK).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT FISHBOURNE ROMAN PALACE, WEST SUSSEX (UK)

			Design of Protective Structure																																						
			Typology of Protective Structure				**Structural System**				**Roof System**				**Roof Material**						**Facade System**				**Facade Material**					**Thermal Control System**					**Drainage System**						
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates,	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh,	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates)	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples				1		1				1		1						1			1								1	1	1			1							1
Deterioration Factors	**Sources of Water**																																								
	Rain penetration	-																																							
	Rising damp	A																																							A
	Condensation	-																																							
	Instability of Microclimate																																								
	Solar gain	A																											A												
	Heat built up	A																											A	A											
	Fluctuations of T and RH	A																											A	A				A							
	Wetting and drying cycles	A																											A	A				A							A
	Crystallization of soluble salts	A																											A	A				A							A
	Freezing	-																																							
	Excessive / insufficient	A																																A							
	Activities of the Living																																								
	Microbiological vegetation	B																																							B
	Plants	-																																							
	Birds	-																																							
	Insects	-																																							
	Rodents	-																																							

Table B.10. Evaluation of architectural design characteristics of protective structures and deterioration factors at Chedworth Roman Villa, Gloucestershire (UK).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT CHEDWORTH ROMAN VILLA, GLOUCESTERSHIRE (UK)

Design of Protective Structure (part 1)

			Typology of Protective Structure				Structural System				Roof System			
		Number of Examples	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height
Number of Examples				1	1					1		1		
Deterioration Factors – Sources of Water	Rain penetration	-												
	Rising damp	-												
	Condensation	A												
Deterioration Factors – Instability of Microclimate	Solar gain	C												
	Heat built up	-												
	Fluctuations of T and RH	A												
	Wetting and drying cycles	C												
	Crystallization of soluble salts	C												
	Freezing	A												
	Excessive / insufficient ventilation	-												
Deterioration Factors – Activities of the Living	Microbiological vegetation	B												
	Plants	-												
	Birds	-												
	Insects	-												
	Rodents	-												

Design of Protective Structure (part 2)

		Roof Material						Facade System			
		Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate / fiberglass plates)	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable
Number of Examples		1						1			
Deterioration Factors – Sources of Water	Rain penetration										
	Rising damp										
	Condensation										
Deterioration Factors – Instability of Microclimate	Solar gain										
	Heat built up										
	Fluctuations of T and RH										
	Wetting and drying cycles										
	Crystallization of soluble salts										
	Freezing										
	Excessive / insufficient ventilation										
Deterioration Factors – Activities of the Living	Microbiological vegetation										
	Plants										
	Birds										
	Insects										
	Rodents										

Design of Protective Structure (part 3)

		Facade Material					Thermal Control System				
		Stone masonry walls	Perforated sheets (Aluminum mesh, PVC textile)	opaque (steel plates, timber cladding)	translucent (polycarbonate / fiberglass plates)	transparent (polycarbonate plates, glass)	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation
Number of Examples				1		1				1	
Deterioration Factors – Sources of Water	Rain penetration										
	Rising damp										
	Condensation									A	
Deterioration Factors – Instability of Microclimate	Solar gain					C					
	Heat built up										
	Fluctuations of T and RH										
	Wetting and drying cycles					C				A	
	Crystallization of soluble salts					C					
	Freezing									A	
	Excessive / insufficient ventilation										
Deterioration Factors – Activities of the Living	Microbiological vegetation										
	Plants										
	Birds										
	Insects										
	Rodents										

Design of Protective Structure (part 4)

		Drainage System						
		Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples		1	1					
Deterioration Factors – Sources of Water	Rain penetration							
	Rising damp							
	Condensation							
Deterioration Factors – Instability of Microclimate	Solar gain							
	Heat built up							
	Fluctuations of T and RH							
	Wetting and drying cycles							
	Crystallization of soluble salts							
	Freezing							
	Excessive / insufficient ventilation							
Deterioration Factors – Activities of the Living	Microbiological vegetation							
	Plants							
	Birds							
	Insects							
	Rodents							

Table B.11. Evaluation of architectural design characteristics of protective structures and deterioration factors at Roman Town House, Dorchester (UK).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT ROMAN TOWN HOUSE, DORCHESTER (UK)

Design of Protective Structure

			Typology of Protective Structure				Structural System				Roof System			
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height
Number of Examples			1		1				1		1			
Deterioration Factors: Sources of Water	Rain penetration	-												
	Rising damp	B												
	Condensation	-												
Deterioration Factors: Instability of Microclimate	Solar gain	A	A											
	Heat built up	-												
	Fluctuations of T and RH	C	C											
	Wetting and drying cycles	C	C											
	Crystallization of soluble salts	C	C											
	Freezing	-												
	Excessive / insufficient ventilation	-												
Deterioration Factors: Activities of the Living	Microbiological vegetation	B												
	Plants	-												
	Birds	-												
	Insects	-												
	Rodents	-												

		Roof Material						Facade System			
		Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate / fiberglass plates)	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable
Number of Examples		1									
Sources of Water	Rain penetration										
	Rising damp										
	Condensation										
Instability of Microclimate	Solar gain										
	Heat built up										
	Fluctuations of T and RH										
	Wetting and drying cycles										
	Crystallization of soluble salts										
	Freezing										
	Excessive / insufficient ventilation										
Activities of the Living	Microbiological vegetation										
	Plants										
	Birds										
	Insects										
	Rodents										

		Facade Material					Thermal Control System				
		Stone masonry walls	Perforated sheets (Aluminum mesh, PVC textile)	opaque (steel plates, timber cladding)	translucent (polycarbonate / fiberglass plates)	transparent (polycarbonate plates, glass)	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation
Number of Examples							1	1	1		
Sources of Water	Rain penetration										
	Rising damp										
	Condensation										
Instability of Microclimate	Solar gain										
	Heat built up										
	Fluctuations of T and RH										
	Wetting and drying cycles										
	Crystallization of soluble salts										
	Freezing										
	Excessive / insufficient ventilation										
Activities of the Living	Microbiological vegetation										
	Plants										
	Birds										
	Insects										
	Rodents										

		Drainage System						
		Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples		1	1				1	
Sources of Water	Rain penetration							
	Rising damp	B	B				B	
	Condensation							
Instability of Microclimate	Solar gain							
	Heat built up							
	Fluctuations of T and RH							
	Wetting and drying cycles	C	C				C	
	Crystallization of soluble salts	C	C				C	
	Freezing							
	Excessive / insufficient ventilation							
Activities of the Living	Microbiological vegetation	B	B				B	
	Plants							
	Birds							
	Insects							
	Rodents							

Table B.12. Evaluation of architectural design characteristics of protective structures and deterioration factors at Roman Villa, Piazza Armerina (Sicily, Italy).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT ROMAN VILLA, PIAZZA ARMERINA (SICILY, ITALY)

			Design of Protective Structure																																						
			Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples				1	1				1		1								1	1	1				1			1	1	1	1	1					1	1	1		
Deterioration Factors	Sources of Water	Rain penetration	C																																						
		Rising damp	C																																		C			
		Condensation	A																A	A									A												
	Instability of Microclimate	Solar gain	A																A	A									A												
		Heat built up	A																A	A									A												
		Fluctuations of T and RH	A																A	A									A												
		Wetting and drying cycles	A																A	A									A												
		Crystallization of soluble salts	A																A	A									A									A			
		Freezing	-																																						
		Excessive / insufficient	-																																						
	Activities of the Living	Microbiological vegetation	B																																		B			
		Plants	-																																						
		Birds	-																																						
		Insects	-																																						
		Rodents	-																																						

Table B.13. Evaluation of architectural design characteristics of protective structures and deterioration factors at Fortification Walls of Capo Soprano, Gela (Sicily, Italy).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT FORTIFICATION WALLS OF CAPO SOPRANO, GELA (SICILY, ITALY)

			Design of Protective Structure																																						
			Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples			1			1			1			1		1					1		1								1	1	1	1			1	1	1				
Deterioration Factors	Sources of Water	Rain penetration	A	A											A																										
		Rising damp	-																																						
		Condensation	A																											A											
	Instability of Microclimate	Solar gain	A	A																										A											
		Heat built up	A																											A											
		Fluctuations of T and RH	-																																						
		Wetting and drying cycles	-																																						
		Crystallization of soluble salts	-																																						
		Freezing	-																																						
		Excessive / insufficient	-																																						
	Activities of the Living	Microbiological vegetation	A																											A											
		Plants	A																											A											
		Birds	-																																						
		Insects	A																											A											
		Rodents	A																											A											

Table B.14. Evaluation of architectural design characteristics of protective structures and deterioration factors at St. Stephen Complex, Um Er-Rasas (Jordan).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT ST. STEPHEN COMPLEX, UM ER-RASAS (JORDAN)

			Design of Protective Structure																																						
			Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate /	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC	opaque (steel plates, timber cladding)	translucent (polycarbonate /	transparent (polycarbonate plates,	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples				1		1			1			1						1			1						1		1	1	1	1			1	1	1				
Deterioration Factors	**Sources of Water**	Rain penetration	-																																								
		Rising damp	A																																	A	A	A				
		Condensation	-																																								
	Instability of Microclimate	Solar gain	-																																								
		Heat built up	-																																								
		Fluctuations of T and RH	-																																								
		Wetting and drying cycles	A																													A	A				A	A	A				
		Crystallization of soluble salts	A																													A	A				A	A	A				
		Freezing	-																																								
		Excessive / insufficient	B																				B											B									
	Activities of the Living	Microbiological vegetation	B																																		B	B	B				
		Plants	-																																								
		Birds	-																																								
		Insects	-																																								
		Rodents	-																																								

Table B.15. Evaluation of architectural design characteristics of protective structures and deterioration factors at Nile Festival Building, Zippori (Israel).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT NILE FESTIVAL BUILDING, ZIPPORI (ISRAEL)

			Design of Protective Structure																			
			Typology of Protective Structure				Structural System				Roof System				Roof Material					
		Deterioration Factors	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate / fiberglass plates)	transparent (polycarbonate plates)
	Number of Examples		1		1				1		1							1		
Deterioration Factors / Sources of Water	Rain penetration	-																		
	Rising damp	-																		
	Condensation	C	C																	
Instability of Microclimate	Solar gain	-																		
	Heat built up	-																		
	Fluctuations of T and RH	-																		
	Wetting and drying cycles	C	C																	
	Crystallization of soluble salts	C	C																	
	Freezing	-																		
	Excessive / insufficient ventilation	-																		
Activities of the Living	Microbiological vegetation	B																		
	Plants	-																		
	Birds	-																		
	Insects	-																		
	Rodents	-																		

		Facade System				Facade Material					Thermal Control System					Drainage System						
		Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC textile)	opaque (steel plates, timber cladding)	translucent (polycarbonate / fiberglass plates)	transparent (polycarbonate plates, glass)	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient site drainage	Inefficient roof drainage	Inefficient surface water drainage	High groundwater levels
	Number of Examples										1		1								1	
Deterioration Factors / Sources of Water	Rain penetration																					
	Rising damp																					
	Condensation										C											
Instability of Microclimate	Solar gain																					
	Heat built up																					
	Fluctuations of T and RH										C											
	Wetting and drying cycles																					
	Crystallization of soluble salts										C											
	Freezing																					
	Excessive / insufficient ventilation																					
Activities of the Living	Microbiological vegetation										B											
	Plants																					
	Birds																					
	Insects																					
	Rodents																					

Table B.16. Evaluation of architectural design characteristics of protective structures and deterioration factors at Great House Ruins, Arizona (USA).

EVALUATION OF ARCHITECTURAL DESIGN CHARACTERISTICS OF PROTECTIVE STRUCTURES AND DETERIORATION FACTORS AT GREAT HOUSE RUINS, ARIZONA (USA)																																									
			Design of Protective Structure																																						
			Typology of Protective Structure				Structural System				Roof System				Roof Material						Facade System				Facade Material					Thermal Control System					Drainage System						
		Number of Examples	Shelter	Enclosure	Built on remains	Built above remains	Masonry	Reinforced concrete	Steel	Timber skeleton	Segmented	Single piece	Louvers	Limited shelter area / excessive roof height	Tiles	Reinforced concrete	Membrane	opaque (steel, copper plates, fiberboard,)	translucent (polycarbonate / fiberglass plates)	transparent (polycarbonate plates)	Impermaeble	Adjusting sides in seasons	Louvers	Permeable	Stone masonry walls	Perforated sheets (Aluminum mesh, PVC textile)	opaque (steel plates, timber cladding)	translucent (polycarbonate / fiberglass plates)	transparent (polycarbonate plates, glass)	Absence of roof insulation	Absence of facade insulation	Natural ventilation	Heating	Mechanical ventilation	Absence of roof drainage	Absence of surface water drainage	Absence of site drainage	Inefficient roof drainage	Inefficient surface water drainage	Inefficient site drainage	High groundwater levels
Number of Examples			1			1			1			1						1												1		1			1	1	1				
Deterioration Factors	Sources of Water	Rain penetration	C	C											C																											
Deterioration Factors	Sources of Water	Rising damp	C	C											C																					C	C	C				
Deterioration Factors	Sources of Water	Condensation	-																																							
Deterioration Factors	Instability of Microclimate	Solar gain	B	B											B																											
Deterioration Factors	Instability of Microclimate	Heat built up	-																																							
Deterioration Factors	Instability of Microclimate	Fluctuations of T and RH	-																																							
Deterioration Factors	Instability of Microclimate	Wetting and drying cycles	C	C											C																					C	C	C				
Deterioration Factors	Instability of Microclimate	Crystallization of soluble salts	C	C																																C	C	C				
Deterioration Factors	Instability of Microclimate	Freezing	C	C																																						
Deterioration Factors	Instability of Microclimate	Excessive / insufficient ventilation	A	A																													A									
Deterioration Factors	Activities of the Living	Microbiological vegetation	-																																							
Deterioration Factors	Activities of the Living	Plants	-																																							
Deterioration Factors	Activities of the Living	Birds	A	A																																						
Deterioration Factors	Activities of the Living	Insects	A	A																																						
Deterioration Factors	Activities of the Living	Rodents	A	A																																						

VITA

Date and Place of Birth: 12.11.197 – AYDIN

M.Sc. İzmir Institute of Technology, Faculty of Architecture, Department of Architectural Restoration (October 2003 – June 2006).
Thesis: "Evaluation of Interventions in Western Stoa of Agora in İzmir."

B.Arch. Dokuz Eylül University, Faculty of Architecture, Department of Architecture (October 1994 – June 1999).

Work Experience

Architect, İzmir Konak Municipality (May 2012 – Present)
Research Assistant, İzmir Institute of Technology, Faculty of Architecture, Department of Architecture (September 2006 – May 2012).
Research Assistant, İzmir Institute of Technology, Faculty of Architecture, Department of Architectural Restoration (August 2004 – September 2006).

Some of the Publications:

Yaka Çetin, Funda, and Başak İpekoğlu. 2013. "Impact of Transparency in the Design of Protective Structures for Conservation of Archaeological Remains." *Journal of Cultural Heritage* 14(3) e-21-24.

Yaka Çetin, Funda, Başak İpekoğlu, and Didier Laroche. 2012. "Reconstruction of Archaeological Sites: Principles Practice and Evaluation." *International Journal of Architectural Heritage* 6(5) 579-603.

Yaka Çetin, Funda, and Başak İpekoğlu. 2011. "Protective Structures for Conservation and Presentation of Archaeological Sites." 5th International Congress "Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basin, İstanbul, 22-25 November 2011.

İpekoğlu, Başak, Funda Yaka, and Kerem Şerifaki. 2010. "Strengthening of the Traditional Wooden Structural System in the Historic "Çalıkuşu House", Kuşadası, Turkey", International Conference on Structural Health Assessment of Timber Structures, Lisbon, 16-17 June 2011.