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Conservation and Restoration of Adobe Architectural Heritage of Bam Citadel (Iran), Affected by the 26 December 2003 Bam Earthquake: Problems and Issues

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Tutor: Prof. Arch. Bianca Gioia Marino
Co-Tutor: Prof. Eng. Aldo Aveta

Dottorando
Eng. Jafar Rouhi

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ABSTRACT

The arguments of “Bam city” and “Bam and its Cultural Landscape” after the 2003 Bam earthquake have been the objects of debates in several studies and international conferences over the last two decades. As a brief explanation, the Citadel of Bam (Arg-e Bam) as an outstanding example of a fortified medieval town is located in the hot and dry weather condition on the southern edge of the Iranian high plateau. This ancient Iranian town is recognized as the largest extant adobe-mud brick complex in the world, which has kept its traditional architecture in desert environment not only up to the day they were severely damaged by the Dec 26, 2003 Bam earthquake, but even now. Since Ban region benefited from abundant underground water and since the Citadel of Bam has withstood intrusion during centuries for its strategic location in the Silk Road, the region of Bam can be considered as one of the first foci for the organization of a civilization which originated and expanded in a multicultural society involving the different religions such as Zoroastrian, Jewish, Islamic, Christian, etc. Based on the available evidences and ruins left in Bam Citadel, it can be perceived that the most of the symbolic features of the traditional buildings have been inspired by natural and cultural needs and the occupants’ requirements.

According to UNESCO World Heritage Committee, the International Centre for the Study of the Preservation and Restoration of Cultural Property and the International Council on Monuments, Iran is identified as the tenth country with the richest cultural and historical offerings to visitors. In spite of this global ranking, unfortunately, this country is located in the area where earthquakes are most frequent; several strong earthquakes during recent and historical times have had destroyed the different regions of the country, and the country will probably continue to be threatened with disastrous earthquakes in the near future. In this regard, the country’s cultural heritage properties are at risk of seismic destruction, and the loss of these outstanding properties would negatively affect their cultural importance as sources of information from the past and symbols of identity, as well as their socio-economic values at local, national, and international levels.

In Iran, adobe architectural heritage is rich and complex. As a ubiquitous form of construction, adobe architecture appears in many constructions, from monuments to dwellings in historic fabric of cities. In this sense, from the ancient times, adobe materials have extensively been used for the construction of mansions, urban houses, citadels, fortifications, defensive walls, towers etc. They have also been widely used in religious buildings, like fire temples and mosques. However, several of these types of monuments are included in the UNESCO World Heritage list such as Tchogha Zanbil (1275-1240 BC), Takht-e Soleyman (3rd to 7th centuries), Shahr-i Sokhta (founded around 3200 BC) and Bam Citadel (6th to 4th centuries BC). In addition to those mentioned World Cultural Heritage, Iranian Cultural Heritage, Handicraft and Tourist Organization (ICHHTO) protects hundreds of adobe monuments throughout the country,

especially in provinces located in the central Iranian high plateau, such as Kerman, Esfahan, Fars, Yazd, Semnan, etc. These cities are not only celebrated for their diversity of styles and influences, but also for the continuity of their traditions on new building practices.

Every adobe monument in Iran is one of a steadily detracting number of country's cultural heritage that is significantly vulnerable to urban development and natural hazards, these two main factors are cited as being responsible for the demolition of the remained historic adobe structures in the country. Therefore, the preservation of the country's few remained historic adobe structures from the aforementioned causes of destruction is imperatively essential. As a worrisome situation, since Iran is an earthquake prone country in the world, these types of structures pertaining to their antiquity and vulnerability, commonly in earthquake are presenting asthenic behavior during moderate to strong ground motions. Therefore, this threatens their existence, as the Dec 26, 2003 Bam earthquake bears ample testimony to this fact. In this earthquake, "Bam Citadel" as the largest adobe complex in the world, listed by UNESCO as a part of the World Heritage Site of "Bam and its Cultural Landscape" was exposed to sever destruction.

Nowadays the survival of the Iranian historic adobe structures are threatened by several external factors that can be related to human effects, biological effects, inherent effects and natural effects, each of which doubled with lack of an appropriate conservation policy can be destructive during an earthquake. In recent decades, similar events as that happened in the city of Bam have indicated that lack of adequate attention, unsuitable attitude and insufficient mobility both in policy and scientific and research activities will contributed to the continuation of such events.

In the present research, the prevailing trend is to attempt to preserve, so far as possible, the Iranian adobe cultural heritage as they have undeniable social, cultural, historical, economical values. However, to achieve the above-mentioned objectives and to show the deficiencies and weakness of Iranian cultural heritage policy from different points of view, as a result, entails the necessity for conducting a study on one seismically endangered Iranian case. Therefore, in this thesis the ancient city of Bam "Bam Citadel" is recognized as a suitable case to make a conceive-known and close scrutiny about factors affecting on severity of seismic damages on adobe monuments of the Citadel of Bam. However, this thesis critically assesses the significance of failure, criteria, theories and strategies of conservation and restoration approaches in Iran.

In addition, based on international charters, recommendations and the activities that have been performed in this arena, it shares some up-to-date technical solutions, suggestions and required remedies to unlock a new aperture for well-preservation of the country's culturally or historically adobe architectural heritage from further deterioration, and especially against the next unpredictable earthquakes. Therefore, the thesis intends hopefully to provide a clear framework, concerning several methodologies to implement in order to safeguard the Iranian adobe monuments. Finally, since the Bam Citadel is a part of "Bam and its Cultural Landscape", some recommendations are proposed for future development of Bam site.

INTRODUCTION

On Friday 26 December 2003 at 01:56:52 GMT (05:26:52 local time at epicenter), a disastrous earthquake leveled the historical city of Bam within few seconds, and put Bam in the headline of all news and press throughout the world. Although the Bam region is located in the south-eastern Iran in an active seismic zone, the city of Bam had not experienced any major historical earthquake before this date. According to data recorded, Bam earthquake was one of the largest earthquakes which has ever occurred in southeast of Iran during the last century. The bulk of damage in Bam occurred in the center of an urban area where besides considerable destruction of manmade constructions, lifeline infrastructures such as hospitals, the water supply system, power lines, educational buildings etc., the earthquake caused the tragic loss of many lives and the destruction of an overwhelming part of its cultural heritage properties.

Bam Citadel is one of the best-preserved deserted Iranian medieval cities that clearly manifest the role of Arg in Iranian culture. This fortification is better than those of the most fortified cities in Iran and is particularly notable for the longevity of its use, which has kept its traditional architecture and urban fabric in Iranian desert environment not only up to the day they were severely damaged by the 2003 Bam earthquake, but even now. The ancient city of Bam started to be inhabited since Achaemenian period (550-330 BC), but it was originally founded during the Sassanid period (224-637 AD), while the ruins traced that most of structures were built during the Safavid period (1502-1722 AD). This Citadel was inhabited until 1850 AD, and continued to be used as a military garrison in Qajar dynasty from 1924 to 1932 AD and after that gradually turned into ruins.

According to the surveys conducted after the earthquake, the main reason for severity of seismic destruction in Bam Citadel was due to the inadequate scientific intervention, inappropriate preservation works and ignorance of the issue of seismic reinforcement of the monuments during restoration measures that already had been executed in Bam Citadel before the 2003 Bam earthquake. However, all those conservation and restoration works were to be subject to criticism and scandal, and demonstrated to be non-viable. It should be cited that in Iran, there is no clear regulation for preventive conservation concerning to the problems of historical heritages against natural disasters, especially seismic events, so more re-surfacing and re-appealing forms of restoration works are coming closer to eclecticism. At odds with European countries, many cultural heritage properties in Iran like Bam Citadel have no established policy, plan or process for managing disaster risk, and also all recent ideologies regarding the thematic of conservation and restoration of cultural heritages are being translated and published. A major part of the “2800 Iranian Seismic Code” is related to the new structural issues and there is nothing referring to the preservation and conservation of historic structures. However, in later crucial revisions of Iranian Seismic Code, there were no considerations about the new and existing traditional adobe constructions. Certainly, this ignorance would be a serious blunder, which will be equivalent to the occurrence of similar incidents every so often in the country.

After the 2003 Bam earthquake, a wide variety of intervention strategies and techniques have been considered for the rehabilitation and the seismic upgrading of the adobe monuments in Bam Citadel. Given the high destruction rate of Bam Citadel during the earthquake, its restoration process is known as one of the largest reconstruction project in the world. Yet after 13 years from Bam earthquake and despite various interventions and rescue operations implemented, ruin scars continue to exist on the Citadel. Here the reconstruction was undertaken in selected areas of the Citadel, and all reconstruction were based on archeological evidences and not on assumption. Fortunately, since the foundations of several walls in some properties were still standing after the earthquake, it made the restoration works move conveniently. At present, as regards to activities have been implemented by a co-operation among governmental and non-governmental institutions and associations at the national and international levels, the Citadel is slowly returning to its past glory as before the earthquake. Although each proposed technique for each monument was differed from the materials used and technical methods applied (typically a combination of traditional and innovative engineering techniques and materials), their suggested methods needed to pass from filters to correspond to international conservation criteria, following international charters and ICOMOS recommendations.

Generally, the objective of this thesis is to create a climate to exchange ideas and techniques in conservation and restoration of adobe architectural heritage, as well as comments and suggestions about their seismic reinforcement. In addition, it aims at creating consciousness in the local population about the importance of the preservation of cultural patrimonies, and the historic urban landscape in special. For this purpose, the Author firstly has tried to have a comprehensive review about of the famous singular monuments of Bam Citadel, which before the 2003 earthquake had been restored, and to evaluate the internationally accepted methods that have been applied for each of those monuments after the earthquake. Then, unlike the several available guidelines in lectures that mostly describe a single approach for seismic retrofitting of adobe monuments, this research through a broad study about the individual and group researches conducted for the preservation and seismic reinforcement of the cultural heritage properties, especially adobe ones, has tried to suggest the ideal techniques with notes in their use in different stages of interventions. In fact, what makes this research distinct from those similar samples is the vastness of its information in various fields related to a scientific anti-seismic intervention in historic adobe structures from applicable laboratory tests, diagnostic techniques, numerical modeling available, to small, medium and large scaled adobe models for evaluating their seismic behavior. The finalization of this research has a very important contribution in the necessity of efforts to upgrade the capacities of the Iranian local authorities in the field of adobe seismic reinforcement and to help the monuments like Bam Citadel throughout the country to continue their historical survival against next potential disastrous earthquakes.

THESIS STRUCTURE

In order to fulfill the aforementioned objectives, the present thesis is organized in five progressive chapters with connected arguments, as follows:

Chapter 1 introduces the area of study, according to Geographical, Climatical, Demographical, Historical, Geological and Seismicity, and Urban Morphological specifications of the city of Bam.

Chapter 2 firstly presents a lecture review on the meaning of "Arg" or "Citadel" in Persian lecture, and then focuses on the Citadel of Bam and introduces different parts of it within three separated fortified quarters. Secondly, it investigates about the architectural typology and morphology of Bam Citadel based on environmental and cultural factors. However, to better survey about the architectural typology of Bam Citadel, this section firstly classifies the effects of natural factors on climate-compatible architectural design of buildings within Bam Citadel, and secondly surveys about the effects of cultural criteria in its architectural typologies. This section along with photographs and drawings found is intended to give the reader a better knowledge of the common architectural terms used for many monuments in Bam Citadel. Thirdly, this chapter presents a general view about the background and characteristic of adobe structures, and then explains different steps for production of adobe-mud bricks, and construction of different parts of adobe structures in Bam Citadel (e.g. adobe foundation, adobe wall, adobe roof, and adobe surface coating). Finally, it classifies the observed mechanism of deterioration in Bam Citadel into four primary causes (human effects, biological effects, inherent effects and natural effects), causes which may threaten the stability of the adobe monuments, each encompassing a number of secondary factors (e.g. moisture and related damages, erosion and other damages due to wind and rainfall).

Chapter 3 firstly presents an overview of the seismicity of Iran and its effect on Iranian adobe cultural heritage during history, and then focuses on the 2003 Bam earthquake and damages induced on "Bam and its Cultural Landscape". After that, it describes the influential factors to the diversity and severity of seismic damages in Bam Citadel. Secondly, it makes a detailed analysis of the typology of seismic damages on different parts of adobe monuments in Bam Citadel. Thirdly, after presenting a definition of the cultural heritages and their values in international level, and after having a glance on criteria and standards for registry of a monument or site in the WHL, it performs a review of the entry of "Bam Citadel and its Cultural Landscape" in the WHL and WHLD until its removal from WHLD. Finally, after an overview of the cultural landscape in the world heritage context, including the notion of cultural landscape and the history of the presentation of cultural landscape in the World Heritage List, it interprets each criterion in which "Bam and its Cultural Landscape" was included in the WHL.

Chapter 4 deals with the history of Iranian cultural heritage policy during three main historical periods including Qajar Dynasty (1785-1925 AD), Pahlavi Dynasty (1925-1979AD), and after Islamic Revolution (1979 AD until now). This chapter also evaluates the basis and problems of conservation works in Bam Citadel before the 2003 earthquake. Furthermore, it explains the past and present state of the conservation works on famous singular monuments of Bam Citadel according to the Location-Geographic Co-ordinates, Period of Construction, Property Description, Property Values, Conservation History before Earthquake, Physical Condition after Earthquake and then Proposed Intervention Plan after Earthquake. Finally, to get a better insight about the effectiveness of technical intervention plans carried out in Bam Citadel, a comparative analysis (SWOT) is conducted between two technical and diverse intervention plans that have been implemented for seismic reinforcement of the properties: one by using locally available materials, and another by using modern materials.

Finally, **Chapter 5** presents the main conclusions of the thesis and a proposal for future works to better preserve the "Bam and its Cultural Landscape" and other adobe monuments throughout the country. Furthermore, to associate to the main problems encountered in a historic adobe structure at different levels of intervention, the possible techniques are presented along with notes of "warning for erroneous solutions".

The aim of this section is firstly to pursue briefly the history and development of leading national European theories in respect to ancient buildings, the cross maturation of these mindsets, and their contribution towards initial movements and current fertility of international approach for the preservation of historic monuments and sites. The general development of the concept is accompanied by a critical selection of the most significant theories and their relationship with current practice in the relevant cultural heritage context. The study intends to raise the general consciousness about the process of the development of traditional approach to the treatment of medieval structures which first was particularly proposed as "restoration movement" in the 19^{th} century (Sir George Gilbert Scott, Eugène Emmanuel Viollet-le-Duc, etc.), the "anti-restoration movement" or "conservation movement" emphasizing the material authenticity and documentary value of the monuments (John Ruskin, William Morris, Camillo

Boito, etc.), and the “modern conservation theory”, which was based on a critical historical restoration of the work of art in its aesthetic, historical and use values (Alois Riegl, Cesare Brandi, etc.), which all were reflected in the Venice Charter (1964) and later in the policies of UNESCO and other related organizations.

Then based on the basic principles that must be considered during the execution of an admissible intervention work, and since the current guidelines and standards in the field of adobe cultural heritage preservation along with striking range of styles, details, clarities, and intents are characterized by the use of inadequate criteria and measures to guide the efforts. Given the existing shortages, the primary objective of this section is to render the technical methods to have scientific anti-seismic measures in historic adobe-mud brick structures. This information covers all available methods for analyzing the material characterization (e.g. laboratory tests on chemical, physical and durability properties), diagnostic investigation before, during and after interventions (e.g. NDT, MDT and DT in site investigation), and mechanical behavior (e.g. small, medium and large-scale laboratory tests) of the historic adobe structures. Then after suggestion of those methods, an overview is taken on the efficiency of the internationally adapted and tested technical retrofitting proposals for seismic upgrading of adobe structures. At the end, all possible technical traditional and modern methods, which have capability to be applied during structural modification of historic adobe structures are proposed. The general ideas presented in this thesis can be widely applicable and that the general planning methodologies outlined in this section can be followed elsewhere for seismic retrofitting of historic adobe structures. In fact, the following section is involved in providing the recommendations and suggestions in the form of guidelines for conservation, restoration and especially seismic retrofitting of culturally or historically adobe architectural heritage of Bam city between two earthquakes. Therefore, the result based on sites specifications can be developed for other cases in Iran and elsewhere around the world.

METHODOLOGY

This research will be the first PhD thesis that comprehensively studied different aspects of Bam earthquake and damages induced on “Bam and its Cultural Landscape” as well as past and present condition of the most pre-earthquake restored adobe monuments of Bam Citadel. Furthermore, to have a general view of the problem of cultural heritage preservation in Iran, the Iranian cultural heritage policy from the late of 19th century until now was scrutinized in details. In addition, due to lack of a comprehensive guideline to implement a scientific structural investigation and intervention on historic abode structures, regarding successful global researches and experiences implemented in this arena and those efficient methods that are widely used on historic stone masonry structures, different methods and techniques along with notes in their use are suggested in this research, which I believe with respect to the international recommendations and site specifications can have capability to be followed on any historic adobe structures. Finally, the research will systematize the information collected and produced, featuring the analyzed solutions.

The idea to organize this research was shaped in my mind since the 2003 Bam earthquake, and since the seismic events are the main threat for the existence of the few remaining Iranian adobe architectural heritage; it seemed that the current cultural heritage policy pursued in the country, and traditional methods of restoration cannot afford the necessaries for the protection of historic adobe structures against a subsequent earthquake, which may happen in the near future.

In this thesis, it was tried to respond to many questions as following: How Iranian authorities and experts are thinking about the issue of cultural heritage preservation? What was the problem of pre-earthquake interventions in Bam Citadel? What are the values of cultural heritage properties? What is cultural heritage landscape? Which parts of adobe monuments may show less stability against seismic motions? With respect to the issue of authenticity of the historic adobe monuments, what type of restoration would be applicable? How can we use traditional methods of restoration in an efficient way? How can engineering knowledge and innovative technologies support restoration of the historic adobe structures? and so forth.

In the case of Bam Citadel, to find the required data for the study, focus groups, in-depth individual interviews, and review of primary and secondary sources and documents (historical, archaeological, architectural and structural information) were employed. Moreover, two annual reports of Arg-e Bam research foundation (2005 & 2008), nomination of Bam and its Cultural Landscape in WHL (UNESCO, 2004), state of conservation reported by World Heritage Committee, ICOMOS evaluations and decisions taken about the Bam site, scientific papers, intervention plans implemented in Bam Citadel and fieldwork reports were applied. Furthermore, it should also be mentioned that in August 2015, the Author have had a site visit from Bam Citadel, during which it was tried to provide a complete pictorial report from activities that have been implemented on the main monuments of Bam Citadel. Along this site visitation, there was also a pre-planned interview with three main figures of the recovery project of Bam Citadel both before and after earthquake: Prof. Mr. Hosein Tayari, Head of Bam Recovery Project until almost five days before earthquake; Prof. Mr. Eskandar Mokhtari Taleghani, Head of Bam Recovery Project from the beginning of earthquake until 2009; and Dr. Mr. Afshin Ebrahimi, Current Head of Bam Recovery Project. Based on the Author's interviews, which are presented in the Chapter 4 of this thesis, it was tried to understand the priorities and principles that were considered at the time of their own administrations.

To have a framework to implement in conservation and restoration works on cultural heritage properties, besides studying the development of the theories of cultural heritage conservation during the 19^{th} and 20^{th} century in Europe, a review was performed on the main international charter and recommendations such as: SPAB Manifesto (1877); Athens Charter (1931); Italian

Restoration Charter (1932); Venice Charter (1964); Italian Charter of Restoration (1972); Declaration of Amsterdam (1975); Nara Document on Authenticity (1994); Burra Charter (1999); Charter of Cracow (2000); ICOMOS- ISCARSAH Charter (2003). Meanwhile, in the case of adobe cultural heritage preservation, the researches and compilations of some research centers, committees, institutes such as CRAterre-ENSAG, ICOMOS-ISCEAH, UNESCO-WHEAP, ICCROM and Getty Conservation Institute (GCI), which jointly cooperate in international projects such as GAIA, WHE, GSAP and Terra were followed. Furthermore, to better explore the seismic behavior of the reinforced and non-reinforced historic adobe monuments, the results of large-scaled adobe model on the shake table test carried out in universities and institutes such as Pontifical Catholic University of Peru, Getty Conservation Institute in USA, Stanford University in USA, IZIIS-Ss., Cyril and Methodius University in Republic of Macedonia, Saitama University in Japan, University of Aveiro in Portugal and University of Sydney (UTS) were also studied. In addition, to suggest the best methods and techniques and to have better knowledge of characterization of adobe materials, both overt and covert deterioration in historic adobe structures, and to evaluate the seismic behavior of reinforced adobe structure through numerical modeling, the results of individual or group researches conducted in this issue were also studied.

PREMESSA

Le discussioni sulla "città di Bam" e su "Bam e il suo scenario culturale" dopo il terremoto di Bam del 2003 sono state oggetto di dibattito in numerosi studi e conferenze internazionali nel corso degli ultimi due decenni. In breve, la cittadella di Bam (Arg-e Bam) è un notevole esempio di città fortificata medievale situata in un clima secco e caldo al limite meridionale dell'altopiano iraniano. L'antica città iraniana è riconosciuta come il più grande complesso esistente al mondo in mattoni d'argilla e fango, che ha mantenuto la sua architettura tradizione nel contesto desertico e non soltanto fino al 26 dicembre del 2003 quando il terremoto di Bam l'ha gravemente danneggiata, ma fino ad oggi. Dato che la regione di Bam gode di abbondante acqua sotterranea, e dato che la cittadella di Bam ha resistito alle invasioni durante i secoli a causa della sua posizione strategica sulla Via della seta, la regione di Bam può essere considerata come uno dei primi nuclei per l'organizzazione di una civiltà che si originò e si evolse in una società multiculturale, che includeva diverse religione come lo Zoroastrismo, l'Ebraismo, l'Islam, il Cristianesimo ecc…. Sulla base delle prove disponibili e delle rovine rimaste della cittadella di Bam, è possibile notare che la maggior parte delle caratteristiche simboliche degli edifici tradizionali sono state ispirate da necessità naturali e culturali e dalle esigenze degli abitanti.

Secondo il Comitato del patrimonio mondiale UNESCO, il Centro internazionale per lo studio, la conservazione e il restauro dei beni culturali e il Comitato internazionale per i monumenti, l'Iran è definito come il decimo paese con la più ricca offerta storico-culturale per i suoi visitatori. Nonostante questa classifica a livello globale, sfortunatamente il paese è situato in un'area in cui i terremoti sono frequentissimi; numerosi forti sismi in tempi recenti e passati hanno distrutto le varie regioni del paese, e la nazione continuerà probabilmente ad essere minacciata da disastrosi terremoti nel prossimo futuro. A tale proposito, i beni afferenti all'eredità culturale del paese sono a rischio distruzione a causa dei sismi, e la perdita di tali straordinari beni avrebbe un impatto negativo sulla loro rilevanza culturale quali fonti di informazioni sul passato e simboli di identità, oltre al loro valore socio-economico a livello locale, nazionale e internazionale.

In Iran il patrimonio architettonico in mattoni d'argilla è ricco e complesso. Essendo una diffusa modalità di costruzione, l'architettura in mattoni d'argilla compare in numerosi edifici, dai monumenti alle abitazioni presenti nel tessuto storico delle città. In tal senso, dai tempi antichi, i materiali argillosi sono stati ampiamente utilizzati per la costruzione di palazzi, case cittadine, cittadelle, fortificazioni, mura difensive, torri, ecc… Sono inoltre stati largamente utilizzati negli edifici religiosi come templi del fuoco e moschee. Tuttavia, molte di queste tipologie di monumenti sono incluse nella lista del patrimonio mondiale UNESCO come Tchogha Zanbil (1275-1240 a. C.), Takht-e Soleyman (III-VII secolo), Shahr-i Sokhta (fondato all'incirca nel 3200 a. C.) e la Cittadella di Bam (VI-IV secolo a. C.). Oltre ai beni culturali di livello internazionale già citati, l'Organizzazione per il turismo, l'artigianato e il patrimonio culturale iraniano preserva centinaia di monumenti in mattoni d'argilla in tutto il paese, specialmente nelle province situate sull'altopiano iraniano centrale, come Kerman, Esfahan, Fars, Yazd, Seman, ecc… Queste città non sono riconosciute solo per la loro diversità di stili e influenze, ma anche per la continuità delle tradizioni nelle nuove costruzioni.

Ogni monumento in mattoni d'argilla in Iran fa parte di un numero costantemente in diminuzione di beni culturali del paese significativamente vulnerabili rispetto allo sviluppo urbano e alle insidie della natura; questi due importanti fattori sono citati in quanto responsabili della demolizione delle restanti strutture storiche in mattoni d'argilla nel paese. Pertanto, la conservazione delle poche strutture storiche in mattoni d'argilla rimanenti a causa delle suddette motivazioni è un imperativo essenziale. Data la preoccupante situazione, essendo l'Iran un paese soggetto a sismi, queste tipologie di costruzioni relativamente alla loro antichità e vulnerabilità, presentano solitamente durante i terremoti una certa fragilità, sia in presenza di movimenti tellurici moderati che intensi. Pertanto, ciò minaccia la loro esistenza, come il terremoto di Bam del 26 dicembre 2003 testimonia ampiamente. Durante questo sisma, la Cittadella di Bam, il più grande complesso in mattoni d'argilla del mondo, incluso dall'UNESCO tra i siti patrimonio mondiale come "Bam e il suo scenario culturale", è stato oggetto di grave distruzione.

Oggigiorno la sopravvivenza delle strutture storiche in mattoni d'argilla in Iran è minacciata da numerosi fattori esterni che possono essere ricondotti all'azione umana, a effetti biologici, intrinsechi e naturali, ognuno dei quali si moltiplica in assenza di appropriate politiche di conservazione e può risultare distruttivo durante un sisma. Negli ultimi decenni, eventi simili hanno avuto luogo nella città di Bam e hanno mostrato che la mancanza di un'adeguata attenzione, comportamenti inappropriati e un'insufficiente dinamicità sia nelle politiche che nelle attività di ricerca scientifica hanno contribuito al perpetrarsi di tali eventi.

In questo lavoro di ricerca, la tendenza prevalente è quella di tentare una conservazione, per quanto possibile, del patrimonio culturale iraniano in mattoni d'argilla in quanto esso possiede un innegabile valore sociale, culturale, storico ed economico. Tuttavia, per raggiungere i suddetti obiettivi e per mostrare le mancanze e le debolezze della politica iraniana sui beni culturali da diversi punti di vista, ne consegue come risultato la necessità di condurre uno studio su un singolo caso simico iraniano che tende ad essere dimenticato. Pertanto, nella presente tesi, l'antica città di Bam, la cittadella di Bam, è individuata come caso adatto a tratteggiare un esame attento dei fattori che hanno aggravato i danni dovuti al sisma sui monumenti in mattoni d'argilla nella Cittadella di Bam. Tuttavia, questa tesi fa una valutazione critica del senso dell'insuccesso, dei criteri, delle teorie e strategie di conservazione e degli approcci nella restaurazione in Iran.

Inoltre, sulla base di atti internazionali, raccomandazioni e attività portate avanti in questo campo, vengono presentate delle soluzioni tecniche aggiornate, dei suggerimenti e dei rimedi necessari per aprire la strada a nuovi efficaci metodi di conservazione del patrimonio culturale storico e nazionale in mattoni d'argilla da ulteriore deterioramento, e in modo particolare dai prossimi, imprevedibili terremoti. Pertanto, la tesi intende fornire un quadro chiaro concernente le numerose metodologie da mettere in atto al fine di salvaguardare i monumenti iraniani in mattoni d'argilla. Finalmente, da quando la Cittadella di Bam è parte di "Bam e il suo scenario culturale", vengono proposte delle raccomandazioni per il futuro sviluppo del sito di Bam.

INTRODUZIONE

Venerdì 26 dicembre 2003, alle 01:56:52, tempo del meridiano di Greenwich (05:26:56 ora locale dell'epicentro), un terremoto disastroso demolì la storica città di Bam in pochi secondi, e fece saltare Bam agli onori della cronaca in tutto il mondo. Sebbene Bam sia situata nella regione sud-orientale dell'Iran in una zona sismica, la città non era mai stata colpita da un grande terremoto prima di allora. Secondo i dati raccolti, il sisma di Bam è stato uno dei maggiori mai verificatisi nel sud-est dell'Iran durante il secolo scorso. La maggior parte dei danni a Bam si verificò nel centro di un'area urbana in cui, oltre alla considerevole distruzione di costruzioni artificiali, infrastrutture vitali come ospedali, sistemi di fornitura d'acqua, linee elettriche, scuole ecc, il terremoto causò la perdita tragica di molte vite e la distruzione di una parte molto consistente dei suoi beni culturali.

La Cittadella di Bam è una delle città medievali iraniane nel deserto meglio conservate, che mostra chiaramente il ruolo della cittadella nella cultura iraniana. Questa fortificazione è migliore di quelle delle maggiori città fortificate in Iran ed è particolarmente ragguardevole per la sua longevità d'uso, mantenendo la sua architettura tradizionale e il tessuto urbano nell'ambiente desertico iraniano, non soltanto al giorno in cui fu gravemente danneggiata nel 2003 dal terremoto di Bam, ma fino ad oggi. L'antica città di Bam cominciò ad essere abitata fin dal periodo achemenide (550-330 a. C.), ma fu fondata originariamente durante il periodo sassanide (224-637 d. C.), mentre le rovine indicano che la maggior parte delle strutture fu costruita durante il periodo safavide (1502-1722 d. C.). Questa cittadella fu abitata fino al 1850 d. C., e continuò ad essere utilizzata come presidio militare durante la dinastia Qajar dal 1924 al 1932 d. C., e successivamente si trasformò in rovine.

Secondo le ricerche condotte dopo il terremoto, la causa principale della gravità della distruzione sismica nella Cittadella di Bam fu dovuta ad un inadeguato intervento scientifico, a lavori di conservazione impropri, all'ignoranza riguardo al consolidamento sismico dei monumenti durante il processo di restauro che era già stato eseguito sulla Cittadella di Bam prima del terremoto del 2003. Tuttavia, tutte quelle misure di conservazione e restauro furono sottoposte a critiche e pettegolezzo e si dimostrarono non attuabili. Va detto che in Iran non esiste una regolamentazione chiara sulla conservazione preventiva per quanto riguarda le problematiche dei beni storici causate da disastri naturali, in modo particolare eventi sismici, quindi diversi lavori di restauro, di rifacimento e abbellimento si avvicinano all'eclettismo. Al contrario dei paesi europei, molti beni culturali iraniani come la Cittadella di Bam, non hanno una politica, un progetto o una prassi consolidata nella gestione del rischio di disastri, e anche tutte le recenti filosofie riguardanti la tematica della conservazione e del restauro dei beni culturali sono in corso di traduzione e pubblicazione. Una parte importante del Codice sismico iraniano 2800 è legato alle nuove questioni strutturali e non c'è alcun riferimento alla preservazione e conservazione degli edifici storici. Tuttavia, in successive, fondamentali revisioni del Codice sismico iraniano, non ci sono state affatto considerazioni circa le costruzioni in mattoni d'argilla, sia nuove che tradizionali e già esistenti. Certamente l'ignoranza sarebbe un errore madornale che equivarrebbe al verificarsi di simili incidenti molto spesso nel paese.

Dopo il terremoto di Bam del 2003, una grande varietà di strategie di intervento e di tecniche è stata presa in considerazione per il recupero e l'adeguamento sismico dei monumenti in mattoni d'argilla nella Cittadella di Bam. Dato l'alto tasso di distruzione della Cittadella di Bam durante il terremoto, il suo processo di restauro è noto come uno dei più grandi progetti di ricostruzione al mondo. Tuttavia, dopo 13 anni dal terremoto, e nonostante vari interventi e operazioni di salvataggio messi in atto, le cicatrici delle rovine continuano a persistere nella cittadella. Qui la ricostruzione è stata intrapresa in aree scelte, e tutta la ricostruzione è stata basata su dati archeologici e non su supposizioni. Fortunatamente, dato che le fondamenta di molti muri di alcuni edifici erano ancora in piedi dopo il terremoto, il restauro ha funzionato in modo adeguato. Attualmente, per quando riguarda le attività realizzate con la collaborazione tra istituzioni governative e non ed associazioni nazionali e internazionali, la cittadella sta lentamente tornando alla sua gloria passata, a prima del terremoto. Sebbene ogni tecnica proposta per singolo monumento fosse differenziata per i materiali utilizzati e le metodologie applicate (tipicamente una combinazione di tecniche e materiali di ingegneria tradizionale e innovativa), i metodi da loro suggeriti dovevano essere sottoposti ad analisi per corrispondere ai criteri internazionali di conservazione, seguendo gli atti internazionali e le raccomandazioni dell'ICOMOS.

In generale, l'obiettivo della presente tesi è di creare un clima di scambio di idee e tecniche di conservazione e restauro dei beni architettonici in mattoni d'argilla, oltre a fornire commenti e suggerimenti circa il consolidamento sismico. Inoltre, essa mira a creare nella popolazione locale una coscienza riguardo all'importanza della conservazione del patrimonio culturale e in modo particolare dello scenario storico urbano. A tale scopo, l'Autore ha prima di tutto tentato di compiere un esame esauriente dei singoli famosi monumenti della Cittadella di Bam, che erano stati restaurati prima del sisma del 2003, e di valutare i metodi internazionalmente accettati che sono stati applicati ad ognuno di questi monumenti dopo il terremoto. Poi, diversamente dalle numerose linee guida fornite durante le conferenze, che descrivono principalmente un singolo approccio per il rimodernamento dei monumenti in mattoni d'argilla, la presente ricerca, attraverso un vasto studio a livello di ricerca individuale e di gruppo condotta per la conservazione e il consolidamento sismico dei beni culturali, specialmente quelli in mattoni d'argilla, ha tentato di suggerire le tecniche ideali con appunti sul loro utilizzo in diverse fasi dell'intervento. Intatti, ciò che rende questa ricerca diversa da modelli simili è la vastità delle sui informazioni in vari campi correlati agli interventi scientifici antisismici su strutture storiche in mattoni, a partire da test condotti in laboratorio, tecniche di diagnostica, lavoro su modelli numerici a disposizione, fino a modelli in mattoni di piccola, media o grande scala per la valutazione degli effetti in caso di sisma. La conclusione di questa ricerca costituisce un importante contributo agli sforzi necessari per aggiornare le abilità delle autorità locali iraniane nel campo del consolidamento sismico delle strutture in mattoni, e aiutare monumenti come la Cittadella di Bam in tutto il paese a continuare a sopravvivere alla storia contro i prossimi terremoti potenzialmente disastrosi.

STRUTTURA DELLA TESI

Per raggiungere i sopracitati obiettivi, il presente lavoro di tesi è organizzato in cinque capitoli progressivi con argomenti correlati come segue:

Capitolo 1: introduce il campo di studio secondo le caratteristiche geografiche, climatiche, demografiche, storiche, geologiche, sismiche, e legate alla morfologia urbana della città di Bam.

Capitolo 2: presenta in primo luogo un'analisi linguistica del significato di "Arg" o "Cittadella" nei testi persiani, si focalizza sulla Cittadella di Bam e presenta successivamente al suo interno tre sezioni fortificate separate. In secondo luogo, analizza la tipologia architettonica e la morfologia della Cittadella di Bam, sulla base di fattori ambientali e culturali. Peraltro, per meglio indagare la tipologia architettonica della Cittadella di Bam, questo capitolo classifica innanzitutto gli effetti dei fattori naturali sui progetti architettonici degli edifici compatibili con il clima all'interno della cittadella, e successivamente analizza gli effetti dei criteri culturali sulle sue tipologie architettoniche. Questa parte, insieme a fotografie e disegni ritrovati, ha lo scopo di fornire al lettore una migliore conoscenza dei comuni termini architettonici utilizzati per molti monumenti nella Cittadella di Bam. In terzo luogo, questo capitolo presenta una visione d'insieme riguardo al contesto e alle caratteristiche delle strutture in mattoni d'argilla, e illustra i diversi passaggi per la produzione di mattoni d'argilla e fango, e la costruzione e diverse parti delle strutture in mattoni d'argilla della Cittadella di Bam (ad esempio fondamenta in mattoni, muri in mattoni, tetti e rivestimenti esterni in mattoni). Alla fine, esso classifica e analizza i meccanismi di deterioramento nella cittadella secondo quattro diverse cause principali (azione umana, effetti biologici, intrinsechi ed effetti naturali), cause che possono minacciare la stabilità dei monumenti in mattoni d'argilla, ognuna delle quali include fattori secondari (umidità e danni correlati, erosione ed altri danni dovuti al vento e alle precipitazioni).

Capitolo 3: presenta in primo luogo un quadro d'insieme della sismicità in Iran e dei suoi effetti sui beni culturali iraniani in mattoni nel corso della storia, e si concentra successivamente sul terremoto del 2003 di Bam e sui danni prodotti su "Bam e il suo scenario culturale". Dopodiché, esso descrive i fattori importanti per la diversità e la gravità dei danni sismici sulla Cittadella di Bam. In secondo luogo, viene compiuta un'analisi dettagliata della tipologia dei danni sismici su diverse parti di monumenti in mattoni d'argilla a Bam. In terzo luogo, dopo aver presentato una definizione di beni culturali e del loro valore a livello internazionale, e dopo aver accennato ai criteri e agli standard per la registrazione di un monumento o di un sito nel WHL, viene affrontata un'analisi della voce "Cittadella di Bam e suo scenario culturale" nel WHL e nel WHLD fino alla sua rimozione dal WHLD. In conclusione, in seguito a una panoramica dello scenario culturale nel contesto del patrimonio mondiale, includendo la nozione di scenario culturale e la storia della presentazione dello scenario culturale nell'elenco del patrimonio mondiale, viene interpretato ogni criterio per cui "Bam e il suo scenario culturale" era inclusa nel WHL.

Capitolo 4: si occupa della storia delle politiche iraniane relative al patrimonio culturale nel corso di tre principali periodi storici, la dinastia Qajar (1785-1925 d. C.), la dinastia Pahlavi (1925-1979 d. C.), e dopo la rivoluzione islamica (1979 d. C. fino a oggi). Questo capitolo analizza anche le basi e i problemi nei lavori di conservazione della Cittadella di Bam prima del terremoto del 2003. Inoltre, esso illustra lo stato passato e presente dei lavori di conservazione di famosi singoli monumenti della cittadella, secondo la loro collocazione geografica, il periodo di costruzione, la descrizione del bene, il suo valore, la storia della conservazione prima del terremoto, la condizione a seguito del terremoto e il progetto di intervento proposto in seguito al sisma. In conclusione, per avere un'idea migliore circa l'efficienza di progetti di intervento tecnico portati avanti nella Cittadella di Bam, viene condotta un'analisi comparativa (SWOT) tra due progetti di interventi tecnici diversi che sono stati attuati per il consolidamento sismico dei beni: uno utilizzando materiali reperibili localmente, e un altro utilizzando materiali moderni.

Capitolo 5: infine presenta le principali conclusioni della tesi e una proposta per lavori futuri al fine di poter meglio preservare "Bam e il suo scenario culturale". Inoltre, ai problemi principali incontrati in una struttura storica in mattoni d'argilla nei diversi livelli di interventi vengono affiancate possibili tecniche, qui presentate, insieme ad appunti che mettono in guardia da soluzione erronee.

Lo scopo di questa parte è di seguire in breve la storia e lo sviluppo delle principali teorie europee relativamente agli edifici antichi, alla maturazione incrociata di queste mentalità, e del loro contributo nei confronti dei primi movimenti e dell'attuale produttività dell'approccio internazionale per la conservazione di monumenti e siti storici. Lo sviluppo generale del concetto è accompagnato da una selezione critica delle teorie più significative e della loro relazione con l'attuale prassi nel contesto dei beni culturali rilevanti. Lo studio intende risvegliare la coscienza generale riguardo al processo di sviluppo di un approccio tradizione al trattamento delle strutture medievali, che fu proposto prima di tutto in modo particolare come "movimento di restaurazione" nel diciannovesimo secolo (sir George Gilbert Scott, Eugène Emmanuel Viollet-le-Duc, ecc…), il "movimento anti restaurazione" o "movimento di conservazione" che metteva l'accento sull'autenticità dei materiali e sul valore di testimonianza dei monumenti (John Ruskin, William Morris, Camillo Boito, ecc…), e la "moderna teoria della conservazione", basata su una restaurazione storicamente critica dell'opera d'arte nella sua estetica, e nel suo valore e uso storico (Alois Riegel, Cesare Brandi, ecc…), che si sarebbe riflettuto nella Carta di Venezia (1964) e successivamente nelle politiche dell'UNESCO e di altre organizzazioni ad esso correlate.

Successivamente basandosi sui principi che devono essere considerati durante l'esecuzione di un lavoro d'intervento accettabile, e secondo le attuali linee guida e gli standard nel campo della conservazione dei beni culturali in mattoni d'argilla e della sorprendente varietà di stili, dettagli, limpidezze e intenti sono caratterizzati dall'utilizzo di criteri e misure inadeguate a portare avanti tali sforzi. Data la carenza esistente, l'obiettivo primario della presente sezione è di fornire i principi tecnici per avere misure antisismiche scientifiche delle strutture storiche in mattoni d'argilla e fango. Queste informazioni coprono tutti i metodi disponibili per l'analisi della caratterizzazione dei materiali (testi di laboratorio sulle proprietà chimiche, fisiche e sulla tenuta), analisi diagnostica prima, durante e dopo gli interventi (NDT, MDT e DT nell'analisi sul campo), e condotta meccanica (test di laboratorio su piccola, media e grande scala) delle strutture storiche in mattoni d'argilla. In seguito, dopo il suggerimento di tali metodi, viene fatta una panoramica sull'efficacia delle proposte di tecniche di ammodernamento adottate e testate a livello internazionale, per il miglioramento sismico delle strutture in mattoni. Alla fine vengono proposti tutti i metodi tradizionali e moderni possibili, che possono essere applicati durante modifiche strutturali degli edifici in mattoni. Le idee generali presentate in questa tesi possono essere ampiamente applicate alle generali metodologie di progettazione delineate in questa parte, e possono essere seguite altrove per l'ammodernamento sismico delle strutture storiche in mattoni. Intatti, la parte seguente intende fornire raccomandazioni e suggerimenti in forma di linee guida per la conservazione, il restauro e, specialmente, per l'ammodernamento dei beni architettonici in mattoni culturalmente e storicamente rilevanti della città di Bam tra due terremoti. Pertanto, i risultati basati su dettagliate analisi sul sito possono essere sviluppate per altri casi in Iran, e da qualsiasi altra parte nel mondo.

METODOLOGIA

La presente ricerca sarà la prima tesi di dottorato che abbia studiato esaustivamente i diversi aspetti del terremoto di Bam e i danni inflitti a "Bam e il suo scenario culturale", oltre alla condizione passata e presente della maggior parte dei monumenti in mattoni d'argilla della Cittadella di Bam restaurati prima del sisma. Inoltre, per avere una panoramica d'insieme del problema della conservazione del patrimonio culturale in Iran, viene analizzata in dettaglio la politica iraniana sui beni culturali dal diciannovesimo secolo fino ad oggi. Per di più, a causa di una carenza di linee guida esaustive per l'attuazione di indagini scientifiche strutturali e di interventi su edifici storici in mattoni d'argilla, in merito a ricerche globali di successo e ad esperienze attuate in questo campo e a quei metodi efficaci ampiamente utilizzati su strutture storiche con muratura in pietra, in questa ricerca vengono suggeriti diversi metodi e tecniche insieme ad appunti sul loro utilizzo, che credo, rispettando le raccomandazioni internazionali e le caratteristiche del sito, possano essere seguite su qualsiasi struttura storica in mattoni. In conclusione, la ricerca schematizzerà le informazioni raccolte e fornite che delineano le soluzioni prese in analisi.

L'idea di organizzare questa ricerca ha preso forma nella mia mente dal terremoto di Bam del 2003, dato che gli eventi sismici sono la principale minaccia all'esistenza dell'esiguo patrimonio architettonico iraniano in mattoni d'argilla; sembrava che la politica per i beni culturali all'epoca perseguita nel paese e i metodi tradizioni di restauro non potessero affrontare la sfida della protezione delle strutture storiche in mattoni d'argilla contro un successivo terremoto, che potrebbe verificarsi in un prossimo futuro.

In questo lavoro di tesi si è tentato di rispondere a molte domande come quelle che seguono: Come vedono gli esperti e le autorità iraniane la questione della conservazione del patrimonio culturale? Qual era il problema degli interventi sulla Cittadella di Bam prima del sisma? Qual è il valore dei beni culturali? Quali parti dei monumenti in mattoni d'argilla possono mostrare una minore stabilità di fronte ai movimenti tellurici? Riguardo alla questione dell'autenticità dei monumenti storici in mattoni, che tipo di restauro sarebbe effettuabile? Come possono essere utilizzati i metodi tradizionali di restauro in modo efficace? Come possono la conoscenza ingegneristica e le tecnologie innovative supportare il restauro delle strutture storiche in mattoni d'argilla? E così via.

Nel caso della Cittadella di Bam, per reperire i dati richiesti dallo studio, sono stati utilizzati gruppi di discussione, approfondite interviste frontali e analisi di fonti primarie e secondarie e di documenti (storici, archeologici, informazioni architettoniche e strutturali). Inoltre, sono stati applicati due rapporti annuali della fondazione Arg-e Bam (2005 e 2008), la candidatura di Bam e del suo scenario culturale per il WHL (UNESCO, 2004), lo stato della conservazione secondo il rapporto del Comitato del patrimonio mondiale, le valutazioni dell'ICOMOS e le decisioni prese riguardo al sito di Bam, testi scientifici, piani di intervento attuati nella Cittadella di Bam e rapporti dei lavori sul campo. In aggiunta, andrebbe menzionato anche che nell'agosto del 2015, l'autore ha potuto visitare il sito della Cittadella di Bam, durante la visita si è cercato di fornire una relazione completa e illustrata delle attività portate avanti sui principali monumenti della cittadella. Oltre alla visita al sito, ha avuto luogo anche un'intervista precedentemente concordata con tre importanti figure del progetto di restauro della Cittadella di Bam, sia prima che dopo il sisma; prof. Eskandar Mokhtari Taleghani, a capo del progetto di restauro di Bam dal terremoto fino al 2009, e il Dr. Afshin Ebrahimi, attualmente a capo del progetto di restauro di Bam. Sulla base delle interviste dell'autore, che vengono riportate nel capitolo 4 della tesi, si è tentato di individuare le priorità e i principi considerati al momento in cui dirigevano i progetti.

Per avere un quadro di riferimento da attuare nei lavori di conservazione e restauro dei beni culturali, oltre allo studio dello sviluppo delle teorie di conservazione del patrimonio nel corso del diciannovesimo e del ventesimo secolo in Europa, è stata effettuata un'analisi dei principali atti e raccomandazioni internazionali, quali: Manifesto SPAB (1877); Carta di Atene (1931); Carta italiana del restauro (1932); Carta di Venezia (1964); Carta italiana del restauro (1972); Dichiarazione di Amsterdam ((1975); Documento di Nara sull'autenticità (1994); Carta di Burra (1999); Carta di Cracovia (2000); Carta ICOMOS-ISCARSAH (2003). Frattanto, nel caso della conservazione di beni culturali in mattoni, sono state monitorate le ricerche e le raccolte di dati di alcuni centri di ricerca, comitati, istituti come CRAterre-ENSAG, ICOMOS-ISCEAH, UNESCO-WHEAP, ICCROM e Getty Conservation Institute (GCI), che collaborano congiuntamente in progetti internazionali come GAIA, WHE, GSAP e Terra. Inoltre, per meglio esplorare la condotta sismica dei monumenti in mattoni d'argilla consolidati e non consolidati, sono stati studiati anche i risultati di test di oscillazione di modelli in mattoni su grande scala eseguiti presso università e istituti come la Pontificia università cattolica del Perù, il Getty Conservation Institute negli Stati Uniti, l'Università di Stanford, l'IZIIS-Ss., l'Università Cirillo e Metodio della Repubblica di Macedonia, l'Università di Saitama in Giappone, l'Università di Aviero in Portogallo e l'Università di Sydney (UTS). Inoltre, per suggerire i migliori metodi e tecniche e per una migliore conoscenza della caratterizzazione dei mattoni d'argilla, sia del deterioramento all'aperto che al chiuso in strutture storiche in mattoni, e per valutare la condotta sismica delle strutture consolidate in mattoni attraverso modelli numerici, sono stati studiati anche i risultati di ricerche individuali o di gruppo condotte sull'argomento.

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CHAPTER 1

The Iranian City of Bam: History and Urban Landscape

1.1 Geography, Climate and Demography

The city of Bam and its cultural landscape, one of the oldest centers of urban life, is located in the middle of Iranian desert, in the southeast corner of Kerman province.[1] Bam is 1,161 km away from Tehran (the Capital city of Iran) and 185 km from Kerman (the Capital of Kerman province). The property of Bam is part of an extensive landscape area on the southern border of the "*Lut Desert*"[2], which with its unique topography and morphology has been developed from the ancient city of Bam, which is called "*Bam Citadel*" or "*Arg-e-Bam*" in the northeast of the present city.

Figure 1.1- The location of Bam city in the Kerman province and Iran's map (Designed by Author).

Table 1.1- The distance between Bam city with its adjacent cities (Designed by Author).

Adjacent city center from Bam city (with the four directions and distances)	
From North: Kerman 185 km	**From West:** Jiroft 120 km
From South: Reagan 100 km - Anbarabad 165 km	**From East:** Fahraj 60 km

Geographically, Bam coordinates between N: 29 º 07´ 00.6´´ and E: 58º 22´ 06.5´´, and lies at an altitude of 1060 m (3,444.9 ft.) above sea level, with the exception of the highest point of Bam citadel which has a height of 60 m. In term of geomorphology, Bam region includes "*Kabudi Mountain Range*" to the north of Bam extending northwest and also the "*Jebal-e-Barez*

[1] Bam encompasses about 1.3 million hectares of desert, the largest area after Kerman (Ghafory-Ashtiany & Mousavi, 2005).

[2] Dasht-e Lut (Persian: دشت لوت, "Emptiness Desert"), also spelled Dasht-i-Lut and known as the Lut Desert, is a large salt desert in southeastern Kerman, Iran, and is the world's 25th largest desert.

Mountain Range" to the southwest of Bam extending northwest-southeast directions. Climatologically, this region has hot summer and cold winter; the city has high temperature with hot winds during the summers, and low temperature with cold winds during the winters. Moreover, there is a noticeable difference between days and nights temperatures.

Kerman province with an area of 180,434 km², 11 percentage of Iran, is the largest province in Iran. This province is composed of 23 townships (Shahrestan), 67 city-districts (Bakhsh), and 57 town-districts (Shahr) (IMIBI, 2010). In the meantime, Bam city as one of the Kerman's township has an area of 17,755 km² and contains one city-district, the central district of Bam includes two cities of Bam and Baravat.[3] The population of these two cities according to Iranian National Census 1996, 2006 and 2011 have respectively been 104.469, 73.823 and 125.764 people.[4] According to the last Iranian Static Census (2011), if the region of Bam as a whole within its districts and rural areas has been taking into consideration for the population distribution, 64.29% of the population live in the urban area and 35.71% of the population live in the rural vicinities.

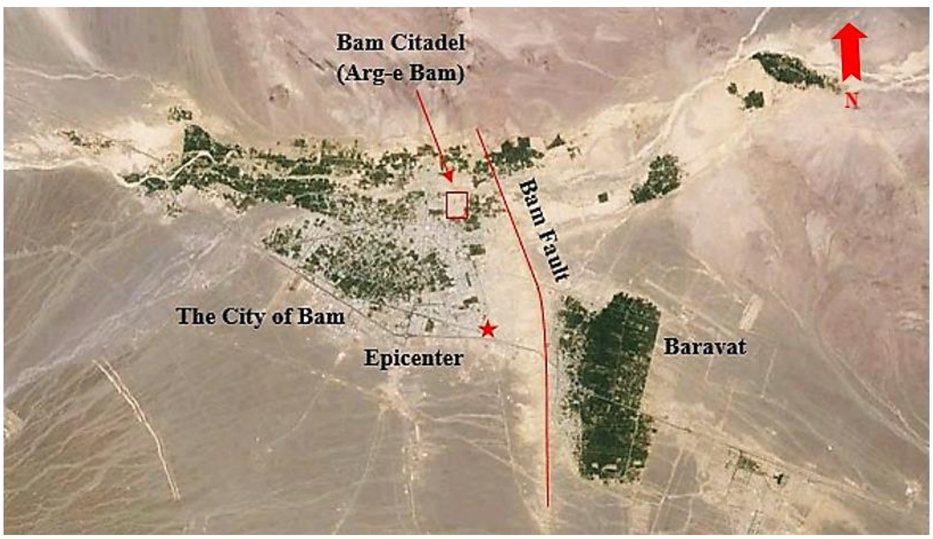

Figure 1.2- View from the location of Bam city, Baravat city, and Bam Citadel (Designed by Author).

In term of plant distribution, Bam region includes 10,000 hectares of heavy forest, 50,000 hectares of low dense forest, and 100,000 hectares of what used to be forest (Ghafory-Ashtiany & Mousavi, 2005). In Bam, the annual precipitation and relative humidity is ranked between

[3] In the year of 1938, Bam become categorized as a township of Kerman province. In years before 2010, the township of Bam included five City-Districts of Bam, Baravat, Fahraj, Narmashir, Roudaband Rigan, and Bam district itself included the city of Bam and the town of Baravat. Now all of those parts except Baravat are separated from Bam township.

[4] Despite the high death toll during the 2003 Bam earthquake, the population of Bam is larger now than it was before the earthquake.

medium to low compared to other parts of the country. The city experiences an average of 298 days of dry weather and 8 days of rainy weather annually (minimum: 3 days) with minimum 10-20 mm and maximum 147 mm of precipitation (Ghafory-Ashtiany & Hosseini, 2008; WHO, 2004). The average annual temperature in Bam is 23°C (average maximum: 44°C, average minimum: −2°C). The absolute highest temperature recorded in the past 60 years is 47.6°C whilst the absolute lowest temperature recorded in the past 60 years is -9 °C. Between 4 to 5 months a year, night temperature reaches to < -0°C, sometimes during December to February there are some recorded snowy days, the temperature usually starts to rise in March. In Bam, winds approximately flow all through the year; max recorded speed: 133 km/hr; less severe storm are common more at the end of winter and beginning of spring (WHO, 2004). In addition, there are some sand winds in some months. Wind directions vary during the year, but more often they blow from the northwest to the southeast. Examples of the prevailing winds in the area are (Shahnoori, 2013): 1) The "*Shah Bad*", a cool and humid wind, is the most important local wind in the region, which blows from the south to the north. Although it does not greatly affect the weather, it does have more impact than other local winds; 2) The "*Lovar Wind*" or "*Tash Bad*" blows in summer and comes from the south-east. It is a hot, dry wind that carries dust particles.[5]

Table 1.2- Bam's climate summary in different months of the year, Climate data of Bam 1956-2010 AD (Source: Iran Meteorological Organization, designed by Author).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record high °C (°F)	30.0 (86)	33.2 (91.8)	38.0 (100.4)	39.6 (103.3)	44.6 (112.3)	47.6 (117.7)	46.6 (115.9)	47.0 (116.6)	43.6 (110.5)	40.0 (104)	34.2 (93.6)	32.0 (89.6)
Record low °C (°F)	−9.0 (15.8)	−5.0 (23)	−3.0 (26.6)	4.0 (39.2)	9.5 (49.1)	18.0 (64.4)	19.0 (66.2)	15.0 (59)	11.0 (51.8)	6.0 (42.8)	−2.0 (28.4)	−7.0 (19.4)
Average precipitation mm (inches)	12.0 (0.472)	8.9 (0.35)	12.2 (0.48)	9.7 (0.382)	5.5 (0.217)	0.6 (0.024)	0.9 (0.035)	0.6 (0.024)	0.2 (0.008)	0.9 (0.035)	2.2 (0.087)	5.1 (0.201)
Average precipitation days (≥ 1.0 mm)	2.1	1.8	2.7	2.3	1.1	0.2	0.1	0.1	0.1	0.4	0.6	1.2
Average snowy days	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Average relative humidity (%)	46	41	36	31	26	21	21	21	22	27	34	42
Hours of Sunshine	7.55	7.71	7.72	8.61	10.03	11.04	10.91	10.86	10.22	9.57	8.4	8

There is one seasonal water flow, "*Posht-e-Rud River*", which virtually runs from west to east through the northern boundary of Bam city. Waters from the Jebal-e Barez Mountains supplies the seasonal Posht-e Rud River at the interface between Bam and Qal'eh Dokhtar.[6] Generally,

[5] In Persian "*Bad*" means "*Wind*".
[6] The Chelekhoneh River and its tributaries gather water from the central parts of the Jebal-e Barez Mountain range. It now runs northeast, although it formerly flowed through the Bam City until it was

due to the small amount of rainfall and surface waters, the main source to supply drinking and agricultural waters for Bam and its surrounding is mainly based on traditional Persian irrigation system of "*Qanat*".[7] Here qanats represent a vibrant example of the ingenious hydraulic structures as the gravitational flow of water inside qanats is assured by a very gentle slope (Ibrion et al., 2014). In this sophisticated system, a series of well-like vertical shafts are manually dug from the mountains to the settlement by connected sloping tunnels, so the water could move by the gravity to the site (see Figure1.3). Nowadays due to overuse of underground water, the groundwater table in the region is low at depths of 30 m. The number of wells and qanats in Bam plain is high, 723 deep wells with 408 mcm capacity, 222 semi-deep wells with 12.5 mcm capacity and 348 qanats with 414 mcm capacity (see Table 1.3). The portion of water used for agriculture is 95.69%, industry 0.15%, and sanitary and drinking water 4.16% (Ghafory-Ashtiany & Mousavi, 2005).

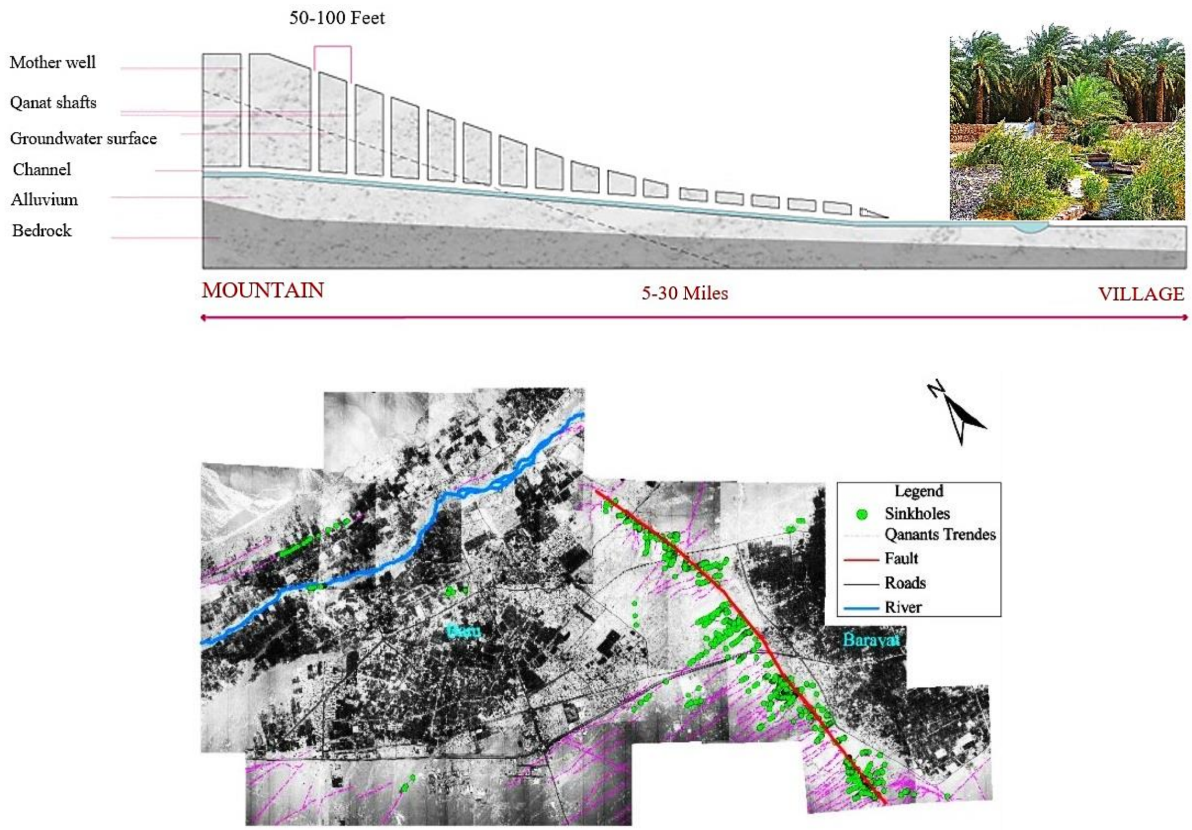

Figure 1.3- (Top) schematic section of Bam's Qanat (Designed by Author); and (Down) mosaic map used for evaluation of the sinkholes in Bam and Baravat (Source: Pellet et al., 2005).

diverted by a dam into a new course that met with the Posht-e Rud northwest of Bam City. Water from the Kafut Mountains also supplies the catchment area (UNESCO-WHC).

[7] There are various theories which support that qanats originated from Persia (Jomehpour, 2009; Kabori, 2010; Mostafaeipour, 2010; Adle, 2009).

Figure 1.4- Aerial photo from Qanat network in Bam region (Photo by Rashedi, 2014. Source: UNESCO-WHC).

Figure 1.5- Subterranean water output in Bam city (Photo by Roghanchi, 2015. Source: https://www.theguardian.com/world/iran-blog/gallery/2015/oct/20/iran-qanat-ancient-water-system-pakam-pictures).

Table 1.3- Number of wells and qanats in Bam-Narmashir and Rahmatabad plains and their capacity in million cube meters (MCM) (Source: Ghafory-Ashtiany & Mousavi, 2005).

Plain name	Nr. of deep wells	Nr. of semi-deep wells	Number of Qanats
Bam-Narmashir plain	723 with 408 mcm capacity	222 with 12.5 mcm capacity	348 with 414 mcm capacity
Rahmatabad plain	118 with 45 mcm capacity	59 with 4 mcm capacity	74 with 43 mcm capacity

The main economic activities in Bam region have highly been dependent upon agriculture, industry, trading and tourism. Due to favorable climate and suitable soil appropriate for agriculture, Bam is a regional agricultural center known for its high-quality dates, citrus crops, henna, wheat, alfalfa, barley, pistachio, maize, cucurbits and dairy products. Most of the surrounding villages in the region have close economic ties with Bam, so they bring their goods there to sell. From an economic standpoint, the finest quality dates by annual production of 120,000 tons play an important role in food and packaging industries in the area. There are more than 1,400,000 palm trees only in the city of Bam. In addition to agriculture, the Bam Citadel (Arg-e Bam), as one of the most remarkable archaeological and historical sites and an important tourist destination in Iran, is also rcognized as a major source of income for Bam people, which yearly attracts numerous investors to Bam city.

Table 1.4- The number of national and international tourists that have visited Arg-e Bam from 1995 to 2010 (Source: archive of RPBCH).

Year	Iranian	International	Total
1995	82285	5623	91908
2000	98568	14434	113002
2005	96747	2225	98972
2010	226832	741	227543

1.2 The Origin and History of Bam City

- Pre-Islamic History

Owning to the destruction of all written documents, there is no precise information concerning the formation of Bam city and its first human settlement. The early sources about the origin of Bam city and its foundation can be divided into four major resources: 1) the legends and stories from ancient times; 2) the history of qanats in the region; 3) the history of Silk Road; and 4) the evidences, remains and archeological activities performed inside Bam Citadel (Arg-e Bam) or/and in the region of Bam. Highlights are listed below:

- Bam in Legends:
The oldest and clearest legacy source about the city of Bam comes from "*The Karnamak-e Ardeshir-e Papakan*" [Deeds of Ardashir, an epical treatise about the founder of the Sassanian Empire (180-242 AD)]. This text reveals that on the road the army of Haftan-bokht, "*Haftvād*"[8] (the lord of the "*Worm*"[9]), was a rebel and fought against Ardashir in the area of Guzaran.[10] M.E. Bastani Parizi argues in his turn that Haftvād was indeed the founder of the Citadel of Bam, while in fact he was from Kerman, and resided in the *Qal'eh Dokhtar*. He also asserts that, "*Haftvād was a historical figure whose minted coins are extant.*"[11]

To overcome Haftvād, Ardashir marched an innumerable army with troops and heroes from different quarters to the battle of the "*Worm*". After a few furious battles with heavy casualties around the city walls, he could not capture the castle of Haftvād. Since Ardeshir failed in man-to-man war, he used a trick to get into the Citadel with disguising himself as a merchant from Khorasan. After several days of confrontation, he was able to kill the magical Worm who protected the city and the Haftvād.[12] As the text reveals, "The Worm burst asunder into two pieces, and such a noise arose from it that all the men in the fortress came on the spot, and confusion prevailed throughout the stronghold." […] "Ardashir commanded that the fortress should be razed to the ground and demolished, while on its site he ordered the city which they call 'Guzaran' to be erected. In that quarter he caused the Atash-I Vahram (the fire temple of Bahman) to be enthroned".[13]

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[8] "*Haft*" means "*seven*" in Persian, and "*vād*" means "*son*".
[9] According to the legend, there was a "*Worm*" as big as a dragon that was the protector of the Citadel.
[10] There is a gate in the Bam Citadel named "*Kot-e Kerm*" and a district named "*Guzaran*" in the north west of new city of Bam, where the magical *Worm* had its house.
[11] Bastani Parizi. *"Bam: II. Ruins of the old town"*, Encyclopaedia Iranica. Retrieved from http://www.iranicaonline.org/articles/bam-in-arabic-town
[12] Shahbazi, Shapur. *"Haftvād",* Encyclopedia Iranica. Retrieved from http://www.iranicaonline.org/articles/haftvad-haftwad
[13] Horne, C.F. (1917). "*The Sacred Books and Early Literature of the East*", Vol. VII: Ancient Persia. New York; London: Parke, Austin, & Lipscomb, pp. 242-243.

The next historical document about the city of Bam, probably the "*Karnamak-e Ardeshir-e Papakan*" was its main source, comes from "*Ferdowsi in Shahnameh*",[14] the most prized epic of Persian literature. The story opens with a description of *Haftvād's* daughter, who works as a spinner. *Haftvād* pays her little attention, instead favoring the seven sons for whom he is named.[15] Ferdowsi combined the story of Ardeshir's campaign with an amazing legend, followed by the story of Akhtar (the story of luck), the daughter of *Haftvād* who made her father rich by raising a special *Worm* (Ronen, 2015).[16]

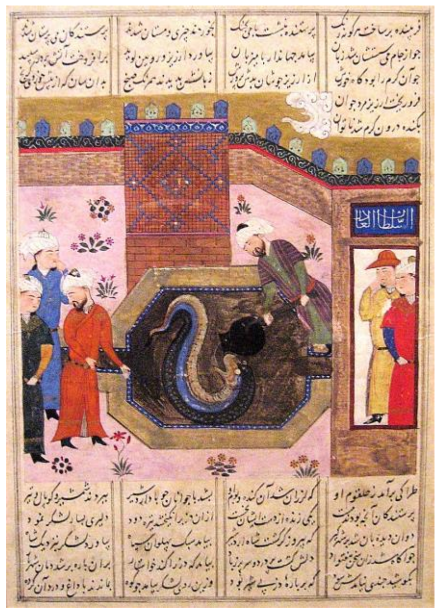

Figure 1.6- A Persian miniature from a 15th - century manuscript of the *Shahnameh* depicting Ardashir killing Haftvād's Worm (Source: Wikipedia).

About the name of Bam city, Bam may owe its name to the old term Vahma (Prayer, Glorification; W. Tomaschek, "Zur historischen Topographie von Persien II").[17] Ḥamdallāh Mustawfi in 1339 AD about the reason for naming Bam city to this name noted that "in this

[14] "In Shahnameh, Ferdowsi idealized Iranian heroes, glorified their ways of life, and defended their traditions with enough zeal and conviction to revitalize the perished Sassanian Empire. He revived all aspects of ancient Persian culture such as religion, ceremonies, physical environments and architecture in a poetic form. In addition, the architectural information revealed in Shahnameh about space utilization and its meaning will become vital to our study. Shahnameh also comprises specific and direct information about the evolution of Args (Citadels), towers, fortresses, and urban spaces such as squares, gates and residential area." (Mehdi-Pour, 2004).

[15] Ferdowsī, Abu'l-Qāsem. (1978-2008 AD). "*Shahnameh (The Book of Kings)*". In: Djalal Khaleghi-Mutlagh (ed.). New York: Bibliotheca Persica, Vol. 6. pp. 75-170.

[16] Ronen, A.C. (2015). *Identities in Crisis in Iran: Politics, Culture, and Religion*. Lanham; Boulder; New York; London: Lexington Books, p. 34.

[17] Bastani Parizi. *"Bam: II. Ruins of the old town"*, Encyclopaedia Iranica. Retrieved from http://www.iranicaonline.org/articles/bam-in-arabic-town

town the Worm of Haftwād burst and for which reason the place took the name of Bam (Bam means burst)."[18] Apart from this, the story of the Worm (*Worm means Kerm in Persian*) became so eminent that it influenced the name of the region (*Kerman*) (Zandiye et al., 2012).

The late Iranian Studies Professor Shapur Shahbazi noted Haftvād's connection to history of Bam, "Despite these legendary elements, the story is clearly woven around a historical base, namely, Ardashir's effort to conquer the Persian coastland and the neighboring regions of Makran and Kerman, and the heavy local resistance that he had to overcome. The maritime trade must have made these regions wealthy, and it is quite possible" […] "that a local industry for making silk had developed on the Persian Gulf, and its patrons had jealously guarded its secret and amassed great wealth in their strongholds. It has been pointed out that already Aristotle had learned 'of a certain great worm with horns, as it were, which produced bombycine or cocoons which the women used in weaving. The entire episode rests on the rationalization of a historical event: on the shore of the Persian Gulf, a mighty pirate, probably influenced by an Indian Nāga cult, had earned the enmity of Zoroastrian priests" […] "and Ardashir vanquished him with great difficulty. This eventually gave rise to a legend concerning a divine worm (Kerm) and the story of Haftvād and his seven sons."[19]

- Evidence of the Traditional Persian Irrigation System (Qanat) in the Region:

The genesis of the city of Bam is fundamentally linked with the invention and development of the traditional Persian irrigation system. In the city of Bam, due to its particular geological condition, underground water by an ancient system named "*Qanat*" provided the main water supplies.[20] As mentioned by Adle (2009), "Indeed, the Bam area seems not only to contain the oldest proven extant qanats in Iran and perhaps in the world, but it is also rich in Neolithic and Prehistoric remains. They tend to show how the growing scarcity of surface water led to the step by step development of techniques allowing the usage of underground waters."[21] However, it appears amazing to observe how in Bam an earthquake fault, a result and a symbol of a most destructive power, has been transformed through men's genius into an outstandingly remarkable means of continual creation for over two thousand years (C.A.) (UNESCO, 2004). However, there is a sense of gratitude mixed with hatred for the existence of this natural phenomenon, which on the one hand killed a lot of people and on the other hand helped continue

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[18] Ḥamdallāh Mostowfi. (740 AD). "*The Geographical Part of Nuzhat-al-Qolūb*", translated by G. Le Strange. (1919). Leyden and London, CHAPTER XIII, p. 139.

[19] Shahbazi, Shapur. "*Haftvād",* Encyclopedia Iranica. Retrieved from http://www.iranicaonline.org/articles/haftvad-haftwad

[20] The technique of using qanats was sufficiently well established in the Achaemenid period (6th-4th centuries BC).

[21] Adle, C., CNRS., ESKEM., DAFA. (2009). *Qanat of Bam: An Archeological Prespective*. In *Qanats of Bam, A Multidisciplinary Approach*. In: Honari, M., Salamat, A., Salih, A., Sutton., J., Taniguchi., J (ed.), UNESCO Tehran Cluster, pp. 33-85.

life in this desert city. Although Bam city is not in a wet region, its qanats help this city to develop in desert environment of Iran.[22]

By a comparison between Bam and Jiroft city, a city in the south of Bam, it would be estimated that certainly the origin of Bam city could date back to 2500 year ago. The Jiroft civilization, partially revealed during the last three years, has been in the process of being recognized as a key point for understanding of the West Asian world at least during the 3rd millennium BC. There met the civilizations of Indus, Mesopotamia, Southern shore of the Persian Gulf and those which flourished on the Iranian Plateau (UNESCO, 2004). Contrary to Jiroft, which benefits from the river Halil-Rud's ample water supply, Bam could not have reached a high degree of development prior to the invention and the perfection of the *qanāts* roughly as far as 2500 years ago.[23] Indeed, recent archaeological discoveries tend to show that Bam came to exist at least on an extensive level because men acquired sophisticated techniques to drill *qanāts* and that there was a most polished political and economical power which acknowledged the importance of that system and sustained it (UNESCO, 2004). Other highlights about the long history of Bam's qanāts in the region are listed as below:

- Dr. Adle, a famous Iranian archeologist, on the eve of the ninth anniversary of Bam earthquake in his interview with ISNA reported on new discoveries of ancient altars (altars of Mehr religion and fire and water worshiping) in Afraz (a part of "*Bam Fault*"). As Dr. Adle said about archeological activities organized in the Afraz area, which the geologists called by the name of *Bam Fault*, "In this vast region that covers an area of over 2500 acres, the team was able to reach results in their excavations in discovering different kinds of altars (similar to the altars in mosques)". He also mentioned that they were not aware of the number of these types of foundations which are unique to this region. He further added that "the small altars have been engraved in small chambers made in the slopes of the faults which were carved by water over time, and the others were in the form of two separate altars which were linked by tunnels and dug in a depth of approximately two meters on each side of the faults. At least half of the tunnel-like altars in Bam are related to the Mehr religion

[22] At the moment, approximately 30-35% of water in Bam city is provided by qanats.
[23] "The Greek historian Polybius in his book (History, IV, 26), describing the invasion of Parthia by Antiochos III in 209 B. C. and obviously referring to the qanāts in the region of Qumes (350 km E of Tehran), wrote that "the Persians, when they were the masters in Asia [i.e. Achaemenid period, 6th to 4th cent. B. C.], conceded the right to cultivate the arid lands up to five generations to those who would irrigate them… The inhabitants enduring great efforts and expenses managed to bring the subterranean waters to the surface by drilling tunnels on long distances." The archaeological discoveries in the south-eastern suburbs of Bam on the Fault date at least from the period when Polybius was written at the beginning of the 2nd century B. C. The sites are situated on the upper level of the Fault where the qanāts end to pour their waters on the lower level of the Fault where the fields were and still are" (UNESCO, 2004).

and there also may be deeper altars available. The double altars were most probably used for water and fire worshiping."[24]

- In the Book "*Bamnameh*", it is said that the deep water well [on top of the cliff of the Citadel] was made by prophet Soleiman and Rostam [a mythical hero of Iran]. Rostam brought craftsmen to dig stone and tools from Egypt and dug down into the well (Waziri Kermani, 1967). Rostam might refer to Achaemenid (550-330 BC) or Sassanid (226-651 AD) periods].[25]

- Archaeological Studies in the Region of Bam:

Culturally, Bam has so far only been known for its magnificent Citadel. It seems as if its magnitude has dazzled everyone, including an archaeologist as experienced as Sir Aurel Stein, who, thus blinded, missed its other astonishing features (Adle, 2009).[26] The excavation and investigation also are appropriate for the valuable architecture of outstanding buildings in the Citadel to define the age and the details during the lifetime of the building (Mokhtari et al., 2008d). The deserted parts of the old city of Bam were regarded by archaeologists and architectural historians as one of the most complete surviving records of a medieval/early modern urban environment anywhere in the world.[27] As said about Bam region by Vesta Sarkhosh Curtis, a curator at the British Museum and editor of Iran, a journal of Iranian studies, "*Historically and archaeologically the whole area is very very rich and a very important part of Iran.*" [28]

The first Archeological activities in Bam region started in 1956, and the excavation was related to the designated zone of the Citadel to provide the plans for the towers and walls, their structures and conducts. Generally, the 2003 Bam earthquake created an exceptional opportunity for archeologists to extend their knowledge about the history of Bam site, as mentioned by an Iranian authority, "*this is a feast for the archaeologists and a nightmare for*

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[24] ISNA. (2013). *"New discoveries in Afraz (Bam fault)"*, an interview with Dr. Adle (Source: Tavoos, translated by Arash Aliasghari).
Retrieved from http://www.tavoosonline.com/Articles/ArticleDetailEn.aspx?src=165&Page=1

[25] Bam3DCG, "*Virtual 3D Reconstruction of Bam Citadel*". Retrieved from http://dsr.nii.ac.jp/Bam3DCG

[26] As mentioned by Adle (2009), "Sir Aurel Stein stayed three days in Bam (April 20-23, 1932) and went around exploring the area, but missed all the archeological sites he was looking for, even when he was standing in the midst of them. He was taken to the fort of Chehel-Cheraq for instance, but the only saw there a ruin "not likely to date back rather than the last two or three centuries". Sir Aurel Stein, Archeological Reconnaissances in North-Western India and South Easter Iran, London, 1937, pp. 158-159."

[27] The Circle of Ancient Iranian Studies (CAIS). (2003). "*Spectacular Medieval Complex on Old Silk Road Now Lies in Ruins*". Retrieved from http://www.cais-soas.com/News/2003/December2003/28-12.htm

[28] The guardian news. (2003). *"In minutes, Bam's 2,000 years of history and its hopes for the future were left in ruins"*. Retrieved from https://www.theguardian.com/environment/2003/dec/27/iran.naturaldisasters2

the architects”.[29] Mike Corfield, a heritage science and conservation consultant from Britain, explained that during the archeological excavation for Bam Salvation Project, they have found out how the city of Bam is developed in the region over the course of history, as he said, “I think as well the tremendous impetuous of the work led to exploration of the countryside. This plus the discovery of archeological remains from 5000 years ago helped us to understand how Bam was supported by different towns and villages around from ancient times to today. All of these indicate the good management in reconstruction of Bam Citadel.”[30]

In this case, after debris removal of Bam Citadel, as part of a program named “*Rescue Archeology*” extensive archaeological activities were executed inside and outside of the Citadel. Throughout Bam region, the earthquake further exposed archaeological remains ‘by revealing the ancient sections of the fortifications with the sudden removal of some’ parts (Bumbaru, 2004). As mentioned by Vatandoust and Mokhtari ‘the sheer extent of scientific information and data collected […] after the earthquake have resulted in the unearthing of a number of new archaeological sites […]’ (Vatandoust & Mokhtari, 2004). This includes remains of ancient settlements and underground water management system, dating at least to the Parthian-Hellenistic period, 2nd century BC. Some highlights of archeological activities in Bam region are listed below:

- As Adle (2009) pointed out, “By the Neolithic-chalcolithic period (more than five thousand years ago), the local communities around Bam had already reached an advanced social and technical stage of evolution. Presently, the most important known sites representing these societies are the Tall- Ateshi in the eastern part of Bam, and the Bidarzen remains just on the north-west of that town to the Bidaran area. A very few Neolithic implements have even been discovered within the Citadel after the earthquake. The continuation of the life in that area in later periods, seems, however, to have annihilated nearly all the remains from that period.”

- Archaeological remains were exposed through excavations taking place at the northwest of the citadel, which also emphasizes the archaeological significance of the citadel (Correia, 2009). The Qale Dokhtar Citadel situated near the north of the Citadel (1.5 km) has ancient mud brick buildings similar to the Four Vaults (Chartaghi), a mihrab with ancient decoration and its name also refers to structures before the Sassanid period (Nourbakhsh, 1974).[31] According to the archaeological evidences and reports, the Kushk Rahim Abad 4 km away from east of Bam dates back to Saljuqi-Patriarch periods (1016-1153 AD). The oldest

[29] Retrieved from http://www.fravahr.org/

[30] Sadigh, S. (2006). *“Reconstruction of Bam Citadel Needs Time and Patience”*, an interview with Mike Corfield, The Circle of Ancient Iranian Studies (CAIS). Retrieved from http://www.cais-soas.com/News/2006/February2006/18-02-reconstruction.htm

[31] Bam3DCG, “*Virtual 3D Reconstruction of Bam Citadel*”. Retrieved from http://dsr.nii.ac.jp/Bam3DCG

findings in the Bam's region go back to 4000-5000 years BC; which have been found in the Bidaroon in the west of Bam and Tal-e Atashi,[32] and in the Darestan, which is located 30 km away from north eastern Bam.

- In addition to Arg-e-Bam, the remained monuments in the Pir Mah Shah castle (Afzal Abad), Jamali castle, Darestan, Ghalea (Ghalea Shahid), Naeim Abad castle and other monuments in the region can indicate the ancient civilization and prosperity of this territory.

- The coins that were discovered in the Citadel belonged to the Parthian period (150 BC - 224 AD) (Armanshahr, 1993).[33]

- 250 thousand piece of potteries, of which some date back to the 3rd millennium BC, were discovered in the Citadel from the removal of debris.[34]

- After the earthquake, newer layers were destroyed and older mud brick structures became evident with large mud bricks similar to ancient constructions; post-earthquake analysis on the Core of Bam's Defense Wall revealed that walls were first built using Sassanian-style mud bricks (Author's personal interview with Prof. Mokhtari, 2015).

- According to Dr. Shahriar Adle's interview with ISNA (2013), "Although the Bam citadel's defensive appears to be made of a single block, in reality it is composed of different layers which have been added to the primary wall over the course of the years and in different eras of history. And this is how the wall became what it is today. During new researches on the primary core, considerable progresses have been made and since the modern science has reached levels that permits us to use the latest technologies to be able to define the exact age of clay blocks, the archaeological team in Bam has collected the necessary samples for dating the formation of the wall, the palace and old castles of the fault region. These analyses are only possible in a few laboratories around the world and in order to achieve our goals, we actually have to wait for the money exchange problem to be solved by the assistance of regional office of UNESCO in Tehran." He added that 6000 to 7000 years ago,

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[32] "A disastrous earthquake in 2003 was a turning point in archaeological research in this region. After the earthquake and in order to complete the cultural heritage file for UNESCO, Adle (2005) explored the cultural landscape of Bam Citadel. He located some new sites amongst which was a huge settlement, named Tell-e Atashi, which has no pottery on the surface but is covered in a significant amount of lithics. Adle interpreted it as a Bronze Age settlement and suggested that the pottery was removed from the surface for unknown reasons.|" (Garazhian& Shakooie, 2013).

[33] Armanshahr, Consulting Engineers of Architecture and Urban Planning. Studies about master plan of the city of Bam. Identifying the city, history and geographical characteristics. Kerman: Ministry of Housing and Urban Development, Housing and Urban Development, Department of Kerman province, Vol.1, 1993. (Published in Persian).

[34] Ahmadi, N. (2008). Summary of the archaeological studies and activities in Bam project. In: Annual report of Arg-e Bam research foundation. Tehran: Resaneh Pardaz-Paygah-e Pazhooheshi-e Bam, pp. 53- 63. (Published in Persian).

at Bam citadel, there used to exist a number of installations. The layers of these installations are situated approximately 10 meters beneath the actual surface of Bam citadel region. Since then and until the Qajar era, various layers have been added to the primary core of the wall and this is what makes the absolute dating of each layer so complicated and difficult. We hope that these analyses will provide us with valuable data for the exact dating of the core situated on the upper section of the palace, which is believed to be linked to the Achaemenian period.

Figure 1.7- Major archeological sites near to the city of Bam (Designed by Author).

Figure 1.8- Some findings in Bam Citadel after the 2003 Bam earthquake (Source: archive of RPBCH).

- Location of Bam in Ancient Trade Route of Silk:

Since ancient time, trade with a history of nearly 2,000-year-old has had an important role on subsistence of Bam's people. From ancient times, this city was situated in the path of one of the most important international trade route that is called “*Spice Road*”,[35] a major transportation route that branched off of the “*Silk Road*”.[36]

Maintaining its position in the middle of the southern trade route, this small-fortified city on the outskirts of the vast Dasht-i-Lut desert with a distance of 350 km west of the Pakistan and 450 km north of the Persian Gulf, was an ideal place to stop for rest. The flourish of Bam was from the 7th to the 11th centuries, when it was located at crossroads of important trade routes and was known for the production of silk and cotton garments (UNESCO, 2004).

As mentioned above, the city of Bam has been known for its production of silk and cotton garments since ancient times, the name Bam being associated with the ‘burst of the worm’ (silk worm). Ibn Hawqal (943-977AD) enlarges upon this statement, mentioning that the material for the fabric appears to grow in the neighbourhood of Bam. He writes, “Over there they weave excellent, beautiful and long-lasting cotton cloths which are sent to places all over the world. There they also make excellent clothes, each of which costs around 30 dinars; these are sold in Khorasan, Iraq and Egypt.”[37] After the entry of 19th century, the Silk Road gradually lost its domination as an international trade route, and in the 20th century, the trade importance of Bam gave way to the Persian Gulf ports.

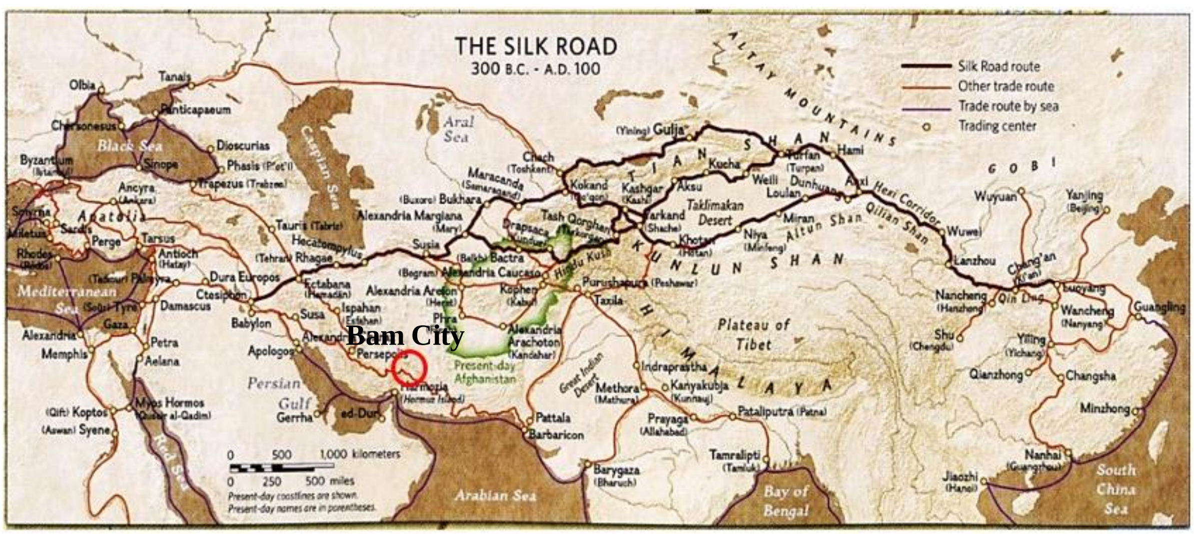

Figure 1.9- Silk Road and other main routes connected (Source: China Discovery. Retrieved from http://www.chinadiscovery.com/china-silk-road-tours/maps.html).

[35] The route started from the sea corridors of the Indian Ocean, extended to Hurmoz port in Persia, and passed through the roads of the city of Bam to reach the east-west Silk Road.

[36] The Silk Road, or Silk Route, refers to the main trade route between historical civilizations in Asia, Northeast Africa and Europe.

[37] UNESCO. (2004). “Bam and its Cultural Landscape”. Retrieved from whc.unesco.org/uploads/nominations/1208bis.pdf

- Post-Islamic History

As preliminary documents and archeological studies that presented in the Bam's Pre-Islamic History, it can be concluded that the ancient city of Bam has been built prior to the Achaemenid period (6th-4th century BC). The references to the city of Bam, an ancient Iranian city that passed various events through history, are more accurate after defeat of the Sassanian Empire (224-651 AD) by the Muslim army. In the early centuries of the Islamic era, the city of Bam is considered as one of the five important cities in Kerman province (Mehriar, 2004). The existing documents about post-Islamic history of Bam city goes back to the Muslim geographers, travelers and local historians from 9th to 15th centuries, and the visitations of the western travelers during the 19th century and the first decades of the 20th century. All these sources give us a comprehensive knowledge about the importance of Bam and its Citadel in the reign and Iran.

- Remarks by Travelers, Geographers and Historians:

The name of Bam first was taken over by languages when Muslim invaded Iranian territory in the mid-7th century.[38] Also, later the name of this ancient city can be found in the notes of well-known European travelers and national historians and geographers. These assertions in their turn well demonstrated that the city of Bam existed at least as early as of the 7th century. The highlights are listed below:

- Balāzori, who wrote "*Ketāb-e Fotuh al-Boldān*" in the 9th century, "attributed the conquest of Bam to Mojash'e b. Mass'ud Salami." In this case, Abū Jaafar Muhammad ibn Jarīr al-Tabarī (839-923 AD) in his book "*Tarikh, Year 30*" reports that "this event took place in the year 30/651-52 AD, when Bam had already been captured by the Arab armies, but they were forced to leave the town following a revolt of the population."[39]

- Mohallabi, Abu Mohammad al-hasan b. Mohmmad b. Hārun (903-963 AD), an Arab statesman who served as vizier and literary patron, "counts Bam among the great cities of Kerman and calls it a (real) city."[40]

- Abul-Kassem ibn Hawqal, a 10th century Muslim Arab writer, geographer and chronicler, described Bam in these statements, "as larger as and healthier than Jiruft, the town being surrounded by palm-groves. Nearby stood the celebrated castle of Bam, held to be impregnable, and there were three mosques, the Masjid-al-Khawarij, the Mosque of the Clothiers (Al-Bazzazin), and the Castle Mosque. Cotton stuffs were largely manufactured

[38] The Arab conquest of Iran led to the end of the Sassanian Empire in 651 AD and the eventual decline of the Zoroastrian religion in the country.

[39] UNESCO. (2004). "*Bam and its Cultural Landscape*". Retrieved from whc.unesco.org/uploads/nominations/1208bis.pdf

[40] Ibid.

here and exported; also napkins, the cloths for turbans, and the scarfs for head-wear known as Taylasan."[41]

- Muhammad ibn Ahmad Sham al-Dīn al-Muqaddasī or al-Maqdisī, (946-991 AD),[42] a medieval Arab geographer, author of "*Aḥsan al-taqāsim fī maarifat al-aqālīm*" (*The Best Divisions in the Knowledge of the Regions*), who visited the city of Bam in the tenth century and well represented the prosperity of Bam at that time. "Mukaddasi divides the province of Kirman into five Kiirahs or districts, called after their chief towns; namely (i) Bardasir, with the sub-district of Khabis to the north; next (ii) Sirjan, on the Fars frontier; then (iii) Bam and (iv) Narmasir on the desert border to the east; and lastly (v) Jiruft to the south, running down to the sea-coast of Hurmuz." […] "Mukaddasi records that the city wall, which made a strong fortification, had four gates, namely, Bab Narmasir, Bab Kuskan, Bab Asbikan, and Bab Kurjin. There were great markets both within the city and outside in the suburbs, while on the river which passed by the castle was the market of the Jarjan bridge. A celebrated bathhouse stood in the Willow street (Zukak-al-Bidh). A league distant from Bam was the mountain called Jabal Kud, where there were mills, surrounded by a large village, and where much cloth was manufactured."[43] Muqaddasī in his text also mentioned to the Bam's foul-tasting water, and notes that qanats provided the principal supply of water.[44]

- Abu Ishaq Ibrahim ibn Muhammad al-Farisi al Istakhri, a Persian medieval geographer in medieval Islam and traveler of the 10th century (died 957 AD) wrote, "In Bam there are palm trees and many villages belong to it; it has a healthier climate than Jiroft. There is an impregnable fortress in the city. Three mosques, in which the Friday prayers are held, exist in the city, namely a mosque for the Khavārejs on the (common) Bazaar near the Palace of Mansur b. Khurdin, further a Main Mosque in the Bazaar of the Batiste Merchants, which belongs to the Orthodox [Muslim], and a Main Mosque in the Fortress. The Main Mosque of the Khavārej contains their divine chest, for payment to the poor. The members of the sect are not numerous, but they live in prosperity. The city of Bam is larger than Jiroft".

[41] Strange, G. Le. (1905). "*The Lands of the Eastern Caliphate*: *Mesopotamia, Persia and Central Asia from the Moslem conquest to the time of Timur*". Cambridge: University Press, p. 312.
[42] As introduced by Strange (1905, p.13), "Mukaddasi, their contemporary, wrote his geography entirely on independent lines, and chiefly from his personal observations of the divers provinces. His work is probably the greatest, it is certainly the most original, of all those which the Arab geographers composed; his descriptions of places, of manners and customs, of products and manufactures, and his careful summaries of the characteristics of each province in turn, are indeed some of the best written pages to be found in all the range of medieval Arab literature."
[43] Strange, G. Le. (1905). "*The Lands of the Eastern Caliphate*: *Mesopotamia, Persia and Central Asia from the Moslem conquest to the time of Timur"*. Cambridge: University Press, pp. 229-312.
[44] Bastani Parizi. *"Bam: II. Ruins of the old town"*, Encyclopaedia Iranica. Retrieved from http://www.iranicaonline.org/articles/bam-in-arabic-town

About the economy of the town, Istakhri briefly states, “In Bam, cotton clothes are made, which are sent to all directions”.[45]

- Yāqūt ibn-'Abdullah al-Rūmī al-Hamawī (1179-1229 AD), an Arab biographer and geographer of Greek origin, called Bam “an important, noble city, which belonged to the most distinguished cities of Kirman”. On its economic importance he wrote, “the inhabitants are able, most of them are weavers; the gowns from there are famous in all countries” […] “The city has well stocked bazaars”.[46] In the beginning of the 13th century, Yāqut still mentions Bam as «Madinat al-Jalil» (The Magnificent city) as one of the large cities of Kerman, adding that its water was supplied by underground pipes[47] and that as the water could not supply the Citadel, it served to irrigate agricultural lands south of the Citadel (UNESCO, 2004).

- Marco Polo (1254-1324 AD) an Italian merchant traveler passed from Bam in 1272 AD and was awestruck by the city’s 38 towers, huge mud walls and fairly-tale citadel and said, “In this plain there are a number of villages and towns which have lofty walls of mud, made as a defense against the banditti, who are numerous.”[48]

- Rashid al-Din Fazlolllāh (1247-1319 AD) in his book “*Tārikh-e Rashidi, Jami al-tawarikh”* wrote about the social problem of Bam, the poverty-stricken conditions of peasants of the province of Bam ruined and in flight because of the extortion and violence participated by the military.[49]

- The British diplomat and author, ambassador, Sir Harford Jones Brydges (travelled 1807-1811 AD) knew Lotf Ali, whom he called, “the last chivalrous figure among the kings of Persia.” Brydges writes sadly of Lotf Ali's death, of his “little son” who was castrated, his daughters who were forced to marry “the scum of the earth” and his wife who was dishonored.[50]

- There is another mention of ancient Bam by Le Strange (1905) in CHAPTER XXII of his book entitled “*The Lands of the Eastern Caliphate*” has descriptions from “The Sirjan district. Bam and Narmasir districts. Rigan. Jiruft and Ramadin, Camadi of Marco Polo.

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[45] UNESCO. (2004). “*Bam and its Cultural Landscape*”. Retrieved from whc.unesco.org/uploads/nominations/1208bis.pdf
[46] Afzal al-Din Kermāni, “*Eqd al-Owlā*”, p. 128.
[47] Yāqut, (vol. 1, p. 737).
[48] Polo, Marco (1254-1323). “*The Adventures of Marco Polo, the Great Traveler*”. In: Holden, Edward Singleton (ed.). New York: D. Appleton and company, pp. 52-53, 1902.
[49] “*Tārikh-e Rashidi, Jami al-tawarikh*”, pp. 10-12.
[50] Brydges, Harford Jones. (1834). “*An Account of the Transactions of His Majesty's Mission to the Court of Persia in the Years 1807–11*”. London: James Bohn, pp. 209-256.

Dilfarld. The Bariz and Rafs mountains. Rudhkan and Manujan. Hurmuz Old and New, Gombroon. The trade of the Rirman province. The high roads." [51]

- Nourbakhsh, an Iranian historian, about the construction history of different parts of Bam Citadel mentioned that, "The mosque [Jame Mosque] of the Citadel had several periods of construction starting from the Saffarid dynasty (861 to 1003 AD). Its huge iwan resembls the great iwans of Parthian (150 BC- 224 AD) and Sassanid (226-651 AD) periods). Its huge scale resembls the Jame mosque and the Arg Alishah in Tabriz, which depicts the vanished greatness of the Saffarid period." […] "The second surrounding walls, stable, house of commander, barrack, small caravanserai possibly belong to the Ilkhanat (1256-1335 AD) or Teimorid (1370-1507 AD) periods. The Four Season building possibly belongs to the Safavid period (1501/1502 to 1722 AD)." (Bam3DCG).[52]

- About the condition of inhabitants of Bam after Ghoz attack (1179-80 AD), which caused vast destruction, Tayari wrote, "The inhabitants who remained after the vast destruction in the bigger city came inside the walls of the present day Citadel and the large citadel shrank to its current size. They replaced the large and luxurious buildings and rich districts with small ordinary houses. This event might have happened in 1409 AD by the order of Teimorid governor of the city." About the history of different parts of Bam Citadel, Tayari also added, "Parts of mosque were also built in the Safavid period. There is a chalk-molded alter in the northwest side of the mosque with an inscription that dates back to 1751 AD." […] "The School of Mirza Naim and its adjacent three houses belong to the Qajar period (1794 to 1925 AD). There is a tomb in the School of Mirza Naim, which belongs to Haj Seyyed Mohammad, father of the founder of the school and one of the most respected clergy of the Qajar period. Parts of the Governor's House, House of Sistani, and the bazaar seem to have been also built in the Qajar period."[53]

- Ḥamdallāh Mustawfi (1281-1349 AD), a Persian, historian, geographer and epic poet who was descended from a family of Arab origin, in the 14th century still refers that, "There is here a strongly fortified castle. The climate of Bam is better than that of Jiruft, but is inclined to be hot".[54]

- Etemad Al Saltaneh (1843-96 AD), a Qajar statesman, scholar, and author, in his book entitled "*Merat al baldan*" described the incident of Lotfali khan e Zand (the last king of

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[51] Strange, G. Le. (1905). "*The Lands of the Eastern Caliphate*: *Mesopotamia, Persia and Central Asia from the Moslem conquest to the time of Timur*". Cambridge: University Press, pp. 311-321.
[52] Bam3DCG, "*Virtual 3D Reconstruction of Bam Citadel*". Retrieved from http://dsr.nii.ac.jp/Bam3DCG
[53] Tayari, H. (2004). "*Arg-e Bam*", Field Survey. Retrieved from personal archive of Dr. Tayari.
[54] Ḥamdallāh Mostowfi. (740 AD). "*The Geographical Part of Nuzhat-al-Qolūb*", translated by G. Le Strange. (1919). Leyden and London, CHAPTER XIII, pp. 137-145.

the Zand dynasty 1750-1794 AD) who was caught and killed by Agha Mohammad khan (the first king of the Qajar dynasty 1794-1925 AD) in the Citadel of Bam in 1794 AD.[55]

- Fīrūz Mīrzā Noṣrat-al-Dawla (1817-1886 AD), who revisited Bam forty years after his first incursion, wrote in his travel diary "*Safar-nāma*" (p. 7), "the fort's garrison, arsenal, and armory are still in place; however, the city [i.e., the citadel's settlement] is completely destroyed" […] "the engineering aspects of the citadel are astonishing" […] "the walls are wide enough to accommodate two artillery pieces. It has a considerable moat. The city walls have been built on a height which even at a gallop is not easily climbed."[56]

- Wazīrī Kermani (died in 1887), an Iranian Historian, who in his famous book "*Jogrāfīā-ye Kermān*" (p.94) reported, "now but for two platoons of soldiers, an officer, a few cannoneers, two artillery pieces with their attendants, and about fifty cavalry whom the provincial government of Kermān has ordered to protect, the citadel is deserted."[57]

- In the late of 18th and early 19th century western travelers impressively expressed the condition of Bam's Bazzar located in the present city of Bam, "small and poor"[58] and "miserably small and insignificant"[59] by Lovett & Smith (1876); "little" by E.C Sykes in 1895;[60] and "seemed bustling" by A. Gabriel (1928).[61]

- The rate of Bam's population in the late of 18th and early 19th century is estimated by western traveler vary from 2000 families by Lovett & Smith (1876);[62] six thousand by A. Gasteiger (1881);[63] P.M. Sykes (1902) estimated the population to be thirteen thousand;[64] and the same figure was cited by A. Gabriel (1928).[65]

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55 Bam3DCG, "*Virtual 3D Reconstruction of Bam Citadel*". Retrieved from http://dsr.nii.ac.jp/Bam3DCG

56 Bastani Parizi. "*Bam: II. Ruins of the old town*", Encyclopaedia Iranica. Retrieved from http://www.iranicaonline.org/articles/bam-in-arabic-town

57 Ibid.

58 Lovett, J., & Smith, E. (1876). "*Eastern Persia: An Account of the Journey of the Persian Boundary Commission of 1870-72*", vol.1. London: Macmillan and Co, p. 85.

59 Ibid, p. 278.

60 Sykes, E.C. (1898). "*Through Persia on a Sidesaddle*" (2nd Edition). London: George Bell & Sons, and Bombay, p. 195.

61 Gabriel, A. (1929). "*Im weltfernen Orient*". München: Berlin, R. Oldenbourg, p. 195.

62 "*Eastern Persia: An Account of the Journey of the Persian Boundary Commission of 1870-72*". p. 167.

63 Gasteiger, A. (1881). "*Von Teheran nach Beludschistan*". Innsbruck, p. 78.

64 Sykes, P.M. (1902). "*Ten, Thousand Miles in Persia*". London: Murray, p. 217.

65 Gabriel, A. (1929). "*Im weltfernen Orient*". München: Berlin, R. Oldenbourg, p. 195.

- Sir Aurel Stein, around his archaeological exploration in north-western India and south-eastern Iran visit to Bamin 1930s, as part of the statement of Stein about his exploration in citadel of Bam he cited, "More interesting was a visit to the large arq of Bam (Figure 1.10), once considered the strongest fortress of Persia. Since its abandonment in the last century, it is slowly crumbling to ruin. The picture presented by the interior, closely packed with vaulted mud-brick houses in all stages of decay, was suggestive of the process through which many an ancient town of Îran is likely to have passed before finally being reduced to a mere mound."[66]

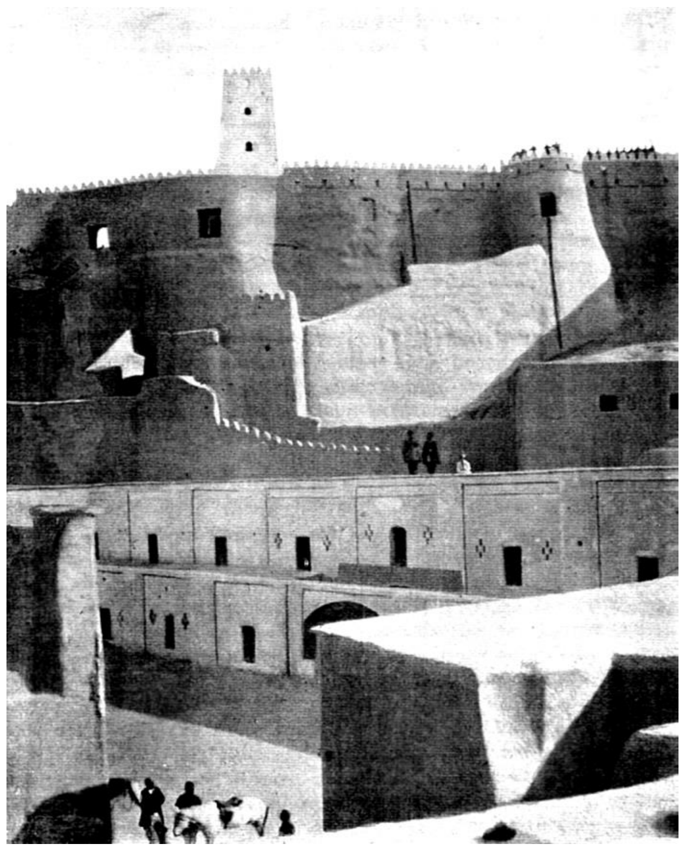

Figure 1.10- A picture of Bam Citadel drawn by Sir Percy Sykes in 1896 (Source: UNESCO, 2004).

During Mowzaffarid dynasty, the king Amir Mobārez al-Din (1301-1363 AD), recaptured the citadel after a four-year siege (Kotobi, 1986).[67] Later, under the Safavids, 16th to the early 18th century, Iran experienced more than two centuries of calmness and relative prosperity. At that time, silk and woolen fabrics were still made as well as cashmeres. Their production lasted until the end of the 18th century.

[66] Sir Aurel Stein. (1937). "*Archaeological Reconnaissances in North-Western India and South-Eastern Īrān*", vol.1. London: Macmillan and Co, p. 159.
[67] Ibid.

During the expedition of Nāder Shāh to India (early 1738), these products, made in Bam and Narmānshir, were sent to his expeditionary crop (Nourbakhsh, 1956).[68] In those periods, the city of Bam played the role of a military or frontier fortress in Iran. Throughout the history, Afghans usually attacked Iran's eastern borders, in this periods two destructive invasion happened by Afghans, one in 1719 AD and the other during 1721-1730 AD.

Figure 1.11- According to the statement of Sir Aurel Stein, it can be said that the citadel is abandoned at the end of 19th century or sooner in Qajar Period (1795-1925 AD). As it can be seen in this photo, the citadel had suffered from vast destruction. Whether it might have been due to another earthquake, or due to human destruction is a question to be investigated (Photo by Sir Aurel Stein, 1930. Source: Digital Archive of Toyo Bunko Rare Books. Retrieved from http://dsr.nii.ac.jp/toyobunko/XIII-6-A-4/V-1/page/0025.html.en).

One of the prominent events in the late 18th century was related to Lotf-'Ali Khān, the last king of the Zands dynasty, when he fled to Bam after the fall of Kerman in 1794 AD. A year later, the governor of Bam captured Lotf-'Ali Khān[69] and turned him over to the founder of the Qajar dynasty, Aqā Mohammad Khān Qajar. The Qajar ruled Iran until 1926 AD. In 1810 AD, Arg-e Bam had to withstand other invasion from Shiraz. Bam was occupied once again by Āqā

[68] Ibid.
[69] Lotf-'Ali Khān was tortured to death, and his followers massacred; the pyramid of skulls erected to celebrate the occasion was still visible in 1810, based on the observation of Lieutenant Henry Pottinger, British traveler (*Travels in Beloochistan and Sinde*, London, 1816, p. 202).

Khan Maḥallātī (the head of the Ismaïli sect) during his 1840-41AD insurrection and remained an unsettled state until around 1855 AD.[70]

However, Bam recovered itself slightly in the mid-19th century, so the construction of the new city started outside of the city wall, and the people of Bam gradually moved out to the new areas of Bam. The new town of Bam - adjacent to the old one - is densely inhabited and was constructed in the 19th and 20th centuries after its predecessor had been attacked by Afghan and other invaders in the 18th and early 19th centuries.[71] Generally, the old city has been inhabited appears to 1874, and then gradually been abandoned (Khosravi, ICHOD's website).[72] The Citadel of Bam was used as an army barracks until 1932, after which it was abandoned (Magiar, 2004). So then, it gradually turned into the ruins, which we know today as the ancient city of Bam.

As mentioned Bastani Parizi about the development of Bam city out of Citadel's wall:

"The restoration of peace allowed the town to grow beyond its walls, and a new settlement was founded along the river in enclosed gardens and date groves 1,000 m to the southwest." […] "Unfettered by walls and fear of invasion, Bam expanded rapidly at the end of the 19th and beginning of the 20th century." […] "Commercial activities also grew in this period: Bam's bazaar expanded from small in the late 19th century to bustling in 1928." […] "The covered *bāzār* consisted of two distinct parts and of a separate Zoroastrian section occupied by some fifty Parsi merchants (according to the 1966 census, Bam had 156 Zoroastrian inhabitants)." […] "As of 1973, the *bāzār* contained 576 commercial establishments, 105 itinerant merchants, and several small-scale building-material factories and produce-processing plants (primarily dates and citrus fruits). The overall population has grown from 15,737 in 1956, to 21,761 a decade later, and in 1976 reached 30,422, most of whom were engaged in agriculture. In contrast to Narmāšīr with its highly diversified agriculture, over the last quarter century Bam agriculture has come to be virtually dominated by date and citrus farming, the produce of which is marketed mainly in Tehran. In recent years, however, certain grains and alfalfa have been cultivated among the fruit trees, providing many yearly harvests of winter feed necessary for livestock (principally sheep and goats)."[73]

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[70] Bastani Parizi. "*Bam: II. Ruins of the old town*", Encyclopaedia Iranica. Retrieved from http://www.iranicaonline.org/articles/bam-in-arabic-town

[71] The Circle of Ancient Iranian Studies (CAIS). (2003). "*Spectacular Medieval Complex on Old Silk Road Now Lies in Ruins*". Retrieved from http://www.cais-soas.com/News/2003/December2003/28-12.htm

[72] Khosravi, Kh. "*Madkha-e Bam*", Iranian Cultural Heritage Organization Document Center (ICHODC), (cited in Persian). Retrieved from http://www.ichodoc.ir/argebam/about.htm

[73] Bastani Parizi. "Bam: II. Ruins of the old town", Encyclopaedia Iranica. Retrieved from http://www.iranicaonline.org/articles/bam-in-arabic-town

Figure 1.12- Abdul Hussein Mirza (Farmanfarma) the governor of Kerman and some of the Bam's Khans on the top of Bam Castle (Source: archive of IICHS, 1880).

Figure 1.13- As shown in this photo, during the Qajar dynasty the Citadel of Bam was used as a military complex (Source: archive of IICHS, 1932).

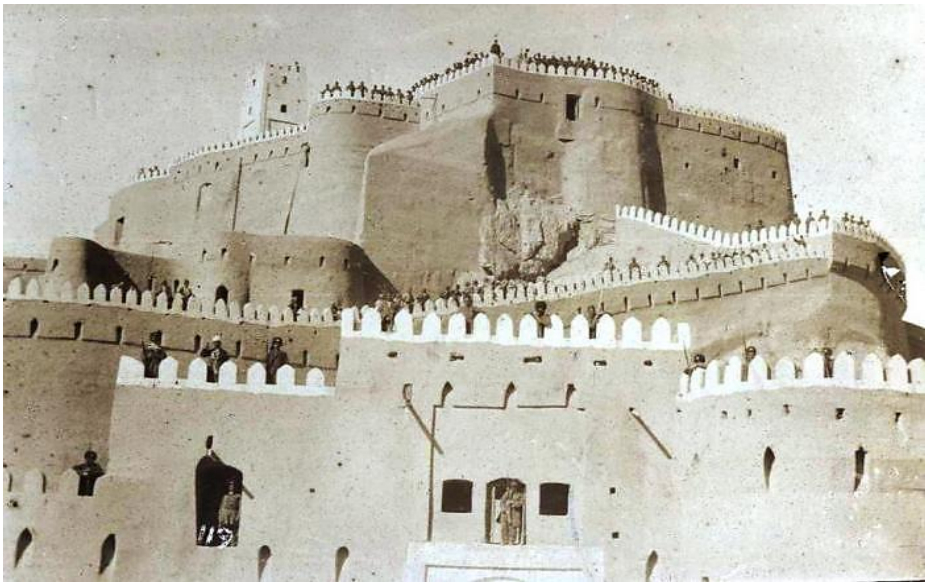

Figure 1.14- The deployment of government troops in the Bam citadel. This picture is of Abdul Mirza (Farmanfarma), the ruler of Kerman from 1930 until 1932 AD, and again from 1933 to 1935 AD (Source: Source: archive of IICHS).

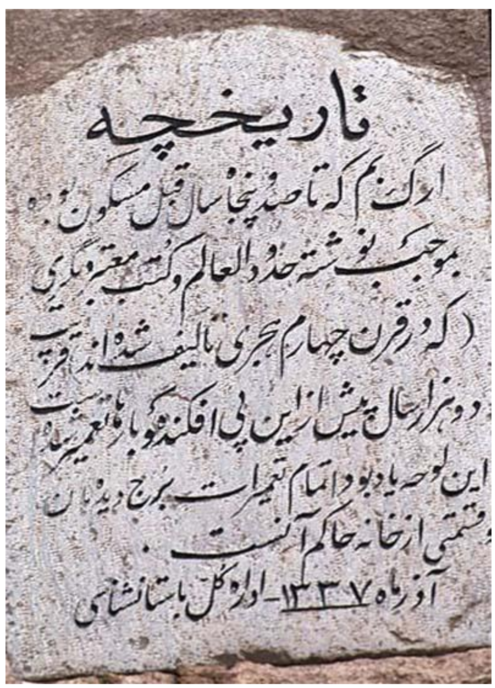

Figure 1.15- Translation of what is written on the inscription of Bam citadel: the Citadel of Bam was inhabited until hundred and fifty years ago, based on *"Al Alam"* and other valid books (written in the fourth century AD) was founded nearly two thousand years ago and has been frequently repaired ever since. This inscription marks the completion of restoration of the garret and the governor's house. Department of Archaeology- December 1958 (Translated by Author).

1.3 Geology and Seismicity

The Iran pleatue lies on the Alpine earthquake belt that runs west-east from the Mediterranean to Asia, the tectonic setting of the region dominated by the collision of the Arabian, Eurasian and Indian plateaus. Actually, the earthquakes in Iran are happened as the result of both reverse and strike-slip faulting within the zone of these deformations.

Major geological structures of Iran are the Alborz Mountains in the north, the Zagros belt in the west and south, the Kopet-Dagh range in the northeast, and the depressions of Great Kavir in the center, Lut in the east, and the Caspian Sea in the north (Zahrai & Heidarzadeh, 2007). The natural geography of Bam is surrounded by the depressions of Great Kavir in the north and Lut in the east. The geomorphology of the region also includes a range of mountains to the north of Bam extending northwest and also the Jebal-e-Barez mountain range to the southwest of Bam extending in a northwest-southeast direction (Manafpour, 2008). The geology of this region is dominated by lithologies ranging from recent Quaternary alluvium to Eocene volcanic rocks. Based on the 1:250,000 geological map prepared by GSI (Geological Survey of Iran), five different lithologies can be observed in the main geological formations in the area, including recent Quaternary alluvium, late Quaternary sandstones and siltstones, Paleogene sedimentary rocks, Eocene volcanic rocks, and intrusive igneous rocks (Granodiorite). Quaternary fine sands and silts form the alluvium around Bam town and its vicinity. These sediments are yellow to brown sand and silt (Qm1), coarse grain brown gravel deposits of flooded plains (Qm2), coarse grain gravel of alluvial fans (Qf2) and coarse grain deposits of the rivers, respectively. Qm2 deposits covered nearly most of the Bam and Baravat areas. The thickness of these sediments having low to medium compaction is about 50 meters (Hosseini et al, 2004). Based on the research conducted by Rezaei et al., (2009), "the grain size in the shallow subsurface (<10 m) decreases across the city from south to north and below ~10 m increases with depth across the entire city. Sorting values range from low to very low across the entire study area. In the study area, we recognized eight sediment types: clay, cohesive sandy mud, cohesive muddy sand, poorly sorted sand, well-rounded gravel, poorly sorted gravel, muddy or sandy gravel, and clayey sand. Our observations at shallow depths (<10 m depth) indicate that fine-grained soils and sediments (clay, clayey sand, cohesive sandy mud, cohesive muddy sand) dominate across the northern quarter of the city. In the central part of the city, fine-grained sediments interfinger with the coarse-grained sediments (poorly sorted sand, well-rounded gravel, poorly sorted gravel, and muddy or sandy gravel) which dominate the southern quarter of the city. Below 10- to 15-m depth, coarse-grained sediments are dominant across the entire city except for the far northeastern edge, near Arg-e-Bam, where volcanic bedrock (ryolite and dacite lava flow) directly underlie the shallow fine-grained sediments and soils."[74]

[74] Rezaei, k., Guest, B., Friedrich, AM., Fayazi, F. (2009). Soil and sediment quality and composition as factors in the distribution of damage at the December 26, 2003, Bam area earthquake in SE Iran (Ms = 6.6), Journal of Soils and Sediments, Springer; 9(1): 23-32.

Kerman province (in which Bam is located) is one of the active seismic provinces of Iran. Many recent and historical catastrophic earthquakes have destroyed different parts of this province from time to time (Jafari, 2008).[75] The trend of the main faults (including the Bam fault)[76] in this region is NS, and NW-SE (see Figure 1.16). These two system intersect in western Lut area. The NW-SE faults (Kuhbanan and Ravar faults) and the north-south faults (Nayband, Chahar-Farsakh, Anduhjerd, Gowk, Sarvestan and Bam faults) have determined the border of the north-south structures in the Lut area with the NW-SE structures. These intersection zones are of the main sources for the disastrous earthquakes (Ibid).

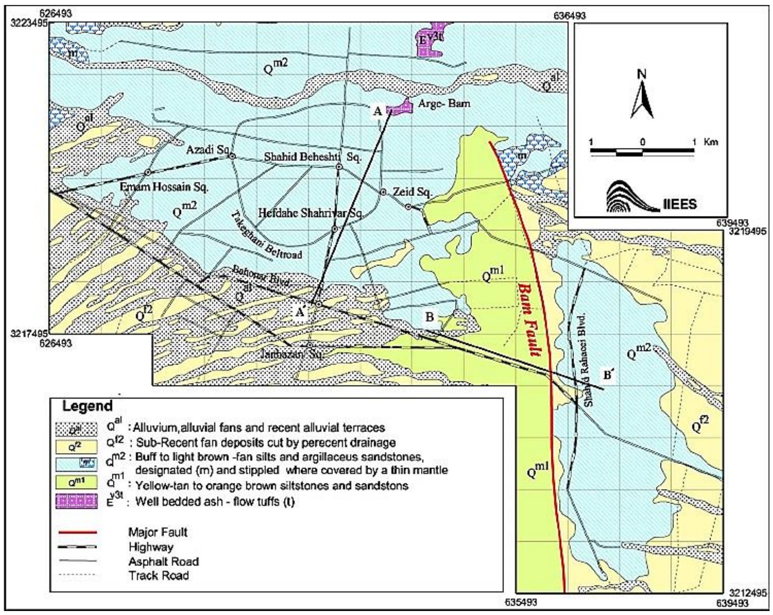

Figure 1.16- Geological map of the Bam region (Source: Pellet et al., 2005).

Towards the northwest of Bam, during recent years between 1981 to 1998, four significant earthquakes with magnitudes greater than 5.6 had shaken the cities and villages of the region located in a distance of almost 100 km (Eshghi & Zare, 2003; Zare, 2004; BHRC, 2004; Beberian, 2005):

- The Golbaf earthquake of 11 June 1981, Mw 6.6; the Golbaf earthquake struck the region of Golbaf in the southern part of the Golbaf valley. In this earthquake, there was a great damage in Golbaf region so that it was associated with 1071 casualties, and a fault rupture occurred along the Gowk fault.

[75] The historical seismicity of the Kerman province is limited to the earthquakes reported after 1800 AD by Ambraseys & Melville (1982) and Berberian (1995). Lack of information has made it difficult to draw a clear picture of the historical seismicity of Kerman.
[76] The main tectonic feature in the Bam region that caused destructive earthquake in 2003 is located in the east of Bam, between Bam and Baravat, with similar name of city (Bam fault).

- The Sirch earthquake of 28 July 1981, Mw 7.1; the Sirch earthquake has been the largest event recorded by seismograph instruments in the Kerman province. This earthquake occurred 49 days after the Golbaf earthquake with 64km of discontinuous surface ruptures that destroyed Sirch and the surrounding villages with approximately 877 deaths.
- The South Golbaf earthquake of 20 November 1989, Mw 5.8; in the lower magnitude of South Golbaf, in which 4 people were killed and 45 injured. The earthquake in its consequences also caused some damage in Golbaf city and was associated with an 11km surface rupture.
- The North Golbaf (Fandogha) earthquake of 14 March 1998, Mw 6.6; in the Fandoga (North Golbaf) earthquake, 5 people were killed and 50 injured. The earthquake was associated with surface faulting (about 20 km length) in northern Golbaf.

In the meantime, the focal mechanism of all those four earthquakes show a compressional and strike slip mechanism along the Gowk and Kuhbanan fault system.

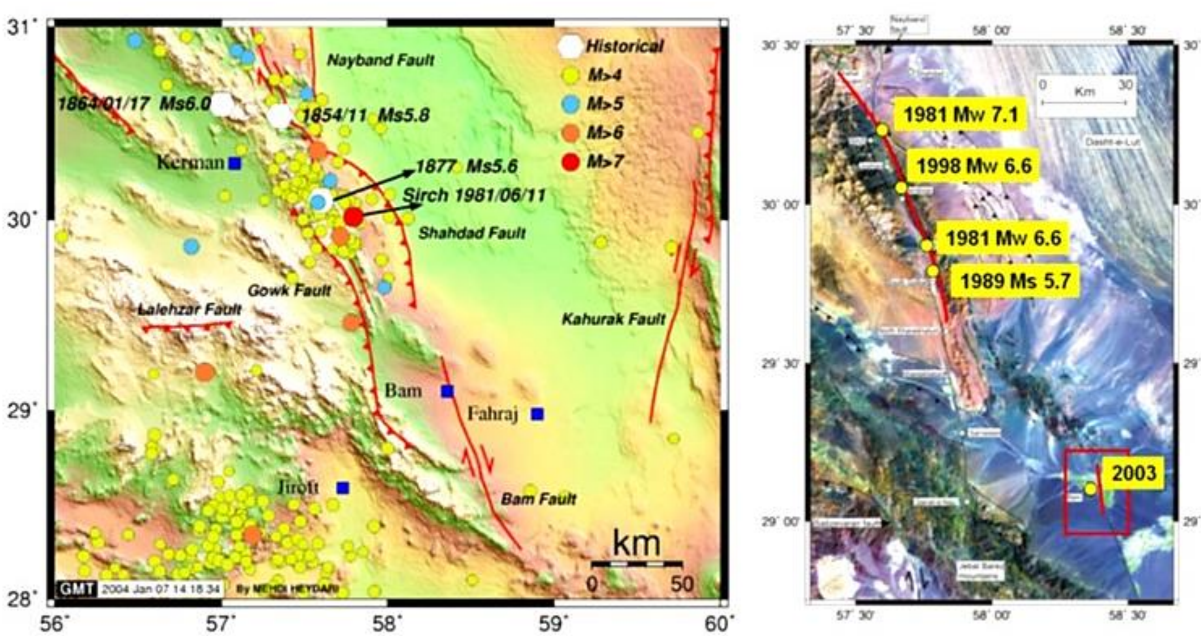

Figure 1.17- (Left) historical seismicity map of the Bam region in SE of Iran together with fault around Bam city (Source: IIEES, 2004); and (Right) four significant earthquakes have occurred in the N-W of Bam city (Source: ICG, 2004).

Following the mentioned earthquake, there were other earthquake as follows; Chahar Farsakh (1998) (Mw 5.3), Bam earthquake (2003) (Mw 6.6), Zarand earthquake (2005) (Mw 6.3) and Kahnug earthquake (2011) (Mw 5.3). There are also historical earthquakes reported in the region: The Sirch 1877 earthquake (Mw 5.6), about 130 km Northwest of Bam, destroyed many villages in Sirch, Abgarm and Hashtada, the Laleh Zar earthquake (1923) (Mw 6.7) that killed 200 and the Golbaf earthquake (1949) (Mw 6.0) (BHRC, 2004).

1.4 Urban Morphology

The identity of Iranian ancient cities had mainly been based on some specific physical characteristics and features, so until now, different from non-Iranian cities, specifically, non-Islamic cities, they have preserved their identities and differences from aliens. In Iran, the physical context of historical cities rather than geographic location and access to water is also related to other factors such as natural environment, tradition, culture, belief, etc., factors which have been obtained during at least thousand years of civilization.

The morphological study of urban hierarchy "Urban morphology" is the study of city appearance, its gradual formation and transformation, and the interaction of influential factors on urban faces, such as streets, urban houses, squares and other public places etc. Body identity, functional identity, historical identity, cultural identity, environmental identity, natural identity, religious identity, human identity, acquired identity, national identity and social identity are the significant effects of the Iranian historical urban identity (Naghizadeh, 2008).[77] In 1997, Moudon argued that urban morphology focuses on city studies as a physical environment, but it establishes an implicit link between the space elements, material, social and economic forces of the city (Moudon, 1997). However, in desert regions of Iran in cities like Bam, the complicated and interrelated factors that have shaped urban character are mostly affected by surrounding weather condition and access to natural water resources.

Bam city is an Iranian desert city with special natural and cultural textures, where this specification made it differ from all other Iranian cities located in desert environment; in this city, we can clearly meet a balance between cultural and natural criteria and their adjustment. The city of Bam is recognized as an Iranian organic garden city. Historically, adequate ground water due to surrounding altitudes and suitable soil appropriate for agriculture have had turned this city into a valuable garden city in the desert environment of Iran, where the agriculture has been the main occupation for the most people of Bam. On the other hand, in term of Bam's urban architecture, since the city is located in the desert environment, to reduce the effects of the region's harsh weather condition, there are common structural and physical features in both urban and residential contexts, which this issue well demonstrates another aspect of Bam people's lives that has been originated from their culture to adjust themselves with natural environment. Accordingly, a particular sort of architectural elements (domes, vaults roof and wind towers), some systems (adapting urban texture with desert life conditions) and materials (adobe and mud-brick) are seen in the urban texture of Bam city, especially before the 2003 Bam earthquake. Generally, the main purpose of this part is to recognize the connection of Bam's natural and cultural textures, how they coincide and connect in Bam's urban cultural landscape, and the causes of disorders in the balance of this relationship over the course of time.

[77] Naghizadeh, M. (2008). *Islamic city and architecture* (1st Edition). Esfahan: Mani publishing Company, p. 121. (Published in Persian).

Actually, there is two dependent cultural and natural connections, which have main roles in the urban development of Bam city, as following:

▪ Close and harmonious relationship between the ground slope of the region and the path of the qanats: since Bam and Baravat are located in an area with low altitudes respect to other areas of the region, the rainfalls originated from west altitudes have flew towards Bam and Baravat, and the groundwater stored under these two cities results in the formation of the aquifers. Therefore, the native people of Bam through their knowledge and in compliance with region's ground slope formed their gardens and farmlands along the streams and rich aquifers.[78] And because of this, qanats due to those aquifers have been drilled along the Bam Fault, which has the largest reserves of underground water, see Figure 1.18.

▪ Close and harmonious relationship between the Bam's urban development and distribution of green spots: in fact, the development of the new city of Bam is basically based on the distribution of gardens which have been formed along the path of the qanats passed from the city.

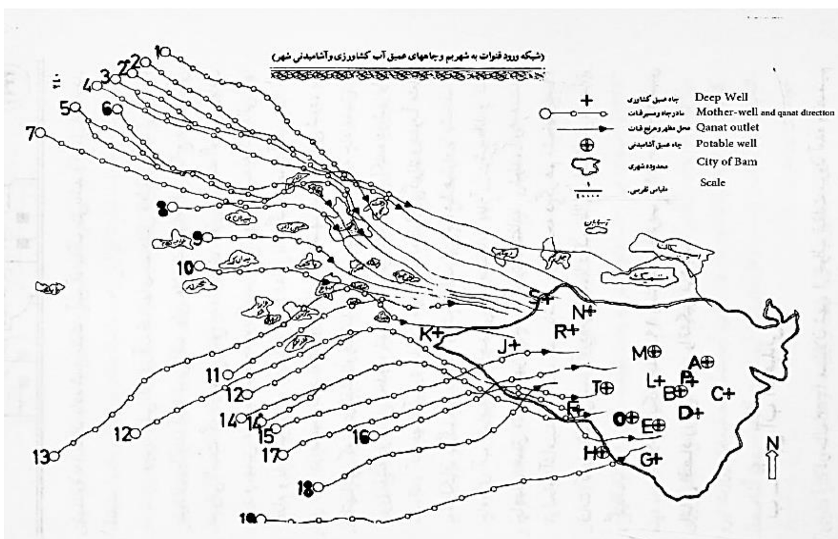

Figure 1.18- Qanats and deep wells in second hydraulic unit west of Bam fault (Afraz) (Source: Sabetian, 2014).

The physical development of the city of Bam is originated from the Citadel of Bam located on the northeastern quadrant of the present city. Because of the existence of the Poshte- Rud River

[78] As mentioned by Adle (2009), "The outstanding character of Bam and its immediate neighbourhood is the result of an intelligent and progressive exploitation of an exceptional natural setting by groups of innovative and enterprising men. People who together not only found out how to survive by discovering a genius way to extract hidden underground waters, but also to use it in a harmonious garden-town where both agriculture and semi-industrial craftsmanship were thriving."

in the northern part of Bam city, the city could not easily developed towards north, for this reason all of its expansion happened in the southern part of the current river. Before Islam, the people of Bam farmed on the land outside of Bam Citadel, even during Sassanid period the agriculture was somehow prevailed outside of the Citadel's walls (Mostowfi, 1989).[79] During Safavid period (1501-1722 AD), the Bam's gardens were gradually expanded outside of the Citadel towards the southern areas, so they formed the future development of the city. Thus, the formation of the new city of Bam had been started during this period, and at this time, the structure of city formed in full coordination with the gardens' structure (Nourbakhsh, 1976).[80] During the late of Qajar period (1794-1925 AD), changes in the appearance of Bam city and its development outside of Bam Citadel was so evident. As describing Bam in 1294/1877, Mohammad-Hasan Khan Sani-od-dowleh (E'temad-os-Saltaneh), "Previously Bam had a few palm groves but now it has about ten thousand palm trees. All kinds of citrus are also now grown in Bam, and contrary to the old days, they are abundant."[81] Only three years after E'temad-os-Saltaneh, the Prince Firuz Mirza Farmanfarma who visited Bam on Moharram 24. 1297/ January 7, 1880 and the following days, reports that, "Not only the fields, gardens, orchards (baghat) and palm groves (nakhliat) are irrigated, but also the waters circulate and pass alog their [the Bamis] buildings… thanks to henna growing, Bam has now much grown and it is a nice little twon (qasabeh) which cannot be compared to what it used to be 43 years ago when [I] saw it."[82]

Generally, the gardens in Bam city like other Iranian garden cities, as a part of city's nature not only have main role on the appearance of the city, but also have influenced on the physical structure of the city. Therefore, the urban structure of Bam city is formed based on gardens and their irrigation system. Actually, the development of the city of Bam has taken place during following main periods of the history (Eshghi et al., 2003):[83]

a. Bam Citadel's periods (500 BC) until 1881
b. Bam city from 1881 to 1921
c. Bam city from 1921 to 1941

[79] Mostowfi, A. (1989). *The Roads during Sassanid Era.* Tehran: Tehran University Publication, pp. 23-26. (Published in Persian).
[80] Nourbakhsh, M.H. (1976). Arg-e Bam along with a brief history of the evolution of Urbanism in Iran . Tehran: Ministry of Industries and Mines Publication, pp. 13-25. (Published in Persian).
[81] Adle, C., CNRS., ESKEM., DAFA. (2009). *Qanat of Bam: An Archeological Prespective*. In *Qanats of Bam, A Multidisciplinary Approach*. In: Honari, M., Salamat, A., Salih, A., Sutton., J., Taniguchi., J (ed.), UNESCO Tehran Cluster, pp. 33-85.
[82] Ibid.
[83] The most of buildings in each period obeyed the structural typology of the relevant period. This periods can be divided as follows (Eshghi et.al., 2003):
▪ the period of domed ceilings of mud brick houses and Roman arches.
▪ the period of masonry buildings with Load bearing walls and ceiling vault.
▪ the period of half-frame buildings.
▪ the period of half-engineering and new engineering buildings.

d. Bam city from 1941 to 1966
e. Bam city from 1956 to 1976
f. Bam city from 1976 afterwards

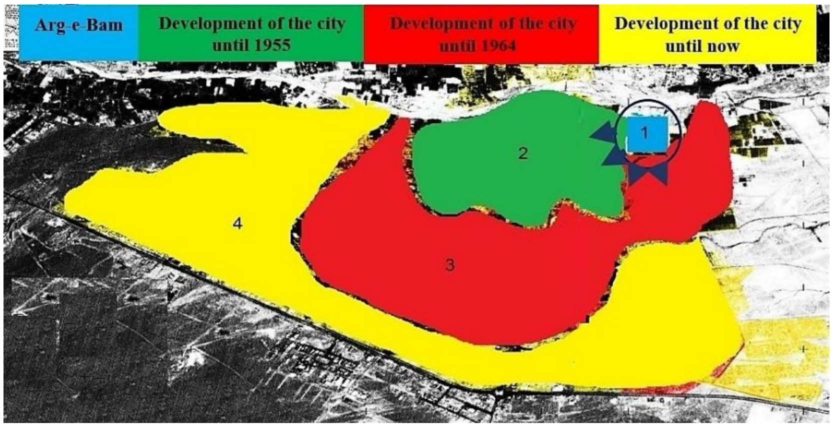

Figure 1.19- Map of the quality of urban development in Bam city in different periods (Source: Eshghi et al., 2003, designed by Author).

The first modern street system of the city dates back to 1930, which under the command of Reza shah was directed from north to south in the southwest of the Bam Citadel (Karimian, 2003).[84] Then, two perpendicular main streets built in 1956 had shaped the structure of the new city of Bam (Behbahani & Shirgir, 2009), see Figure 1.20.

Figure 1.20- In 1956 two perpendicular main streets were built in the city of Bam, which shaped the structure of the city (Source: Behbahani & Shirgir, 2009).

[84] Karimian, H. (2004). Bam City from Genesis to Destruction. Athar Journal, Research Institute of Cultural Heritage, Handicrafts and Tourism; No. 36: 17-37. (Published in Persian).

As Parsizade et al. (2006) pointed, “For the first time in 1963, the municipality of Bam installed a piped water system, which was not completed until 1992, when the city’s ‘Water and Sewage Company’ was established.”[85] Until 1977, although the city of Bam was somehow developed heterogeneously but the negative impact of urban growth was not so felt on arrangement of gardens. As can be seen in Figure 1.21 the garden pieces at this time are regular square or rectangular shapes, and the connection between natural and built environment was stable (Behbahani & Shirgir, 2009).

Figure 1.21- Aerial image of the city of Bam in 1977, the main two streets had influence on the gardens system but the connection between natural and built environment is standing (Source: Behbahani & Shirgir, 2009).

Then from 1977 to 1986, gradually based on the urban size and needs of the urban population, the roads’ hierarchically had been changed simultaneously; the streets had been wider, and there had been built more internal roads and internal alleys. In this period, the introduction of water pumping equipments combined with the dramatic rise of the Iranian population after revolution in 1979 changed the country’s landscape (Adle, 2009). Because of population growth, in addition to the new east-west oriented streets, a number of squares and a bypass were built near to city center. However, the most of the urban developments were near these squares and in north-west and north-east directions. These new streets had a significant influence on the sizes of the gardens as they were divided into smaller pieces of lands and the distances between the pieces were increased. Some gardens in the city center were also completely removed in the new urban structure (Behbahani & Shirgir, 2009).

[85] Shahnoori, S. (2013). Sustainable Reconstruction of Houses in Seismic Desert Areas (The PhD thesis Architectural Engineering, Technische Universiteit Delft, Netherlands). Retrieved from http://repository.tudelft.nl/islandora/object/uuid:aa3f1934-1d92-4aff-82b8-f6599640d2e8/?collection=research

As can be seen from aerial photos taken in 1998 and 2003, between years 1986 to 2003, the city was developed more towards southern lands with new streets built in this period. The size and the number of the gardens were reduced by the new road systems and building constructions. Land use changes were without considering the land capacities and the new road systems were uncoordinated with the garden systems (Behbahani & Shirgir, 2009).

Figure 1.22- (Left) Aerial image of the city of Bam in 1998, more streets are built in this period of time and garden lands are divided into smaller pieces because of urban developments; and (right) aerial image of the city of Bam in 2003, After the earthquake more streets were built in this period of time and therefore more garden lands and farms were destructed. Urban edges are destroyed and the street network is more chaotic in the central parts of the city (Source: Behbahani & Shirgir, 2009).

After the earthquake of 2003, besides of damages induced by the earthquake on Bam's cultural landscape, city's post-disaster reconstruction and city's recent urban development have also had negative impact on reduction of green area of the city, more streets were built and therefore more garden lands and farms were destructed. In this case, changes in use of land were without considering the land capacities, and the new road systems were uncoordinated with the garden system (Behbahani & Shirgir, 2009).

As can be seen in Figure 1.19, approximately the half of Bam city was built before 1988, the year that the Iranian code of practice for seismic resistant design of buildings was entry into force. According to statistics published by management and planning organization, until 1996 approximately 57 percentage of the buildings had been built before the obligation of Iranian code of practice for seismic resistant design of buildings. Therefore, the high rate of destruction during the 2003 Bam earthquake was not unexpected. On the other hand, according to another statistics that has been delivered by the same organization, until 1996 the distribution of buildings in Bam city based on their structural system and loadbearing were divided in three different groups: engineering (1%), half-engineering (29%) and non-engineering (70%) buildings (Eshghi et al., 2003).

Figure 1.23- Change in green space of Bam city in years between 2004 until 2016 (Source: Google earth).

In term of Bam's construction typology, in modern Bam before the earthquake, the typology of houses regardless of their material facet comprised of (Shahnoori, 2013):

- Town houses: single-family houses is the recent major trend;
- Neighbourhood houses: based on ancient Persian architecture these are communal houses in which relatives live close together and where each neighbourhood is a known and trusted territory for its inhabitants. In the past, close relatives lived together in separate spaces of big houses and other relatives lived in the neighbourhood. The hierarchy from the most public to the most private areas, starting from the street and leading to the entrance of a house was an important criterion;
- District houses: the heterogeneous houses in this group accommodate inhabitants from various segments of society; these people are more flexible about accepting others so they reinforce the modern fabric. In such a small city, there is still a sense of social connection between inhabitants;
- Multi-functional houses (or mixed function houses): these are an emerging type as far as modernization and modern life style is concerned. These are street-dependent houses. Normally the ground floor includes different functions such as shops, but the first and the second (if there is a second floor) are residential with separate entrances. These are compact houses and because of their economic benefits, they are getting more popular;
- Garden houses: these vary from very large traditional houses located mostly in the middle of the garden to the normally sized houses located in various spots of the garden;
- Village houses: these vicinity houses are not located in the city centre but are prevalent in the villages. They mostly are low-quality small houses with a small yard or no yard. The size of the site or garden may be larger in rural areas. Therefore, the density of these houses varies quite considerably.

Although before the 2003 Bam earthquake, the majority of buildings in the city of Bam could be described as adobe construction with high architectural value, but since then the most of the city's buildings were newly built based on following principles of engineering. In term of forms and designs, the new systems and materials used after the earthquake have no homogeneousness with Bam's cultural landscape.

In term of urban morphology, the most important principle for the formation of urban spaces in Bam city is the relationship between environmental status and constructed spaces. Three species of urban and spatial organization has been identified: the first one is 'dense textures' in relatively older parts, which had faced large damages after the earthquake, so in new urban morphology they have almost no place; the second species is 'modern and checkerboard textures'; and the third is 'organic and garden textures' with spatial organization and urban landscape quite different from the other two species. Although Bam city is formed according to the quality of the landscape and visual features and high quality of ecology, it does not mean to say that buildings damaged by the earthquake had no architectural values. Nevertheless, exceptional values for this city (its natural and ecological values) are beyond the architectural aspects that have supported life in this city. In the recent period after the earthquake, the new buildings regardless to spatial organization of the urban landscape partly have deteriorated those qualities. The reality is that the architecture of buildings that had been used in the reconstruction of the city are lacked of certain features. The main elements of spatial organization and urban system in Bam can be identified into several main elements as following:

1) Urban pattern; the texture of Bam city, apart from dense, modern and organic textures is generally influenced by the direction of surface water that flows where upon the urban skeleton is formed. In any case, the city was formed with straight streets; from 1930 onwards, it still retains its organic quality.

2**)** Organized as occupied and empty space; trees in Bam city have multiple functions, bedsides of framing and having other specifications, they also reduce the effect of sandstorm. In the city of Bam, occupied spaces (buildings) are located with the lowest density among empty spaces (gardens). Accordingly, the occupancy level of the buildings in most parts of the city is very low, as far as about 75 percent of occupancy level is between 0 to 20%, 12 percent is between 20 to 40 % and 3 percent is between 40 to 60 %.

3) Sky line: similar to other spatial features, skyline has a very important role in urban landscape of Bam city. There is a proportionality between the height of palm trees and buildings. Most of the buildings in Bam city have one or two or three floors, which exactly are influenced by the surrounding gardens. Hence, in the city of Bam, the height of palm trees acts as one of the main factors on the height of the buildings (the maximum height of palm tree is almost 12 m), so far the buildigs height are almost in this range of height.

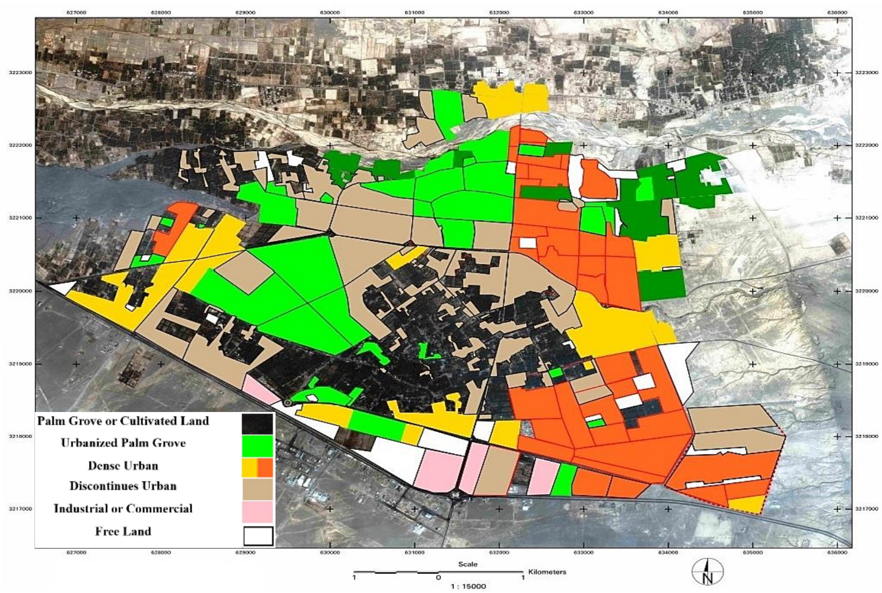

Figure 1.24- Land use map of Bam city (Designed by Author).

4) Belief: some spaces and characteristics found in the old urban layout of Bam have resulted from beliefs, thoughts and culture of Iranian people. For example, privacy is very important and respected in this city, so it shows its impact in the form and shape of the houses. In Bam city, all of the houses are enclosed by high walls (around of 2-2.10 m) so that it guarantees the visual privacy of the house residents; in this case pedestrians cannot see inside of the houses that overlook the street.

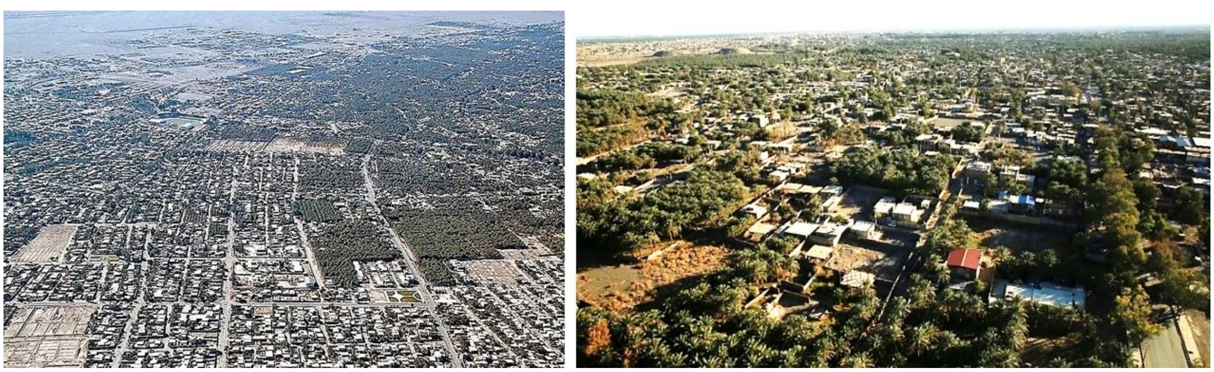

Figure 1.25- (Left) a bird view from Bam’s Urban Landscape, a combination of environmental and constructed spaces (Photo by Gavari, 2014. Source: http://www.skyscrapercity.com/showthread.php?t=1431867); and (Right) A Bird view from Garden House in Bam city (Photo by Rashedi, 2014. Source: UNESCO-WHC).

6) Main streets: most of the streets in Bam city have boulevards, which are lined with trees, eucalyptus and date palm, even in two sides of streets there are robust trees. The water of qanats

and spring surface water ran along roadside channels, where they irrigate many gardens around the town.

Figure 1.26- (Left) covered public space in Emam Khomeini Square of Bam city; and (Right) covered Bazaar of Bam city (Photos by Rouhi, 2015).

Figure 1.27- Bird view from Shahid Rajai Boulevard of Bam city (Photo by Sadeghi, 2011. Source: Fars News Agency).

In the case of Bam's post-earthquake reconstruction, authorities based on large extent seismic destruction have been faced with many challenges regarding the differences between designing a new city and reconstructing the existing one, as well as the issues and criteria related to urban design. Keeping in mind the post-earthquake reconstruction experiences of Iranian past urban earthquakes, the strategies applied in Bam city can be defined as one of the successful examples in the country. Although during the years following the earthquake, a lot of efforts have been made to maintain the city's cultural landscape, but now still existed some problems.

One of this problem is related to the preservation of Bam's green textures and qanats within its cultural landscape. Unfortunately there are evidences that shown some landowners in the city for having possibility to change the usage of their lands have tried to dry up the city's precious palm groves, which constitute an important part of Bam's cultural landscape. However, this issue should be at the centre of any conservation program and management strategy for the city's future urban policy. About the issue of the protection of Bam's qanats, since 2003 Bam earthquake some valuable activities have been taken, which are related to the inscription of Bam's qanat in UNESCO WHL as a part of "Persian Qanat".[86]

Another problem regard to Bam's Cultural Landscape is the ignorance of city's visual identity as one of the Iranian desert city. Here the new city's form rapidly followed many unconnected concepts, so they caused confusion in urban appearance of the city. Since Bam as one of the Iranian historic cities has been formed gradually according to conceptual patterns and rules, and its form of urban spaces is dependent on the morphology of the site, the historical background and the local culture of people, in recent years many non-local agents with unknown architecture, in contrast with traditional design system have influenced the appearance of the city's newly reconstructed parts. In fact, now Bam with this leading feature is losing its identity as a desert city of Iran. Actually, the reason for all these disproportions can be found in the advent of western architectural styles in Iran and the little attention of the local authorities to the protection of Bam's vernacular architectural designs.

Figure 1.28- Drying up the palm groves of Bam city with their landowners (Photo by Mir Asadi, 2012. Soure: http://www.aminmirasadi.blogfa.com/category/18).

[86] The documents related to the nomination of "Persian Qanat" can be seen in http://whc.unesco.org/en/list/1506/documents/

Behbahani & Shirgir (2009) through analyzing of aerial photos of Bam city in subsequent years before the 2003 Bam earthquake have made a comprehensive study on the effective variables in physical and structural transformation of the city of Bam with special emphasis on relationship between the city and nature. Through this study, they have tried to display the reasons for destruction of Bam's gardens through history, and to give an ideal zoning map for its future development. As a result of this study, it was emphasis that considering a preserved green area near the fault line and distinguishing between three different zones of farm lands, gardens and garden-houses in the city is an important issue for planning the future developments (Behbahani & Shirgir, 2009).

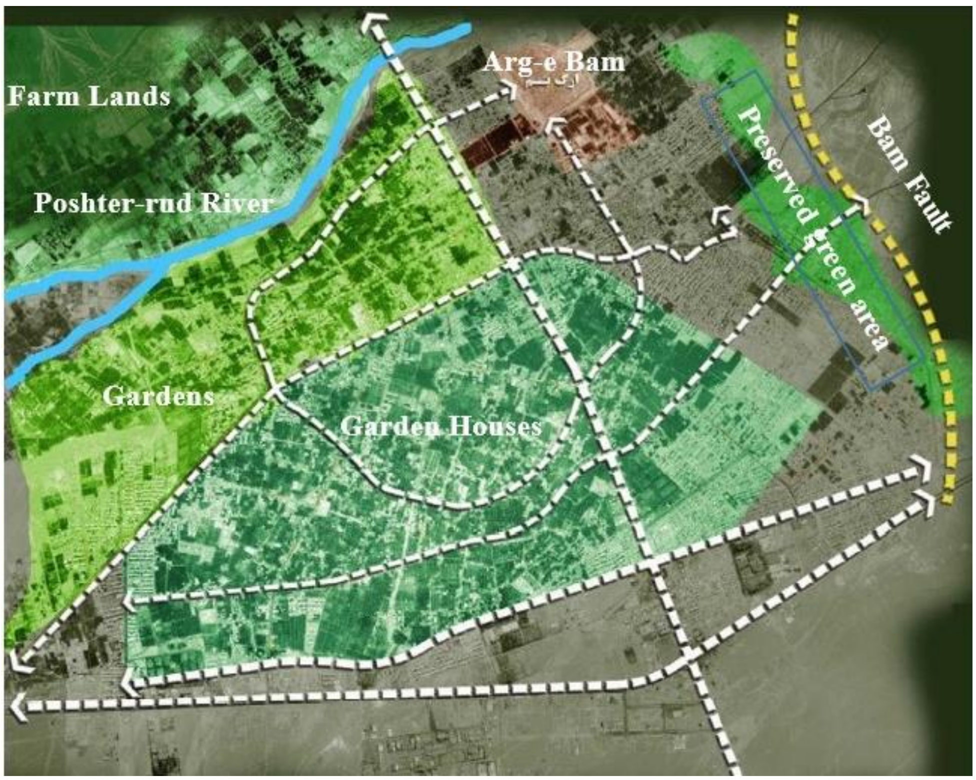

Figure 1.29- The suggested plan with Behbahani & Shirgir (2009) for the preservation of Bam's green textures (Source: Behbahani & Shirgir, 2009).

CHAPTER 2

Bam Citadel (Arg-e Bam): Structures and Architectures

2.1 Bam Citadel (Arg-e Bam)

According to "Dehkhoda Dictionary"[87], "*Arg*" in Persian language means: "*a small citadel within a large fortification.*" (Overwhelming proof).[88]

When I look at the inner part of the citadel, I can say nothing except of goodness (Ferdowsi, 10th century).[89]

The Arg as a prominent space type emerged from a long-standing Persian tradition. ARG (or ARK) is the inner fortress or citadel of a walled city. The *arg* may also serve as the residence of a ruler and include other court and government offices (Arg-Encyclopaedia Iraniaca).[90] As more explanation cited by J. R. Perry about the background of the Iranian Args in "*Encyclopaedia Iraniaca*", "From Safavid through Qajar times, the *arg* of a provincial capital was generally the military headquarters and administrative center of the city and its dependencies. Though an *arg* is sometimes referred to as a *qaḷʿa*, the generic term for fortress, the latter term should more strictly designate an isolated fort or one sited at a strategic point outside the town it defends. The *arg* always lay inside the city wall, sometimes adjacent to it and functioning as part of the defenses; it is analogous to the Roman *arx*, from which the Persian word may have derived, as well as the Norman keep (*donjon*). Its etymology is obscure: the term appears in Middle Persian only in the compound *argbed* a military rank and, though evidently in use during the 3rd/9th century, does not occur frequently in New Persian before the early 11th/17th century. It is used also by Persian writers of Central Asia and northern India to designate the fortress of a city (e.g., Bukhara, Delhi)."[91]

From the past, most of Args usually had been erected on natural features of the cliffs or steep slopes, where they acted as a natural defense against possible enemies. Since pre-historic and early historic times, Args have been built along important land routes with social, political, economic and defensive purposes. The feature of height for Args could create a panoramic view over the surrounding land and make it possible to see every slightest provocation around the area. Since the process of the formation and expansion of cities in the world is generally based upon the interrelation of culture and environment. The genesis of the cities in the Iranian Plateau was usually influenced by several factors such as religion, economy, military, sociopolitical and physical environment. In all cases, natural resources along with other factors could be good enough for the formation of a city in Iranian territory. In the meantime, defense against foreign invasions, and existence of a fortress could be a reason for the formation of

[87] "*Dehkhoda Dictionary*" is the largest comprehensive Persian Dictionary.
[88] Encyclopedia of "*Borhan-e Qata*" in Persian.
[89] Translated by Author.
[90] Encyclopedia Iranica, "*ARG*". Retrieved from http://www.iranicaonline.org/articles/arg-or-ark-the-inner-fortress-or-citadel-of-a-walled-city
[91] Ibid.

cities, like what can be seen in cities such as Kashan and Tabriz. Moreover, the importance of commercial routes (like Silk Road) have been the reason for the establishment of cities such as Bam and Nishabur. Furthermore, religious activity also initiated the emergence of great cities such as Mashhad and Qom. In addition, sociopolitical factors have been a motivating factor in the formation of cities such as Persepolis and Isfahan.[92]

According to environmental condition and availability of materials in any region, Args were built in various techniques and forms over the Iranian plateau. For example, in the hot-arid area of Iran, they were built out of adobe-mud bricks. In the northern and western areas, they were built out of stones and baked bricks. However, in Iran all of the Citadels have analogous features, such as watchtowers, entrance gates, fortress, moats, mobile bridges, and a distinctive architectural layout.

As defined by Cuneo (1986), a Citadel as an ensemble consisted of "La citta della (ark o hisn) e la citta vera e propria (sahrestan o madina o qal'a), e quartieri esterni (rabad)."[93] Bosworth & Asimov (2003) in book entitled, 'History of Civilizations of Central Asia' more precisely have explained about the division of different parts of a historic town in the Central Asia, "The original-pre-Islamic-nucleus of the settlement was transformed into an arg or kubandi (fortified citadel), next to which the actual town, the *shahristan*, which was also walled. Outside this wall the district of the tradesmen and craftsmen, the *rabad* (suburb). Some towns do actually follow this plan, but it is by no means in evidence everywhere and at all times. In Samarkand, for example, in addition to the arg and the *shahristan* (the site of Afrasiab), two other, adjoining, urban areas took shape, the *shahr-I darun* (inner twon) and the *shahr-i-birun* (outer town), beyond which lay the *rabad*." […] "The towns in the northern regions of Central Asia, where the population was predominantly nomadic, were quite small, with an arg and a shahristan. The outer raband were small and at times non-existent because of the danger of attacks by the nomads."[94] In following, after brief description about Bam Citadel, its development within three distinguishable fortified sectors is explained.

On the fringe of the 'Lut Desert' lies the spectacular and impressive Citadel of Bam (Arg-e Bam) with its enlivening sceneries. This Citadel which in ancient times was the city of Bam is located in the northwest quadrant of the modern city of Bam (its geographical position is 36˚, 5 min north and 58˚, 27 min east), a city in the southeast of Kerman province of southeastern Iran. The ancient city of Bam is a well-preserved deserted medieval city that clearly manifests the role of Arg in Iranian culture. This fortification is better than those of the most fortified cities

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92 In Bam, an Iranian desert city that is originated from Arg-e Bam, an accumulation of various factors have contributed on the formation of this settlement, and this reflects its strategic role in the region and country.

93 Cuneo, P. (1986). *Storia dell'urbanistica. Il mondo islamico*. Bari: Laterza (ed.), p, 279.

94 Bosworth, C.E., Asimov, M.S. (2003). *History of Civilizations of Central Asia.* vol. 4, part. 2, First Indian edition, Delhi, pp. 507-508.

in Iran and is particularly notable for the longevity of its use, which has kept its traditional architecture and urban fabric in Iranian desert environment not only up to the day it was severely damaged by the 2003 Bam earthquake, but even now. As it was intruded during centuries for its strategic location in the Silk Road, Bam Citadel can be considered as one of the first foci for the organization of a civilization in which a multicultural society developed involving different religions such as Zoroastrian, Jewish, Islamic, Christian, etc. Indeed, its urban fabric, its walls and architecture have gone through *a straight line of evolution during centuries without ever being ruined by the introduction of alien or awkward elements* (UNESCO, 2004). In fact, the original functions and architectural elements of Bam Citadel certainly can be a veritable encyclopedia of Iranian traditional cities. It contains all typical spaces of an ancient Persian city, including residential buildings, passageways, mosques and other religious centers, schools, public bath, gymnasium, caravanserai, bazzar, coffee-house, barracks and administrative offices.

As already reviewed about the origin and history of Bam city, Bam Citadel almost started to be inhabited since Achaemenian period (550-330 BC)[95] but originally had been founded during the Sassanid period (224-637 AD), while ruins traced that most of the structures were built during the Safavid period (1502-1722 AD). The Citadel was inhabited until the late of 19th century,[96] and continued to be used as a military garrison until 1932, and following that gradually turned to ruins.

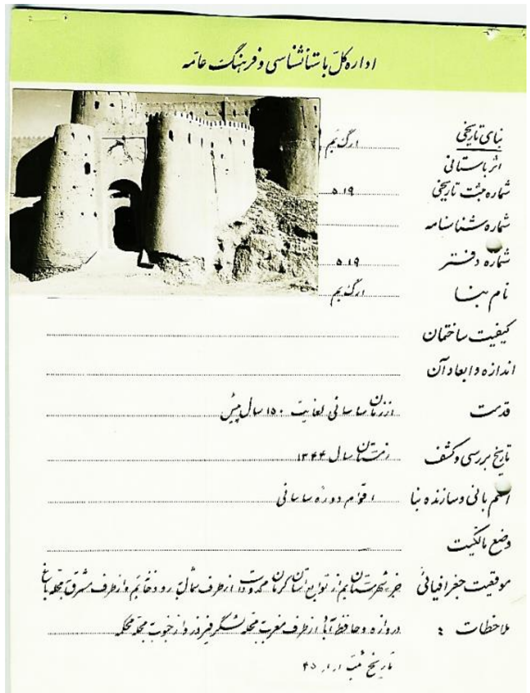
This magnificent Citadel before the 2003 earthquake was considered to be the largest existing adobe-mud brick complex in the world. However, the Citadel of Bam was registered on the Iranian national monument list (No. 519) in 1966 AD and UNESCO listed it as a part of United Nations World Heritage Site as the "Bam and its Cultural Landscape" in 2004 AD. All structures in Bam Citadel are entirely composed of unfired mud bricks, clay, straw and the trunks of palm trees. Meanwhile, there are two distinct types of traditional construction techniques; the first one is a method for construction of walls by overlying mud layers, known in Farsi as "*Chine*", whereas the second one consists of joining flat square mud bricks by mud mortar, known as "*khesht*".

As explained by the Khosro Khosravi in Iranian Cultural Heritage Organization Document Center's (ICHODC) website about Bam Citadel, "The ancient city of Bam has the characteristics of Iranian cities, especially the cities of Khorasan province during the Islamic

[95] "[…] it seems that Bam probably had originally during the Seleucid or the Parthian periods a square plan like the one in Herat: a square walled town in the south dominated by a fortress outside its wall in the north (in Harat the fort being the Kohan-Dezh which is also on the north side of the town outside its wall and of town outside its wall and not the Qal'eh-ye Ekhtiyar-od Din, which is also the north of the city, but inside its walls)." (Adle, 2009).

[96] By providing more security in the region, the people slowly started to move into surrounding area, which now is known as the new city of Bam.

period, and consisted of Qal’a or Arg (Hakem-neshin) included of storage and prison, the main part of the city (so-called Shahrestan) and around it (Suburbs) which were separated by the ramparts.” Khosravi also added that, “*Today, sometimes mistakenly the whole Bam Citadel is called Arg*”[97].



اداره کل باستانشناسی و فرهنگ عامه

بنای تاریخی	ارگ بم
اثر باستانی	
شماره ثبت تاریخی	۵۱۹
شماره شناسنامه	
شماره دفتر	۵۱۹
نام بنا	ارگ بم
کیفیت ساختمان	
اندازه و ابعاد آن	
قدمت	
تاریخ بررسی و کشف	
اسم بانی و سازنده بنا	
وضع مالکیت	
موقعیت جغرافیائی	
ملاحظات :	

Figure 2.1- Original letter of the inscription of Bam Citadel in Iranian national monument list (No. 519) on the March 21, 1956 (Source: archive of ICHHTO).

Gaube (1979) also about the overall configuration of Bam Citadel mentioned to its three sections that forming the main body of Bam Citadel, “The inner city, the madina, is dominated a famous citadel. A wall with four gates protected the madina. The four gates were oriented towards the points of the compass. A rabad lay outside the madina, and palm grows lined the whole settlement” (Gaube, 1979, p.112).[98]

From plan point of view of Bam Citadel, Gangler et al. (2004) pointed out that, “In the plan of the present circumvallated old city (see Figure 2. 2) a rather regular network of streets, oriented north south and east west, becomes apparent, and different stages of growth can be isolated. The original mandina had a square shape, the citadel lying in the north within the city wall. Later, the city was extended to the east, and even much later a second extension was added in the north-west. Thus, medieval Bam had a square shape, a citadel at the edge of the madina,

[97] Khosravi, Kh. “*Madkha-e Bam*”, Iranian Cultural Heritage Organization Document Center (ICHODC), (cited in Persian). Retrieved from http://www.ichodoc.ir/argebam/about.htm
[98] Gaube, H. (1979). *Iranian cities*. Hagop Kevokiat Series on Near Eastern Art and Civilization, Vol. 2. University Press, New York, pp. 99-132.

and four gates, which most probably were in the middle of each side and were connected by a regular system of streets. Bam seems to be the western example of what we call-eastern “Iranian Cities”.[99]

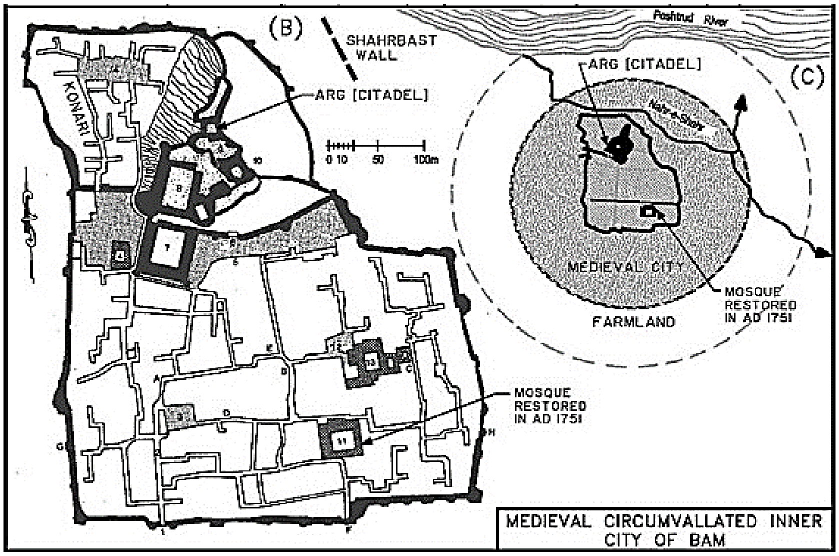


Figure 2.2- (Left) medieval circumvallated inner city of Bam (Source: Berberian, 2005), now the whole of ancient city of Bam is named as Arg.

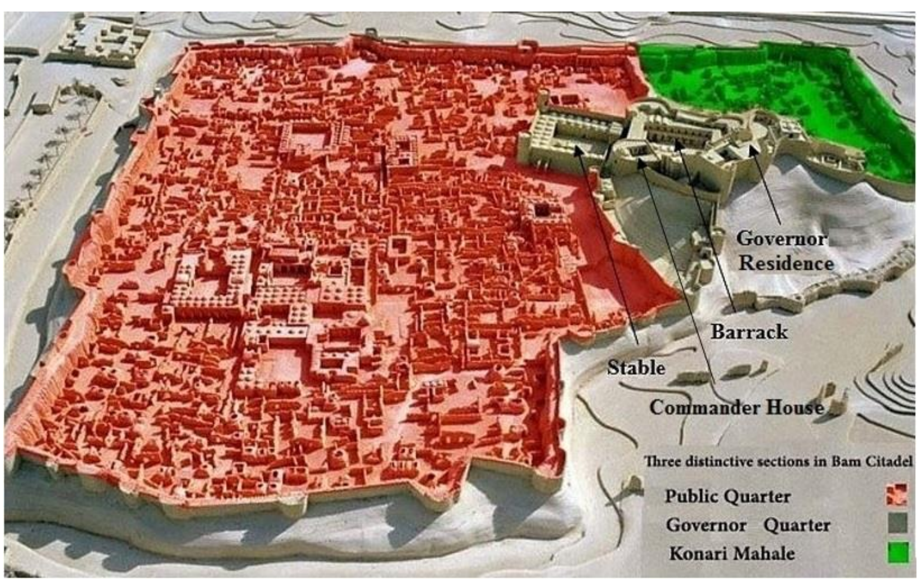


Figure 2.3- Three fortified quarters of Bam Citadel (Designed by Author).

[99] Gangler, D.A., Heinz Gaube, H., Petruccioli, A. (2004). Bukhara, the Eastern Dome of Islam: Urban Development, Urban Space, architecture and population. Menges, A (ed.), Bild & Text Joachim Baun. Fellbanch, Druckaus Munster GmbH Kornwestheim, pp. 33-34.

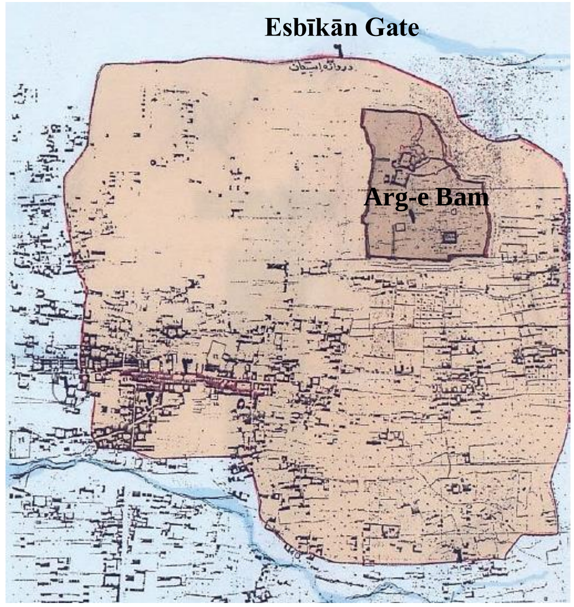


Figure 2.4-. Ancient plan Bam distinguishes the trend of the outer walls (Share-bast), those of the inner walls (today Arg-e Bam) the northern sector and the rocky mound of the Citadel with governmental structures (Source: personal archive of Prof. Tayari 2006).[100]

Adle (2009), who performed vast archeological studies on Bam region, more especially Bam Citadel, accurately about the origin Bam Citadel's plan and its development during history explained that, "Indeed the plan adopted in Bam seems to be a Central Asiatic one, a cultural sphere with which the present eastern Iran often shared the same features. The "town" in the Citadel, which does not include the upper fort in the north, is rectangular versus circular or irregular; yet, towns built on circular plans existed in the neighbouring province of Fars and beyond. Their example was not followed, perhaps because they were postdating Bam. These were the royal Sassanian cities of Firuzabad (3rd cent. A.D., before 224 A.D) and Ctesiphon, the Capital city of the empire Firuzabad, or more precisely Ardashir Khorrah "Ardashir's Glory", was founded by that emperor who was also the one who established the Sassanid dynasty and whose name is mingled with the mythical history of Bam together with Haftvad. Later in the 8th century, Firuzabad inspired the circular plan of the nearby town of Darabgerd, while Ctesiphon gave birth to the "Round City" of the Caliph AL-Mansur (i.e. Baghdad) founded in 141/755."[101]

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[100] As can be seen in this photo, Espikan gate is located in western area of northern rampart of Shahre-bast near to north-west Bam Citadel, and Espikan Gate and the eastern rampart of this gate along to west should be considered as a continues of Bam Citadel. It is noteworthy that in 1993, in the south-west of Esbīkān Gate and inner area of western rampart of Bam Citadel, the two-storey 'Pakhshab' of Bam Citadel was found, and through which the water supply system into the Bam Citadel was identified (Mehriar, 2004).
[101] Adle, C., CNRS., ESKEM., DAFA. (2009). *Qanat of Bam: An Archeological Prespective*. In *Qanats of Bam, A Multidisciplinary Approach*. In: Honari, M., Salamat, A., Salih, A., Sutton., J., Taniguchi., J (ed.), UNESCO Tehran Cluster, pp. 33-85.

Adle also added that, “The rectangular plan of Bam is likely to stem or probably has the same origins as the rectangular form of what is known as Greek/Hellenistic-inspired form in Central Asia. As its original plan seems to have been square, then Indian influences cannot be totally ruled out either, but more tangible and well-known examples of such plan are represented in Herat (ancient Alexandria in Aria), or in Merv (Alexandria in Margiana) which were both founded by Alexander (4th cent. B.C.). If the general plan of the Citadel is looked at with attention, which seems never to have been the case, it becomes if not self-evident but at least clear enough that the present eastern section of the “town” in the Citadel and its walls are in fact an addition to the original plan.” […] “As it might be expected, the equivalent of this extension of the “town” in the Citadel towards the East seems to have submitted to the same principle too. Its length seems to be roughly equivalent to half of the original length of the southern wall of the Citadel, while the extension on the South-North direction appears to be about twice that distance. At the present stage of my investigation and as I do not yet have my photogrammetric drawings, it is hard to be more precise, but it seems that the architects have submitted the extension to the constraints ruling a “Golden Rectangle”. In this case the extension has been determined by putting one tip of a pair of compasses on the SW tower of the Citadel and the other on the tip of the south-eastern rock of the Citadel’s mound in order to trace an arc starting from that point and ending on its intersection with the extension towards the East of the southern wall of the Citadel. In either case, 1/3-2/3 division or more probably the Golden Rule application, the outcome is nearly the same and shows that the extension is probably the consequence of the existence of a square original plan with a fort on a mound on its northern side. The square plan explains not only the presence of the hook next to the tower, but also in a way the existence of the Big Tower on the western Wall as well as the presence of the Southern Gate in their odd places where they stand now: the South Entrance is not, as it might be expected, in the middle of the present southern Wall of the Citadel, but is placed on its western side, and the Big Tower is to be found not in the middle of western wall, but on its southern part. In fact, the Big Tower of the western wall occupies more or less the middle of the original square plan and the Southern Gate roughly the middle of its southern wall.”[102]

From another point of view, Mehdi-Pour (2010) has dedicated a poetic analysis on the Citadel of Bam, and speculates the influences of Zoroastrianism cosmologies on Bam Citadel’s urban morphology. As the result of Mehdi-Pour studies, the origin of Bam Citadel because of all the conceptual and architectural elements of the “*Anahita*”[103] temple was identified as a background of Zoroaster philosophy. The reasons of Mehdi-Pour (2010) for this assentation is that,

[102] Ibid.

[103] In Zoroastrian cosmology, Anahita, the goddess of water, is the representative of the light of Ahura Mazda in Getik (the terrestrial world). She received an order from Ahura Mazda to build a temple on the top of Hurikaa Mountains to worship the holy fire. Therefore, the first Zoroastrian temples were dedicated to Anahita and housed an internal flame, the symbol of divine wisdom. Accordingly, the temple was the sacred space where a person could receive the ultimate divine light. Anahita then became associated with the concept of light (Mehdi-Pour, 2004).

“Zoroastrian cosmology conceptualized cities to be built on the north-south axis and to be divided into three sections, including common people, military and clergy.”[…] “The Citadel was generally divided into three sections and each section was separated by the city’s continuous inner walls. The arrangement of spaces within the citadel is based on a particular hierarchical order suited for three different classes of society, called the Sharistan (common area), the Quarkhaneh (military section); and the Arg (castle) and the Chaharfasl (seat of governor), which belonged to the royal family and clergy. The castle, the major landmark of the citadel, was located on the north-south axis.”[104]

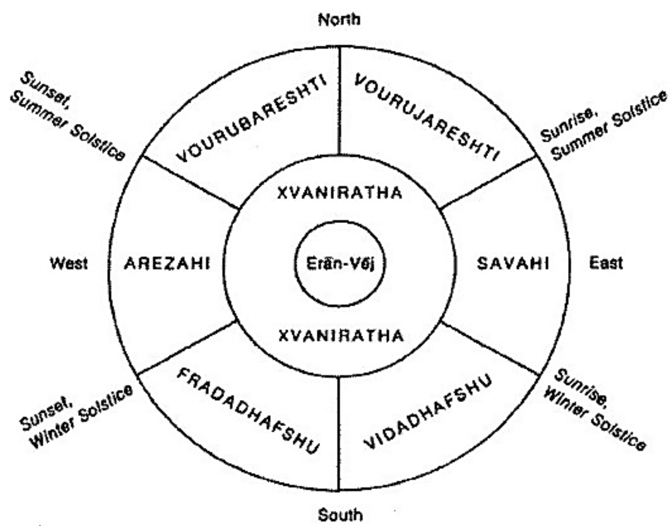

Figure 2.5- Division of seven mythic Keshvars (Source: Mehdi-Pour, 2004).

Similar to what was argued with Mehdi-Pour (2010), in his book “*Arg-e Bam*”, Nourbakhsh (1974) referred that in Bam Citadel there is probably a resemblance between architectural elements of its Governor’s District with Firuzabad temple, which was built by Ardashir (founder of the Sassanid dynasty) close to the city of Bam. Similar elements are as follow (Bam3DCG):

- The Fire tower, (watch tower of the Citadel);
- Four Vaults (Chartaghi) for holding fire (Atashgah), (Four seasons or Chahar Fasl building of the Citadel);
- Water resources, like a spring or a water well, which was dug inside a rock because ancient Persians believed that Nahid or the Water Goddess was born from stone, (deep water well in the Governor’s District of the Citadel).

[104] Mehdi-Pour. (2010), Interpretive Narrative as Manifestation of a Historic Setting-Case Study: The Historic City of Bam in Iran. (The Master thesis of Architecture, the Faculty of Graduate Studies and Research in partial fulfillment of the requirements, Carleton University, Ottawa, Canada). Retervied from https://curve.carleton.ca/01c375f0-1f5b-4549-9400-7df8b005f195

As discussed before, the main areas of Bam Citadel as an ensemble is divided into three different fortified quarters: Governor Quarter (arg or ark or hisn) , Public or Residential Quarter (sahrestan or madina or qal'a) and Konari Mahale (rabad or suburb) (see Figure 2.3).

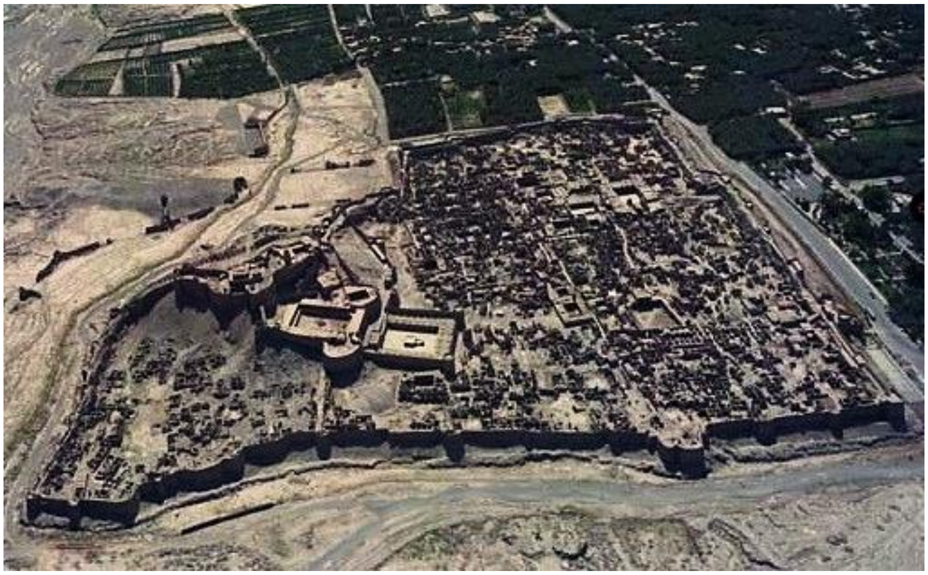

Figure 2.6- Aerial photo from Bam Citadel before the 2003 Bam earthquake (Source: archive of ICHHTO).

In urban development of Bam Citadel each additional parts is extended into the existing parts over time passed. Through design and architecture of the Citadel, it can be realized that what genius thought was behind the installation of its different parts within an assembly.[105] In the past, decisions about the development of the city, were usually made by the local rulers; they concerned the birth, growth, and revitalization of the city and would include the location of primary mosque, the distribution of the land in the projected boundaries of the city to various ethnic, familial, or tribal affiliations and the location and configuration of the city's gates and walls (Hakim, 2008).

In Bam Citadel, a particular importance was attached to the defensive capability of the city's gates and surrounding wall to protect the city from possible onslaughts. Bam Citadel consisted of a moat with 10-15 meters wide and 1.4 meters depth around the city walls,[106] the moat of Bam Citadel along south Main Entrance gate consisted of a drawbridge that span the moat, and

[105] The southern areas of the altitude of rocky mountain of Bam Citadel is surrounded by four ramparts, which the direction of each of which is related to the expansion of the Hakem-neshin in different historical periods (Mehriar, 2004).
[106] When the Citadel of Bam was under siege, the defenders had to fill the moat with water. Once during the Saljuq period, the inhabitants of Bam brought water from as far away as twenty *farsang*s (ca. 120 kms) to fill the moat, but this precipitated the ruin of the *rabaż* and the city wall (Ḵabīṣī, p. 103).

the moat along with gigantic walls of 6-7 meters height and 1.815 meters length, which consists of 38 main watchtowers in every 30-40 meters with 6-18 meters height.[107] To enter the Citadel, there were four gates, consisting of the Kot-e Kerm[108], Šāhnešīn, Qūrk̲āna, and Ḡolām-k̲āna gates, the names of which go back to Qajar times (UNESCO, 2004).[109] The significant changes and more recent urban development of the Citadel of Bam took place in the "*Public*" or "*Residential Quarter*", where the inhabitants lived in for more than two thousand years. The Public Quarter of Bam Citadel is located at the foot of the citadel, in the southern part of the city. Here based on structural evidences, we can precisely understand the transformations of an Iranian ancient city at different courses of the history. There was practically nothing regular about the internal planning of the city. To a certain extent, the main streets, which ran from one gate to another, determined the city's plan; more specially, the streets did not run in straight lines and there were sharp bends. Generally, the access to different parts of the Pubic Quarter was possible with two different types of street networks following quasi-winding and narrow lanes and twisting alleys:[110] 1) no roofed street, which were considered as pubic passage ways and had to be at least wide enough for a packed animal to pass; 2) the private roofed street, which were normally built in streets that ended to the houses of the wealthy families, like Sābāt-e Johudhā.

The Public Quarter comprises the main entrance gate of the entire fortified city and the bazaar alongside the main passageway from the first gate to the second gate at north-south spinal axis, and some 400 houses with their essential public facilities that were common in the urban fabric of Iranian historical cities. Based on social order of the society, the houses in residential quarter of Bam Citadel were differ from each other:

- Small houses with 2-3 rooms without any additional structural elements for the low-income families;
- Medium-sized houses with 3-4 rooms and courtyard surrounded with iwans for the middle class families;
- Luxury houses with one or two courtyards[111]; in some houses there were two or three kitchens with guests and servants' sections, air conditioning system, private stable and

[107] Meanwhile, there were two large towers within interior fence that known as "*Stay-Awake Towers*" or "*Bidar-Bash Towers*", which also include the dais. The sum of the towers in the city wall of the Arg-e Bam is 49 ones.
[108] Above the Citadel is a place still famous as "*Kot-e Kerm*"; *Kot* in local parlance means "*hole or refuge*", and *Kerm* means "*worm*".
[109] In the time of invasions, all gates were closed and no one could enter. The people might have stayed in the citadel for a long period of time while the soldiers defended them.
[110] The system of narrow alleys with tall walls gives a better airflow and makes a part of the street in the shade.
[111] Each courtyard has different functions in different seasons, one for hot seasons and another for cold seasons.

room with beautiful stucco and lattice windows for aristocrats and the wealthy families.[112] All of these houses with one, two or occasionally three stories in height were connected and even interconnected, but they had separated individual spaces.

Although the Second Gate embedded on the north fence of Mardom-neshin conduct to Mardom-neshin, among the fortifications of other parts of Hakem-neshin this gate connect all of them (Mehriar, 2004). The Governor Quarter of Bam Citadel within a fortified area consisted of four main parts including of Stable, Barrack, Commander House and Governor Residence, see Figure 2.3.[113] In addition, the north fortification of Bam Citadel located at a little distance with Poshte-Rud River, where the fortification of the wall of 'Shahre Bast' is erected. Therefore, it is appropriate that the space between the two northern ramparts of Bam Citadel can be considered as a part of military areas, which is connected to the Citadel (Mehriar, 2004).

In the north-west corner of the Bam Citadel at the foot of the city, within its own enclosure wall with an area of about 175 square meters is situated the "*Konāri Mahale*",[114] whose real function has not been realized until now, and more information in this regards needs more archaeological investigation. As regards to available photos and by doing a comparison between buildings located in the Konāri Mahale with other parts of Bam Citadel, it is understandable that its buildings were more affected by erosion. Little attention to this quarter and its separating from public quarter reveals that the existing buildings did not belong to very rich people. However, whatever the situation, the houses of this section obviously belonged to the lower rank of society and were separated from the rest of *Sharistan*.[115] In this case, there are some hypotheses about the function of the Konāri Mahale: Some believe that this part of the city is probably added to the walls of the present day Citadel, according to Nourbakhsh (1978), "this type of house is not a typical Iranian house, even in the seventeenth century."[116] According to Author's interview with Dr. Tayari and Mr. Tohidi, there is other assumptions, once is that this enclosure belonged either to peasants or to a religious sector, and another is that this part might was a prison or a place for the captives.

[112] There are few of this type of houses in the Arg-e Bam.
[113] In Chapter four, each part of Governor Quarter is explained in detail.
[114] "*Mahale*" in English is translated as "*neighborhood*", the name of "*Konari Mahale*" is driven from two *Konar tree (Lotus)* that were located in this district (Tohidi, p.42, 2014).
[115] Gaube Heinz, Iranian cities, p. 119.
[116] Nourbakhsh, H. (1978). *Arg-e Bam*. Kerman: Markaz-e Kerman Shanasi, p. 127.

2.2 The Impact of Environmental and Cultural Factors on Architectural Typology of Bam Citadel

The glory of Persian architecture is the result of development from various civilizations through a straight line of evolution over centuries. The history of this architecture is the story of a notable culture with thousands of years of practice of traditional art and science. However, Persian architecture beyond the evident typology is formed through a conceptual framework, which has a great deal of importance to show an ideal climate-responsive design. The physical features of Iranian traditional houses reflect natural, cultural needs and the occupant's requirements (Nabavi et al., 2013). In fact, the evolution of Persian architecture is a consequence of experience-based knowledge, which Iranian have acquired through trial and error over time. Specifically, in the hot and arid regions of Iran, vernacular architecture has frequently intimated the formation of cities and the architectural combinations. The ancient city of Bam by itself is a field, the origin of which can be considered as one of the first foci for the organization of civilization in the hot and arid environment of Iran throughout history, where the traces of architecture have had organized the spaces in such a way that to act as a medium to emphasize the relevance of human lifestyle.

Bam Citadel is the leading example of an indigenous architecture that expresses the common historical and cultural roots of ancient peoples spread over a vast region of the world well before modern geo-political boundaries were drawn (EMAP Architecture, 2004).[117] This medieval town as the outstanding example of Iranian national heritage and the largest extant adobe-mud brick complex in the world is particularly notable for the longevity of its use, which has kept its traditional architecture and urban fabric in Iranian desert environment not only up to the day they were severely damaged by the 2003 Bam earthquake, but even now (Rouhi et al., 2017a). In Bam Citadel, the architectural domains, which are impressed by natural and cultural forces, can exactly represent themselves as a preface to declare the identity of a small society in the desert environment of Iran. From the beginning, all architectural and vernacular forms in Bam Citadel have been used to improve the quality of living. At the same time, any kind of cultural and social transformations have also been followed by architects, so they rapidly adjusted the new cultural values within architectural design (Rouhi, 2016a). Based on the available evidences and ruins remained from traditional architecture of Bam Citadel, more than a few architectonic elements with those illustrating various strategies have been developed with major cultural and natural potentials. In spite of the review on such traditional experiences, not only we are able to address various thoughts that merged in Persian traditional architecture, but also

[117] EMAP Architecture. (2004). "*View from Bam: one of the finest and most ancient mud cities in the world*". Posted in Free Library by FARLEX. Retrieved from http://www.thefreelibrary.com/View+from+Bam%3A+one+of+the+finest+and+most+ancient+mud+cities+in+the...-a0114062044

we can find out many mysterious techniques that Persian architects utilized to create meaningful spaces.

Generally, this part attempts to show the strengths of Persian architecture in assimilation of forms, spaces and elements in such a way that a correlation is created between dominant parameters and a comfortable atmosphere is provided for its residents. Traditional residential buildings in Persian architecture have been designed based on culture, religion, tradition and an ideal harmony with the climate of each region and lifestyle. However, to better survey about the architectural typology of Bam Citadel, this part firstly classifies the effects of natural factors on climate-compatible architectural design of buildings within Bam Citadel, and secondly surveys about the effects of cultural criteria in its architectural typologies. This section along with photographs and drawings found is intended to give the reader a better knowledge of the common architectural terms used for many monuments found in Bam Citadel. These details express various tastes, time periods, and the materials that were available when a building was constructed. In fact, by such a way it is possible to get a complete resource about the norm of Persian architecture in one of the most important historical sites of Iran, in which the consciousness of the creators have contributed to the evolution of the sustainable architecture in hot and arid climate of Iran.

- The Influence of Environment on Architectural Typology

Iran is one of the unique countries in the world with different climates in different regions. This environmental characteristic promoted Iranian traditional architectures to use efficient natural climatic designs in order to cope with the difficulties of influential weather conditions. In Iran, the hot and arid region encompasses the majority of the central Iranian plateau, where lower levels of humidity and the lack of clouds result in extreme temperature fluctuations during both day and night (Iranmanesh & Bigdeli, 2009). The main problem in this weather condition is the very fierce sunlight. To combat with sun and to delay the heat, permanent residents have used buildings with big thermal mass. It takes a long time for the heavy adobe walls to get warm during hot days, and maintain the heat during cold nights. There is a lot of shading and ventilation that captures favorable winds. The openings are limited and covered to deter direct light. The inner courtyards as an important part of Iranian house in hot and dry climate, which are shaded and opened to the sky, these spaces through their pools and plants serve as a cooling system, because of water and vegetation properties of decreasing temperature by evaporation.

One of the fundamental beliefs of the Iranians that inspired from Zoroastrian religion lied in the sanctity of the four elements of nature (i.e. water, wind, earth and fire). This concept is certainly a reason that nature is manifested in Persian traditional architecture. Iran is one of the unique countries in world which has a variety of climates in different areas. As a result, this environmental characteristic motivated Iranian regional architects to use efficient climatic responsive design strategies in order to cope with the difficulties of each weather condition. In Persian architecture, environmental adaptability has played a major role in building design, as far as Iranian architects initiated to utilize different construction methods and building systems to adapt their lifestyle with surrounding environments. In this case, they also obtained valuable experiences in the field of architectural designs, construction techniques and selection of suitable local materials. It should also be noted that although climate, geographic location and availability of materials have a great deal of importance in Persian traditional architecture, the selected materials would withstand against applied loads, climate changes, extreme heat and cold, rainfall and snowfall.

In his report 'Comparative Plan of Kerman Cultural Historical Axis', Moradi (2002) has considered nine principles in the formation of Kerman traditional architecture, which can be generalized to the city of Bam as a city of Kerman Province. These include (1) reflection of the heat of the sun; (2) proper directions of buildings; (3) prevention of penetration of very hot and cold weather; (4) protection of people in the complex; (5) providing desirable and cool weather; (6) making use of evaporative cooling; (7) creation of desirable weather in the yard;(8) optimum use of sun's heat; and (9) keeping the room cool in summer and warm in winter. In order to meet the aforementioned principles, Bam's local architects achieved an ideal climate-responsive design as a consequence of experience-based knowledge, which they have acquired through trial and error over time, some of which are investigated below.

- **Material**

A city in a desert climate is basically vulnerable to desert expansion and desertification and also to the harsh climate of the desert. This phenomenon prompted designers and architects to use natural climatic approaches in order to adapt to these harsh conditions (Taleghani et al, 2010). Since in desert environment of Iran there is a limited selection to find a proper construction material, this phenomenon prompted Iranian vernacular architects to use clay in the form of adobe-mud brick as their main construction material, which is locally available throughout the central Iranian plateau. As Pope (1965) noted, "Available building materials dictate major form in traditional Iranian architecture. Heavy clays, readily available at various places throughout the plateau, have encouraged the development of the most primitive of all building techniques, molded mud, compressed as solidly as possible, which allows them to dry quickly. This technique, used in Iran from ancient times, has never been completely abandoned. The abundance of heavy plastic earth, in conjunction with a tenacious lime mortar, also facilitated the development and use of brick."[118]

Adobe-mud brick structures serve as a significant heat reservoir due to the thermal properties inherent in the massive walls and roofs. In climates typified by extreme temperature fluctuations during both day and night, the high thermal mass of adobe mediates the temperature of the

[118] Pope, A.U. (1965). *Persian Architecture*. New York (N.Y): George Braziller, p. 9.

living spaces. After sunset, when the temperature drops rapidly, the body of massive adobe-mud brick structures will continue to transfer heat to the interior spaces of the house for several hours due to the time-lag effect. Furthermore, this construction material is recognized as one of the sustainable construction materials, meaning that they have little impact on the surrounding environment. Their “embodied costs,” which means the cost to individuals and society overall in its creation, storage, distribution, use and maintenance are very low (Austin & Holmes, 2006). In addition, the construction practice of adobe structure is naturally simple and does not require any special energy resources. Skilled technicians (engineers and architects) are generally not involved in this type of construction, hence the term ‘non-engineered construction’ and ‘informal construction’ (Figure 2.7) have also been used to refer to such constructions (Blondet et al., 2011).

Figure 2.7- Adobe-mud brick production at Bam Citadel’s workshop (Photo by Rouhi, 2015).

- **The Height of Buildings**

Since the best building shape is the one that allows minimum heat transfer between inside and outside of the building, changes in building height can also be considered as one of the main factors to control the shadow inside of the building; when height increase in one direction, where it is under the sun, the inner part behind it can enjoy its shade. Furthermore, since the sun radiation on the horizontal surfaces is stronger than that on the vertical surfaces, in the buildings of Bam Citadel wherever it was possible, the walls around the roof were built higher to reduce the direct effects of sunrays on roofs. The best example of this construction strategy could be seen in the Stable of Bam Citadel, where the traditional architectures tried to increase the height of its enclosure walls to control the sunrays in the ceilings of the Stable. In addition, the buildings and courtyards in the Citadel were built under the street level (between almost 30 cm to 50 cm), whereby the fluctuations of temperatures and heat transfer between inside and outside of the buildings were to be reduced.

- **The Buildings' Orientation**

The topography is a critical parameter that determines the architecture of buildings in the hot and arid climatic zone of Iran. However, the buildings' orientation is important to maximize room's usage, staying away from sand storm and receiving the proper daylight during the summer and winter. In Bam, traditional residential houses are almost oriented in two distinct directions. Owing to the characteristics of the sun (in all seasons) and wind (during the hot seasons), in this region, the North-South and West-East are suitable positions for buildings' orientation in order to provide a comfortable living place for the residents throughout the year even under severely undesirable weather condition.

- **The Buildings' Plan**

Iranian traditional architecture in hot and arid climate is generally based on a symmetrical layout and four-sided design towards the four geographical directions (north, south, east and west) to reduce the absorption of sun's radiation in harsh weather conditions. While the absorption of sun radiation increases in one direction, the occupants could change their room according to the usage for daily activities. Most of the houses in Bam Citadel are formed along an orientation, which is near the orientation of north to south. This specification allows the houses to be divided into two parts, a part in the north and the other in the south of the house, which is typically called "a house for four seasons". During the cold seasons in these houses, the residents live in spaces located in the northern part of the yard which face the south direction and receive more sunray and heat (the 'Winter Part' or 'Zemestan-Neshin'). During the warm seasons, the residents move to the opposite spaces located in southern part of the yard which face the north direction which are shady and receive less sunray (the 'Summer Part' or 'Tabestan-Neshin'). This seasonal movement occurring between spaces in the house is one example of human responses to climate condition (Memarian & Sadoughi, 2011).

- **Courtyard**

In Iran, courtyard houses are the most prominent types of houses (Moradi & Akhtarkavan, 2008). In Bam Citadel, almost all traditional houses are known to have a courtyard. These kinds of houses are a sample of an environmentally responsive building form in hot and arid regions of Iran. The courtyard as the heart of the house in the spatial, social and environmental context fulfills several functions for the residents and its users in hot and arid regions. This part with its inherent features in a rectangular plot can provide security, privacy and comfort within the house. The central courtyard, consisting of a little pond and a garden with trees, shrubs and flowers not only links different areas of the house inside a beautiful space but also increases the relative humidity, natural lighting and ventilation (see Figure 2.8). The humidity provided by the water and the plants as well as the shade provided by high walls, can increase the relative humidity of the air and cool the air in order to create a microclimate in the middle of the house (Karimi & Hosseini, 2012). Moreover, when the heat capacity of air is very low the courtyard very soon adapts the temperature of surrounding environment (Azami et al., 2005). Around the courtyard, there are rooms and spaces of the house which open to the central courtyard. In this way, the courtyard also functions as a space that connects the different parts of the house. In Bam Citadel, based on the economic situation and social level of the household and the size of the buildings the courtyards varied from one to even up to three.

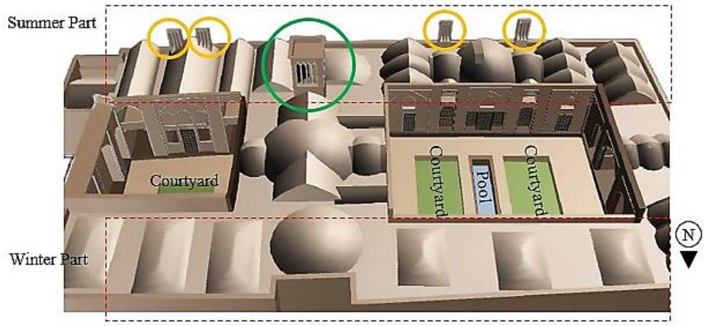

Figure 2.8- Different parts of Sistani's House in Plan (Source: archive of Bam3DCG, designed by Author).

- **Iwans**

Iwans were a trademark of the Sassanid architecture of Persia (224-651 AD), which later found their way into the Arab and Islamic architecture and started developing in the 7th century AD ('Dictionary of Islamic architecture: Ivvan'). An iwan is defined as a rectangular hall or space, usually vaulted, walled on three sides, with one end directly opening to the central courtyard. The design objective of an iwan or semi-open areas is to provide shade and cool places of living during the day (Pirnia, 2005b). In Bam Citadel, iwans were a usual architectural element in mosques, madrasas, caravanserais and houses of wealthy people, and they were more elaborately decorated with chalk trim and muqarnas. Moreover, here iwans were usually oriented to the north, south and west directions, where they always provided shady spots during the sweltering heat of the summer afternoons.

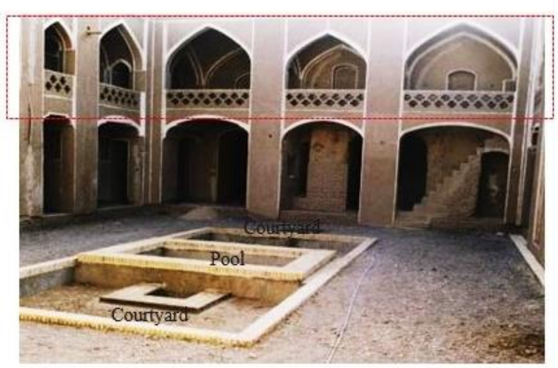

Figure 2.9- Iwans in the West Sabat House of Bam Citadel (Source: archive of ICHHTO, before the 2003 Bam earthquake).

- **Curved Roof**

The best form of architecture is the one that loses the least volume of heat during winter and absorbs the greatest volume of coldness during summer. Apart from thermal mass (delay in heat transfer) and thermal resistance of adobe structures, the curved roof as a passive cooling system provides further advantages to create a thermal equilibrium inside the house in a desert environment. From a geometric point of view, due to having convex and unbalanced surface, the impact of the angle of the sunray on curved roof is different from one point to another, and a part of it always remains in the shade during the day. Meanwhile, the external surface area of a curved roof is larger than its internal surface area so that at the time of heat transfer a lower rate of heat will be attracted by the internal surface.

As a consequence of the advantages of curved roofs, a domed roof is always exposed to winds blown in different directions, which is why if an air vent is present at the apex of a domed or cylindrical roof, it takes the favorable wind and conducts airflows from outside into the main rooms (see Figure 2.10 (right)). Furthermore, from pre-historic time, the ceiling light, provided by air vents, is known as an effective tool to sum up a lot of lights for interior space of buildings. Rotation of sunlight from the ceiling light as a channel with circular section where air particles in a thin line is visible gives special glory to the whole area of the buildings. In Bam Citadel, even in streets for providing shadow, there were interlinked arches between two walls of the allays called “Sabat” to make the high temperature of the city tolerable, like “Sābāt-e Johudhā”. In hot and arid areas of Iran, Sabats usually covers Bazzar.

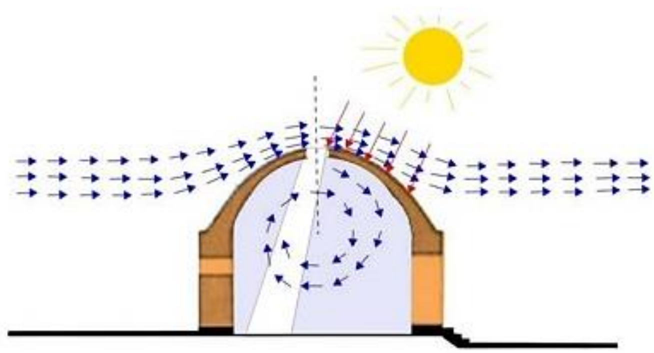

Figure 2.10- (Left) roofed allay in Sābāt-e Johudhā (Photo by Ysuda, 2001. Source: archive of Bam3DCG); and (Right) the effects of sun and wind on curved adobe roofs, which are exposed to minimum sunbeam and maximum wind breeze (Designed by Author).

- **Wind Tower**

In hot and arid areas of Iran, traditional architects had to rely on natural ventilation to dispose from the agonizing heat of this weather condition and to keep the internal space of the buildings more pleasant and livable. A wind tower is a centuries-old Persian architectural element that takes advantage of natural ventilation in buildings. This traditional Persian-influenced architecture has been used for centuries in many countries of hot and arid, and hot and humid climates, particularly throughout the Middle East. Evidence about the commander's house of Bam Citadel consisting of three adjacent wind towers, each in different directions, reveals that the existence of wind towers in Bam region belonged to the pre-Islamic era. A typical wind tower consists of a tower with vertical wings at the top of the roof, which its arteries are opened in the direction of desirable winds and closed in the direction of undesirable winds and sandstorm. The function of a wind tower is that its vertical wings conduct cold air within the rooms while leading out the hot and pollutant air from inside the building (see Figure 2.11). According to the directions of the favorable winds, wind towers were constructed in various designs: uni-directional, bi-directional and multi-directional. In uni-directional wind tower, the crest of wind tower is towards the pleasant breeze. Since in Bam Citadel, the direction of wind is usually from north and north-west, this type of wind tower was usually more common. In bi-directional wind tower, the differential pressure on one side causes immediate removal of hot and pollutant air from the other sides. The function of this wind tower is partly more accurate and ideal than uni-directional wind tower. In this method, one side of the wind tower faces away from the direction of the prevailing winds and draws down fresh breeze inside the house, while the other sides draws up the hot air. In multi- directional wind tower, the arteries of wind towers could drag the winds from any directions. They are larger than other types and are built in four or eight directions.

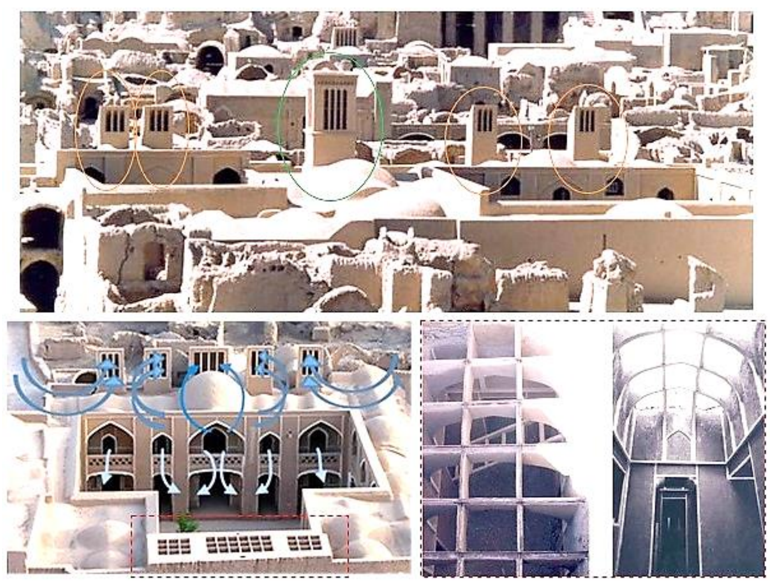

Figure 2.11- (Top) wind towers in Sistani's House of Bam Citadel (Source: archive of RPBCH, before the 2003 Bam earthquake); and (Down) the function of wind towers in the Jewish House, and the internal space of wind tower in northern side of Jewish House from inside and outside (Source: archive of RPBCH, before the 2003 Bam earthquake, designed by Author).

- **Windows and Doors**

The heat absorbed from windows and doors could be minimized by their installation in exact location, their shape and the way they opened. In Bam Citadel, there were few windows, where most of them faced to the south and located at top of the walls to prevent the heat absorption from the ground. These windows and doors were usually small and sometimes covered by net-like wooden or brick covers.

Figure 2.12- Samples of windows in Bam Citadel designed with net-like wooden and brick covers (Photos by Rouhi, 2015).

- **Downpipe**

In every structure, whether ancient or new, the first thing that must be considered is conductivity of non-conditioned water like rainfall. In adobe-mud structures, water is known as one of the main causes of deterioration and destruction. In order to prevent accumulation of rainfall in a corner of a building, some downpipes were embedded in different parts of the adobe wall to conduct water to outer side. It should be noted that the length of downpipe is very important in the time of its design since the collected water in the foot of the adobe wall might cause damages.

Figure 2.13- Downpipes on the ceilings of Bazaar of Bam Citadel (Photo by Rouhi, 2015).

- **Heater**

From the caveman era up to now, fire has had an important role in human's life. At first, it was in the form of hole in the ground at the center of a place where they lived. Over time, with the development of civilization, people placed heater inside of the walls. In different parts of Iran, regardless of the type of materials, virtually heaters have the same shape with different materials. In Bam Citadel, the heaters were embedded in the walls. Bam's architects usually followed the conventional architectural styles of their own time for decoration of heaters. There, heaters in both public and governor's district were built of adobe-mud brick and their decoration were usually with chalk trim or brick bumps on the surface of the adobe walls. Meanwhile, there was an architectural compliance between decoration and design of heater with other parts of the rooms like roofs and niches.

Figure 2.14- Samples of architectural form of heaters in the Stable of Bam Citadel (Photo by Rouhi, 2015).

- The Influence of Culture on Architecture

Architecture and culture are two relevant issues that introduce the identity of a society. The architecture domain can determine any civilization and represent itself as an introduction to declare the cultural values of a society. Therefore, from the beginning, all architectural and vernacular forms were used to improve the quality of living. As a result, architecture has to follow any kind of cultural and social transformation and rapidly adjust itself to it. In term of cultural influence on architecture, here at the Citadel of Bam, we ar confronted with two important historical periods, pre-Islamic period and post-Islamic period, so each one has had a significant role in the evolution of the architecture of Bam Citadel. In the former case, the term Iranian pre-Islamic architecture originated from ancient Persia; this architecture has played a significant contribution to human civilization throughout history from borders of China to the Mediterranean Coastlines, and from the Persian Gulf to the north of Caspian Sea. In the latter case, since the Muslim culture throughout Islamic history was inspired by spiritual essence, Islamic architects have considered climate and environment as two of the most important factors that generate a correlation between the spiritual demands of the inhabitants, the environment and the climate, and applied these factors to create a formal form (Memarian & Sadoughi, 2011). Accordingly, Iranian architecture in Iranian territories with hot and arid climate possesses its own specifications combined with Islamic belief criteria.

- **Privacy**

Since the residents' living environment is strongly related to their cultural, personal and social identity (Dovey, 1985; Proshansky et al., 1983), the development of Islam provided knowledge especially in relation to guidance and direction in life according to religious principles and obligations (Proshansky et al., 1983). Spiritual aspects in Iranian traditional architecture have deep origins in the country's culture and thoughts. A prominent involvement of Persian architectural elements with Islamic thoughts is related to private life, which shows itself as a spatial-physical architecture in Iranian traditional houses. Iranian traditional architecture defines its architectural principles from an explicit definition of the public and private spaces within a spatial hierarchy in accordance with Islamic thoughts.

Indeed, the influence of Islamic culture on Iranian architecture portrays excellent evidence of how spatial organization in housing is formed by the values of privacy. Optimum visual privacy is a predominant design objective to ensure the safety and privacy of female family members within Muslim homes (Al-Kodmany, 1999). As mentioned by Pirnia (2005b) about the importance of the issue of privacy in Iranian architecture, "one of the most important principles considered in Iranian traditional architecture, especially after Islam, is the principle of privacy." The interior spaces in Iranian Islamic architecture are separated from the exterior space by a wall. Behind the door, there is only a projected part named narthex, where guests wait till the host opens the door. This strategy was used to respect the privacy of males and females in order to avoid unnecessary communication in social relationship. This is the influence of Islamic culture on Iranian architecture. Following the subject of privacy, there is another set of two metal handles on the door: one handle with soft sound is shaped as a ring for use by females and another with rough sound is shaped as a hammer for use by males; through the sound of each handle the residents could easily find out the gender of their guest (see Figure 2.15 (right)).

- **Introversion**

As already mentioned, some concepts in Iranian Islamic architecture seem to be derived from Islamic beliefs and also the vernacular architecture. Introversion is one of the concepts that value the private life and its sanctity. In the hot and arid climate of Iran, this introversion has shown itself in term of a central courtyard as a space with an independent, central, internal and open geometric design (see figure 2.15 (left)). All traditional houses in Bam Citadel were designed in introverted type, so the whole house have been surrounded by perimeter walls. In this case, the benefits of introversion were to be twofold: firstly, it can be considered as one of the concepts that value the private life and its sanctity, and secondly, it protected the inhabitants from windstorm and sun radiations.

Figure 2.15- (Left) the narthex of the Ameri House in the city of Bam (Photo by Rouhi, 2015); and (Right) metal handles of a door opener in the Mirza Naem School of Bam Citadel (Photo by Rouhi, 2015).

- **Decoration**

One of key factors that has had such an impressive role in Persian traditional architecture was architectural decoration. As examples of this approach can be seen in stone raised patterns of Persepolis in Achaemenian era, Sassanid dried brick decorations, tile lining in Seljuk era, brick laying in Patriarch era, Mogharnas of Qajar era, etc., which all have implied the artistic talents, lifestyle, custom and culture of Iranian people. Architectural decorations applied in different parts of Bam Citadel have exactly shown the process of the evaluation of Persian traditional architecture in different periods of history. The predominant coating materials which had been used in the process of ornamental work in building the Citadel were chalk trim, sieved straw and mud and straw.

Figure 2.16- (Left) bricklaying and thatch coating on the top of the arch shows that change in the height is related to another era (Photo by Rouhi, 2015); and (Right) brick decoration in the south wall of the Barrack of Bam Citadel (Photo by Rouhi, 2015).

In one of the examples, we can refer to the decoration of niches in Bam Citadel. Iranian architects for setting of decorations and available objects have usually created indentation on the walls. In different structures of Bam Citadel, niches had a very important role. The main reason for creating niches in Bam Citadel was its limited space for setting of luminous objects, and making their availability easier. Furthermore, niches were also embedded on the upper floors of buildings, because they could decrease the dead load of the walls.

Figure 2.17- Decoration of niche in the West of Sabat House (Left), and Governor's House (Right) (Source: archive of RPBCH).

- **Battlement**

Battlement is another architectural element, which in term of form and shape is influenced by culture. These architectural elements, besides their guarding and security aspects, because of their abundance added a sense of beauty to the enclosure wall of Bam Citadel.

In Bam Citadel, the shape of battlements on city wall and that of the governor's district are the same, but there are some minor differences in their form. Given that Bam Citadel over time have widely been subjected to some changes, these changes in battlements were more obvious than any other parts. By approaching the present time, less accuracy in their conservation and restoration can be seen. The question that may arise here is whether the battlements had the same form in Medes, Sassanid and Achaemenian periods? The answer to this question could be that since the dimension of brick moulds in various periods have been different from one period to another period, if there were any differences in shape (8×32×10 cm, 32× 36×36 cm, 12×42×42 cm, etc.), it could be due to the size of bricks at the desired time. Now archeologists are estimating the age of different parts of Bam Citadel according to this specification.

Figure 2.18- Variations of the Battlements in the First Gate of Bam Citadel before the 2003 Bam earthquake (Source: archive of RPBCH, designed by Author).

2.3 The Background and Characteristic of Adobe-Mud Brick Structure, and its Construction Techniques in Bam Citadel

In order to preserve and protect historical buildings and monuments from the potential impacts of earthquakes, the first phase is to understand how ancient communities built their cities (Harrouni et al., 2017).

Adobe is the name for a style of building construction that uses bricks made from mud (National Park Service, 2011). Mud is one of man's oldest building materials and most ancient civilizations used it in different forms. Adobe-mud bricks (often called adobe bricks) is a Spanish word that originally derives from the Arabic word "*al-tob*" meaning "sundried or unbaked brick"; the term has its roots in Egyptian hieroglyphs. However, today the term of adobe is used in English as an "earthen construction" to describe all types of construction techniques using mud or soil raw materials. This versatile building material is widely available and in some parts of the world, especially in remote areas, it is the only material available over there (Adam & Agip, 2001). The use of sun-dried blocks dates back to approximately 8000 BC., and until the end of the last century it was estimated that around 30 % of the World's population lived in earth-made constructions (Houben & Guillard, 1994). In the first world, cities like Jericho, Catal Huyuk and Babylon were constructed out of adobe bricks. Materials obtained from soil served for erecting common houses, but also for great monuments such as Arch of Ctesiphon in Iran, or pharaoh's tombs in Egypt. It is significant that the oldest surviving examples of this building form are in the treeless landscapes and in the most arid areas of the world (Sruthi, 2013).

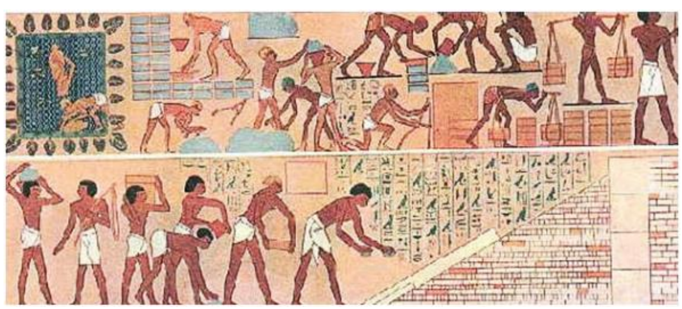

Figure 2.19- Photo of adobe making in Egypt, Thebes, Tomb of Rekhmire - 15th century BC (the entire fresco) (Source: earth-auroville.com).

Buildings made up of adobe-mud brick are common in the Latin America, Australia, North Africa, Middle East, South Asia, China and Interior Asia, East Europe and Sub-Saharan Africa. In Egyptian hieroglyphics document, Biblical accounts refer to early use of adobes and the use of mud-bricks for construction of buildings in the ancient world. As a ubiquitous form of construction material, adobe-mud brick structures are still built up in many regions of the world with hot/arid climate conditions, because of their low costs of manufacturing, transportation and on-site workmanship, simple and unsophisticated construction technique and excellent thermal properties. Approximately 50% of the population in developing countries, including the majority of the rural population and at least 20% of the urban and sub-urban population, live in earthen dwellings (Houben & Guillard, 1994).

The scientific study of traditional structures, which have been used for millennia, reveals the specific construction methods that were used by traditional builders, who mastered the most advanced structural skills (Hejazi & Mehdizadeh, 2015). Traditionally in Iran, availability of materials in living environment has a main role in local architecture of a particular area. As Pirnia (2005a) noted, "clay is an available building material in Iran that dictated major form in traditional Iranian architecture. Heavy clays have encouraged the development of the most primitive of all building techniques. Bricklayers compressed solidly molded mud and allowed it to dry. Tenacious lime mortar also eased the development and use of brick." Adobe constructions techniques, "*Khesht*" and "*Chineh*" in Persian, constitute a large part of Iranian history and civilization, consisting of ancient cities and archaeological sites. Recent excavations in Iran have shown that this traditional construction technique can be dated back to the 6th millennium BC. By far a large part of the country's heritage had been made using adobe-mud brick construction technique. In Iran, this technique architecturally, artistically and technically developed during the Achaemenid, Parthian and Sassanid periods and gradually reached the present outstanding level (e.g. Bam Citadel, Iran).

Figure 2.20- Adobe complex of Chogha Zanbil in the Khuzestan Province of Iran, dating back to 1250 BC. (Photo by Molon, 1999. Source: http://www.molon.de/).

The advantages and possibilities of mud construction are endless (Sruthi, 2013). Generally, adobe-mud brick structures have several advantages and relatively few disadvantages over other conventional construction techniques. Adobe materials are recognized as one of the sustainable building materials, meaning that they are environmentally friendly and have little impact on the environment. It takes more than 300 times as much energy to produce a commercial concrete block than a sundried adobe block of the same volume (Wright, 1978). Furthermore, as Sruthi (2013) pointed out, "building with mud has become an important factor in planning new development. Following the recent energy crisis, technological progress has been made in certain countries, and the enthusiasm of architects and land developers has added in the spread of these new techniques. Today we are able to choose between the conventional 'international architecture' and a more 'down to earth' approach that combines reasonable cost with traditional cultural motifs in a modern way."

On the other hand, for these buildings, the "embodied costs", which means the cost to individuals and society overall in its creation, storage, distribution, use, and maintenance, are very low (Austin & Holmes, 2006). Adobe buildings are very effective in different climatic conditions; they are an excellent insulator, which provide good thermal insulation and acoustic properties in climates typified by extreme temperature fluctuations during both day and night. Meanwhile, the high thermal mass of adobe mediates the living space temperature. Furthermore, this construction technique is relatively simple and uncomplicated, and in simplicity, they can be combined by complex structural components such as arches, vaults and domes. Moreover, adobes are fireproof, biodegradable and non-toxic, detoxifier, durable and afford great flexibility in the design/color/surface of the construction.

Beside the aformentioned advantages, this construction technique has also some disadvantages that can be summarized as follows: they have extremely low resistance against deterioration factors; and because of their moderately low compressive strength and low tensile strength, they have poor seismic resistance. In the next parts, after a description of all steps needed for production of an adobe-mud brick, and construction of different parts of an adobe structure, all the causes of deterioration seen in Bam Citadel will be expressed in details.

- Adobe Foundation

Since foundations have to bear the total weight of other components of a structure, they are one of the most important parts of each structure. In the Citadel of Bam, adobe buildings made by "*Khesht*" and "*Chineh*" have directly been built on the natural ground. Generally, there is not any designed foundation for most of the buildings in the Citadel (Mokhtari et al., 2008e). To build walls from adobe-mud brick, traditional builders in the Arg-e Bam have usually dug a wide trench, at least 60 cm deep.

In Bam Citadel, the wall's basements have just the thickness of the trench but with less thickness, and the thickness was gradually moderated towards the roofs. Then after the foundations had been built up, the remained empty spaces between walls and trenches were filled with the same original soil. Whereas due to the heavy weight of the adobe buildings, there was a risk of soil subsidence, the foundations were always consolidated under pressure. In addition, to provide a relative moisture barrier and to reduce the penetration risk of unwelcome water accumulated at the foot of adobe walls, there was also a bonding course of lime that was evenly distributed under the basements. Generally, in Bam Citadel we are confronted with two different types of foundation: rock bed base and consolidated bed base. Buildings in the Arg-e Bam, apart from the governor's quarter that had been built in a level of rock bed, in other parts were built in a level of soft soil.

Figure 2.21- Bedrock base of the Governor's District of Bam Citadel (Photo by Rouhi, 2015).

- Adobe Walls: Chineh and Khesht

Given that life in cities, which are located in the Central Iranian Plateau, involves its own difficulties, these conurbations are formed in a unique vernacular style. The most frequent building material in this area has always been mud, which is available everywhere. When wet, it can simply be plastered on walls without shaping. Alternatively, it can be tampered and formed into large blocks with more or less rectangular sides. The city of Bam, as one of Iran's desert communities, is not only celebrated for its diversity of styles and influences, but also for the continuity of its traditions in new building practices. In this city, especially in the Arg-e Bam, the earthen construction technique is identified into two groups: (1) "*Khesht*" (referring to handmade adobe-mud brick); and (2) "*Chineh*" (referring to rammed earth, which is somewhat different in implementation).[119]

I. Chineh

Chineh is a construction technique that its required soil is taken from the site's ground, and specially prepared and treated by continuous massaging of the material by human feets. In the city of Bam, due to asthenia characteristic of chineh's walls, this method is generally used for

[119] Numerous earth building methods with distinctive variations are recognized worldwide (Correia & Fernandes, 2006). In Bam in Iran, a highly studied site following the 2003 earthquake, the majority of construction is in adobe or chineh with only a few examples of rammed earth (Langenbach, 2004).

non-load bearing walls, very common for the fence of gardens and farms in agricultural and rural contexts.

A chineh is usually shaped in the form of a conical wall and is constructed on the natural ground level without any foundation. Sometimes in places where the land is not so dry, a one-inch thick layer of lime is laid all over the wall’s basement. The bottom of the wall close to the ground is always too thick, and as it gets less and less thick as it reaches the upper parts. Traditionally chineh has been performed layer by layer, so that each layer has a height from 50 to 80 cm, and the next layers are simply laid on the previous ones, constituting a horizontal dry joint. However, since the shrinkage of the previously constructed layer of a chineh, while it is being dried might cause some cracks in the newly built layers, in every two or three layers of chineh a row of adobe-mud brick is used. This layer also increases the monolithic characteristic of a chineh wall.

Figure 2.22- Steps for construction of a chine wall, as a part of courtyard’s wall (Photo by Ghane Ezabadi, 2013. Source: http://www.yazdfarda.com).

II. Khesht

Physical properties of walls made of adobe-mud bricks, “*Khesht*”, are similar to those of “*Chineh*”. Kheshts are used to construct on site load-bearing walls. Since the construction practice of kheshts are normally simple and does not require any additional energy resources. These buildings are manually built by those who live in them, with the assistance of persons skilled in adobe production. The material used to realize the compressed adobe-mud block is made of three different constituents with the following proportions: 1) 1 volume of soil; 2) 1/2 volume of chopped straw; and 3) 1/3 or more volume of water to guarantee normal consistency. All of the materials are mixed manually, and if the adobe mixture has a high enough percentage of clay, the straw is not always necessary.[120] In this method to produce adobe bricks, some steps are to be followed. In this section, according to the Author's observations of Bam site (August 2015), all steps are briefly described as follow:

Figure 2.23- Brick manufacturing workshop of the Bam Citadel, close to Ice House or Yakhdan of Bam Citadel (Photo by Rouhi 2015).

Step 1: Finding a suitable soil, and rummaging it vigorously to get rid of all pieces of rocks, woods and any other impure pieces:[121]

Finding the right soil's quarry is exactly important in adobe brick and mortar production. To make high quality adobe brick, a certain amount of ingredients (gravel, sand, silt and clay) is necessary. The soil particle of an adobe-mud brick is typically made from local soil in the owner's yard or nearby with a high enough clay content of 20% and through adding other ingredients.[122] In the Citadel of Bam, according to the data from CRATerre, the adobe bricks for using in the reconstruction process are made from a quarry from "*Nezam Abad*", a village near the city of Bam. Table 2.1 shows the chemical composition of *Nezam Abad* quarry. The grain size distribution graph of *Nezam Abad* soil is shown in Figure 2.24, as the graph shows,

[120] As the Author's visitation from Bam's workshop revealed, no chopped straw was added to the soil, although straw has several advantages in adobe making: first, it adds tensile strength; second, it causes lighter weight of adobe bricks; and third, by retaining of the moisture, it reduces excessive shrinkage cracks as the material dries. However, as research conducted by Yetgin et al. (2008) shows, the addition of straw fibers decreases the compressive strength. On the other hand, Straw has beneficial effects in terms of tensile strength, but at long-term and if adverse conditions are observed, it will decompose, leaving undesired voids that have negative impact on the mechanical properties (Silvia et al., 2014).

[121] From adobe's mixture, pebbles should normally be removed.

[122] However, it is just possible to use earth, if there is good cohesion, which is achievable by the balance between the different components and their grain fraction (Correia & Fernandes, 2006). If the soil has low clay content and presents excessive content of stones and gravel, it may result in an earthen material with low compressive strength and water resistance (Silvia et al., 2014). On the other hand, if the clay content of the soil is excessive, it may result in excessive cracking due to shrinkage (Warren, 1999).

the percentage of ingredients in Bam soil are as follows: coarse sand (< 2 mm) 17.5%; fine sand (< 0.2 mm) 32.5%; silt (< 0.02 mm) 30%; and clay (< 0.002 mm) 20%.

Table 2.1- The chemical composition of *Nezam Abad* soil (Source: archive of RPBCH).

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O
46.48%	6.21%	11.34%	12.69%	5.14%	2.09%	2.13%

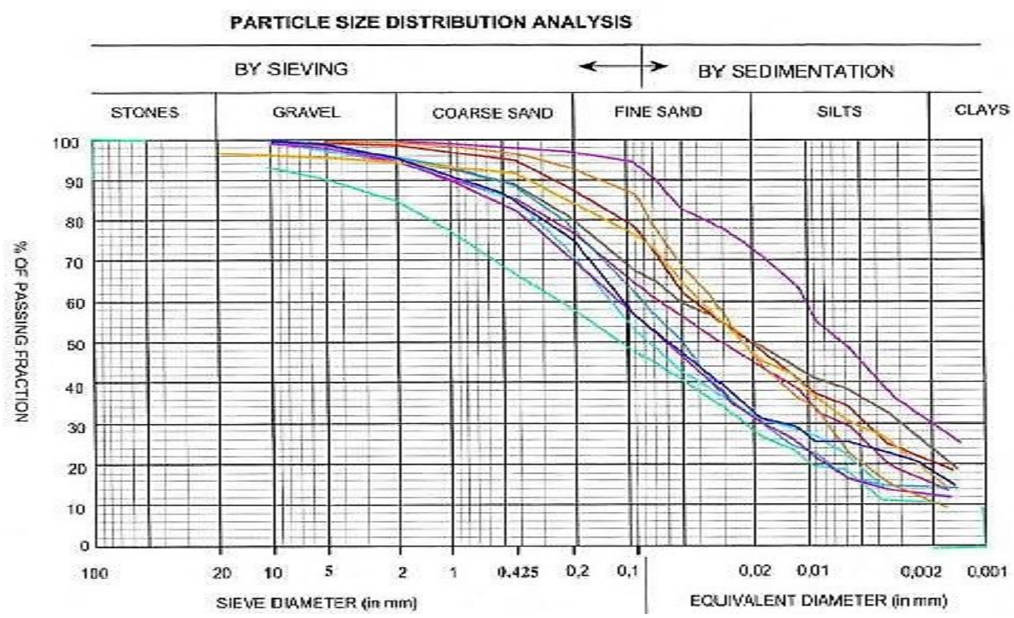

Figure 2.24- Particle size distribution analysis of *Nezam Abad* soil (Source: archive of RPBCH).

All particles fractions have their role in the behavior of earthen materials. However, clay has a major importance. It acts as a binder by surrounding and attaching the silt, sand and gravel particles, giving cohesion to the material, while the other particles behave as the filler of that matrix (Silva et al., 2009). Depending on the site where the soil is dug out, it will be composed of different percentage of clay, silt, sand and other materials. Its characteristics, therefore, may differ from site to site, and the preparation of the correct mixture for a specific application may also differ (Minke, 2006). The fine-grained raw material for adobe-mud brick construction is generally from recent stream or river sediments or residual soils. A wide range of soils with wind-blown origin is not commonly suitable for this type of mixture. To determine the suitability of soil needed for adobe composition, there are some sample field tests and standardized laboratory test. In these methods, the purpose is to know whether the soil is proper for adobe composition or not, and by these tests, it is possible to know the four fundamental properties of the soil (Granularity, Compressibility, Plasticity and Cohesion),[123] samples of these tests are shown in APPENDIX I.

[123] Standardized, laboratory test costs relatively a lot according to the laboratory. This type of tests will take a few days as the sedimentation test is done over several days.

Table 2.2- Different methods used in simple field tests on adobe mixture (Source: Auroville Earth Institute, EARTH AS A RAW MATERIAL).

Granularity	Looking and touching	Look at a dry or humid soil and touch it to define the percentage and the size of the grain sizes.
Compressibility	Pressing	Add a little water. If the soil is dry, try to get wet soil and compress it by hand to make a ball. Evaluate how much pressure you need.
Plasticity	Shaping the ball	Add more water and make a cohesive ball. Evaluate how easy it is to shape it and how cohesive it is.
	Stretching the ball	Pull the ball like rubber elastic and try to break it. Evaluate the strength of the ball.
	Sticking a knife	Stick a knife into the cohesive ball and pull it out. Evaluate how the soil sticks on it.
	Cutting the ball	The ball is cut into 2 pieces. Examine the aspect of the cut.
	Water absorption	Print with the thumb a small depression on the ball. Fill it with water and evaluate the time of absorption.
Cohesion	Diluting the ball	Add much more water to the ball and try to loosen the cohesion of the soil. Evaluate how much the soil sticks to the hand.
	Washing the soil	Add much more water to the soil and wash away silt and clay. Evaluate the amount of fine sand which remains in the palm.
Humus content	Smelling the soil	Take some wet soil and smell it.

Table 2.3- The standardized laboratory tests on adobe mixture (Source: Auroville Earth Institute, EARTH AS A RAW MATERIAL).

Granularity	Grain size distribution by sieving and sedimentation
Compressibility	Proctor for getting the optimum moisture content (OMC)
Plasticity	Atterberg’s limits to get these limits: ▪ LL = Liquid Limit (%) ▪ PL = Plastic Limit (%) ▪ PI = Plasticity Index (%) Note: PI = LL - PL
Cohesion	8 test (sample prepared with a mortar < 2 mm)

Step 2: Mixing of the soil with water and chopped straw or other additives:
Once soil is lying in a pool of water for two days, the materials should be mixed thoroughly and uniformly.[124] In the time of the composition of material, it must be taken into account that the water content should be high enough to make a stiff mud. At the time of mixing, depending on the quality of soil some other additives or stabilizers may be added to the mixture.[125]

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[124] In some parts of the world, the production of adobe bricks is even industrialized, so they are performed with special machines.
[125] If a locally available soil is not adequate for earth construction, there are two possible solutions: transporting a suitable soil from another location or improving the properties of the available soil by stabilization. The second option is generally the most popular, since the first can result in logistic problems, such as long transportation distances, that can make the construction more expensive. On the other hand, the stabilization of the soil is not always feasible or economical (Silva, 2013).

The additives are ingredients that when mixed with adobe mixture, they improve its physical/chemical properties. As Silva et al. (2009) stated, “Stabilization aim the improvement of the mechanical properties, achieving better cohesion, limiting the shrinkage/swelling effects and achieving better resistance to harmful effects wind and water. Stabilization can be mechanical, physical or chemical. Mechanical stabilization involves the compaction of the earth resulting in changes in its density, mechanical strength, compressibility, permeability and porosity. Physical stabilization involves acting in the earth’s physical properties, as for example, by changing its texture, or by using elctro-osmosis for draining water. Chemical stabilization involves the addition of other materials capable of reacting physically/chemically with the earth grains, modifying then the earthen material.” These physical properties include compressive strength, density, porosity, depth of penetration, abrasion resistance and hardness. As Ahmadi (2008) mentioned about adobe’s additives, “they must be durable, easily applicable, cheap, reversible and they should not be chemically hazardous”.[126] There are two sources of organic materials: a plant source, e.g., straw, palm leaves, and rice husks; and an animal source, e.g., animal hair and dung) (Torraca, 1988). Furthermore, in modern adobe construction technique, some chemical additives such as lime or bitumen and Portland cement are used, which improve the quality of the adobe mixture.[127] According to regional availability, additives are different from region to region. Traditional architectures, as a consequence of experience-based knowledge, which they have acquired through trial and error over time, have been able to realize the positive effects of each additive in the structural performance. In the case of Bam Citadel, because of the availability of straw in the region, this additive often was added to the mixture to decrease the micro cracking effect caused by drying shrinkage, enhance the tensile strength, decrease density and speed up drying of adobe-mud brick. Apart from straw, during reconstruction process of Bam Citadel after the 2003 earthquake, palm fibers, suggested by the University of Dresden, were used as adobe’s additive in ‘Sistani House’ and ‘Tower No.1’. Here, sleeping of the mixture means that after preparing the mixture, having the mixture rest for almost 48 hours under nylon plastic to get better moisture. The results of the tests applied to consolidate adobe by local materials at the CRATerre centre are presented in APPENDIX II.

After the 2003 Bam earthquake, 15 samples of adobe bricks with different characteristics in the ‘Friday Mosque’ were put under different laboratory experiments. The related information with different sample codes is presented in Table 2.4, as can be seen in this table, the adobe bricks in Friday Mosque consisted of different materials such as straw, snail, pumice, ash, piece of pottery, animal excrement and so on.

[126] Ahmadi, S. (2008). Adobe conservation: Evaluation of silicone and acrylic Consolidants (The Master thesis, Queen’s University Kingston, Ontario, Canada). Retrieved from www.collectionscanada.gc.ca/obj/thesescanada/vol2/OKQ/TC-OKQ-1523.pdf

[127] It should be noted that chemical additives are not common in heritage earth constructions. Meanwhile, in spite of the advantages of earth’s stabilization, it should only be used if necessary, without any systematic disproportionate application, since it can significantly increase the production cost and spoil the original characteristics of the earth (Houben& Guillaud, 1994).

Figure 2.25- (Left) lying of soil in a pool of water; and (Right) mixing of the soil with chopped straw or other additives (Photo by Rouhi, 2015).

Figure 2.26- For better penetration of water within clay particles, the adobe mixture is laid under nylon plastic (Photo by Rouhi, 2015).

Table 2.4- Adobe bricks compositions and their dimensions in Friday Mosque of Bam Citadel (Source: Rasekh, 2008).

No.	Sample Code	Dimension (cm)	Composition
1	AB-W-Mb/Q14	25×25×5	Large stone, piece of pottery and straw
2	AB-W-Mb/U12	23×23×5	Bick, ash and straw
3	AB-W-Mb/O2	23×23×5	Large stone, brick and straw
4	AB-W-Mb/KM3	23×23×5	Large stone, walnut shell, snail and straw
5	AB-W-Mb/E12	24×24×4	piece of pottery, ash and straw
6	AB-W-Mb/E18	25×25×5	Large stone, piece of pottery, piece of wood and straw
7	AB-W-Mb/G21	23×23×4.5	Piece of pottery, ash, animal excrement and straw
8	AB-W-Mb/S10	23×23×5	Large stone, piece of wood and straw
9	AB-W-Mb/S6	25×25×5	Stone, seed of Sunflower and straw
10	AB-W-Mb/I24	24×24/5×5	Piece of pottery, piece of wood with large dimension and straw
11	AB-W-Mb/Q4	27×27×4.5	Large stone and straw
12	AB-W-Mb/E6	25×25×5	Straw
13	AB-W-Mb/NO20	25×23×5.5	Bick, snail, pumice and straw
14	AB-W-Mb/Q18	23×24×4	Large stone, walnut shell, ash and straw
15	AB-W-Mb/S22	23×23×5	Snail and straw

Step 3: The moulding of adobe-mud brick:

Since the characteristic of adobe structure is crucial to cater the local needs in different courses of the history, Iranian architectures have applied some changes in adobe's form, dimension and material to achieve an optimum state. For adobe moulding, it requires a large open space for laying and drying of the adobe bricks; this area must be cleaned and flatted. Adobe-mud bricks can be manufactured in any size; it all depends on the size of the wooden moulds where adobe's mixture is formed. About the properties of the mould, it should be noted that to prevent the impairing of mould during the forming of mixture, the mould is usually created with hardwood such as walnut and sycamore and its sides are fastened in the form of male and female. In the Bam Citadel, the most common size were about 25×25×5cm or 23×23×5cm**,** but other required sizes were applied.[128]

Table 2.5- Dimensions of adobe-mud bricks in some historical and archeological sites in Kerman province in different periods (Designed by Author).

Site Name	Geographical Location	Historical Period	Adobe Dimension (cm)
Tali lblis	Kerman, south eastern	5th millennium	38×35×20- 80×35×20
Konar sandal	Kerman, Jiroft	3th millennium	40×40×10- 60×30×15
Shahdad	Kerman, south eastern	2th -3th millennium	39×22×8.5
Arg-e Bam	Kerman, south eastern	Parthian	23×23×5 - 25×25×5 23×23×4 - 23×23×7
Darzin Castel	Kerman, Bam, east	Sassanid	27×27×7
Daselgerd castel	Kerman	Seljuk	35×35×11

At the beginning, once again all particles are well blended and kneaded thoroughly and uniformly. Before moulding, the mould is wet to prevent sticking of clay to the mould; by doing this work, the mould will be easily lifted away from the brick when it is lifted up). Afterwards, the following steps are performed repeatedly until the requested portion of adobe-mud bricks are produced:[129]

1) the mould is laid on the prepared ground,
2) the adobe-mud mixture is firmly pushed into all corners and tamped down firmly,
3) the surface of adobe-mud brick is leveled either by hand or by a timber piece, a trowel or a wire. Mostly, the surface of adobe-mud bricks are scratched by hand ("*Panjeh Keshi*" in Persian) in order to increase mortar's adhesiveness with adobe bricks,
4) and then the mould is carefully unmolded, and brick is left to dry in a shaded place.

Step 4: Drying of adobe-mud brick:

128 Moulds of different sizes are used to form the adobe bricks. Each mould according to requirements may make one, two, four or six adobe bricks, depending on its sizes.

129 In some parts of the world the production of adobe bricks is industrialized, and all the steps for moulding high quality adobe bricks are done with special machines.

This is the critical step in the production of adobe-mud bricks when the shrinkages begin to occur. In order to minimize the shrinkage effects (mainly cracking), special precautions should be taken, such as avoiding drying in direct exposure to the sun (slow drying in shade reduces the rate of evaporation and cracking), and severe wind (cracks are also extreme on windy days when the shrinking of clay occurs more rapidly). After at least two days of drying horizontally, the adobe-mud bricks must be stacked vertically, i.e. “chain making”. In this way, air circulation between adobe-mud bricks causes better drying up. After two more days, adobe bricks are finally dried, and then they are piled up and ready to use in construction process.

Figure 2.27- The process of adobe moulding under a shaded space in Bam Citadel’s workshop (Photos by Rouhi, 2015).

Figure 2.28- Chaining of adobe bricks to better aeration, and their pilling up after drying (Photos by Rouhi, 2015).

Finally, following the preparation of adobe bricks, they are laid course by course. Each course is overlapped at the corners and is laid along the whole wall by mud mortar. In Figure 2.29, the quality of brickwork in different positions at Corner, T-joint and Cross-joint is shown. Meanwhile, all the adobes surfaces in the time of construction should be wet for better adhesiveness. Adobe walls, because of their low structural strength usually have almost two or three stories height. All the windows, doors and other similar elements in this construction technique are usually built by curved brickwork on the top to distribute the weight more evenly along the walls' sides.

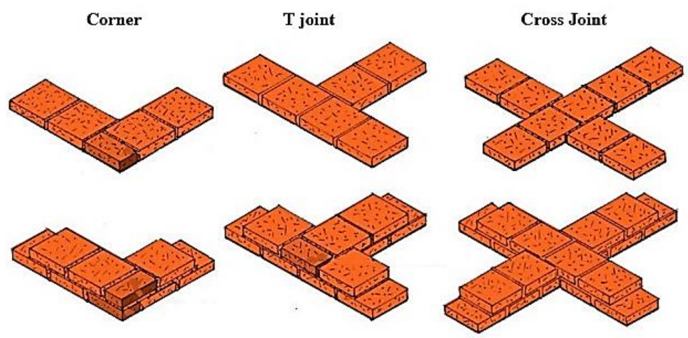


Figure 2.29- Adobe brickwork in different position at Corner, T-joint and Cross-joint (Designed by Author).

- Roofs: Arches, Vaults and Domes

From many centuries ago in this Citadel, a fortified medieval town located in the desert environment of Iran where no wood is visible or it is very scarce, some construction techniques were developed in such way that buildings were covered with repeated arches upon the walls and entrances as vaulted, domed and arched roofs.[130] One the on hand, the reason for using this type of architecture can be found in the availability of clay in the region, a flexible material that can be formed in any type of architectural design. On the other hand, from geometric point of view, the curved roofs by their convex surface provide further advantages to create a thermal equilibrium inside the building in a desert environment.

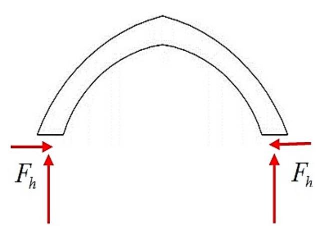
In term of aesthetic values, buildings with curved roofs have many architectural functions. The aesthetic influence of this type of roofs can be found in their external and internal parts. The external part of roofs that consists of such elements as arches, vaults, domes and wind towers, in addition to their particular functions, gives a beautiful character to urban appearance, as we can see in the city of Yazd in large scale. The internal part of roofs with its architectural designs, which is a sequence of other internal architectural elements, gives a charming atmosphere to the interior space of the buildings.

[130] In the semi-desert areas of Iran, which have a temperate climate, since there is enough wood so most of the roofs are flats.

- **The Arches**

The arches are fundamental elements in Persian architecture (Hejazi & Mehdizadeh, 2015); thus, they have many architectural and structural functions. The main function of an arch is to bridge an opening between walls. Meanwhile, the origin of domed and vaulted roofs are initially formed by arches; by expanding an arch in vertical dimension, vault, and with its rotation on the vertical axis, domes will be created. In the Citadel of Bam, there are many forms of arch, and arched lintels can be seen over openings such as ports, gates, verandas, doors, windows, etc. An arch is mainly characterized as a curve of the brickwork at the ratio of the height to span, and so is connected to the wall by its upper or outer curve. Merely a small arch can also be used as a façade to hide the structures behind it. In the case of structural performance of arches, the applied load from the extrados is tolerated by arch's flanks and then transmitted by pillars to the ground.[131] It should be noted that in almost all types of adobe roofs, the structure transfers the thrust to the side's walls.

In Bam Citadel after the 2003 Bam earthquake, in order to reconstruct all damaged arches and to achieve an ideal formula for length and height of arches in a desired span, some tests were performed to achieve the ideal size and ratio of arches (see Figure 2.30). Sometimes to have a framework for making arches, some gypsum form which are fixed on side walls are placed under the abutment of arches. Meanwhile, at the time of arch construction, to fill the gap between the adobe-mud bricks, some wedge-shaped bricks ("*Karband*" in Persian) are inserted in the outer mortar joints (see Figure 2.31).



$$F_h = 0.3M_V - 118$$
$$F_h = (Shearforces K_g)$$
$$Mv = (ArchsWeight)$$

Arch's Span (M)	R_v = 1 (M)	R_v = 1.5 (M)	R_v = 2 (M)
R_h (M)	0.43	0.64	0.86
M_V (Kg)	560	792	1022
F_h (Kg)	95	183	270

Figure 2.30- Formula for erection of arches in Bam Citadel after the 2003 Bam earthquake (Source: Meqdadian, 2008).

- Bucket Arch

Bucket or Basket-handle arch is an oval form that is largely concentrated on springer lines. The objectives for applying the Bucket arches have usually been for ornamentation rather than

[131] It should be noted that in almost all types of adobe roofs, the structure transfers the thrust to the sides' walls.

strength. In the Citadel of Bam, these arches are more common than other types of arches, and mostly can be found in the southern facade of the houses (winter settlement), where their height is shorter than the northern side (summer settlement). Meanwhile, in two-storey buildings, façades on the bottom floors are generally in the form of Bucket arch. Apart from those, in spaces where pillars instead of walls had limitation in raising height, architectural ribs were erected in the form of Basket.

Figure 2.31- Using of gypsum forms and Karband for arches' construction in Bam Citadel (Source: (Left) archive of RPBCH; and (Right) Rouhi, 2015).

- Pointed Arch

Pointed Arches are created from two curved arches. The height of Pointed Arches is usually adopted according to room openings. One of the advantages of these types of arches is the capability of their height for being high and low within a fixed span. For example, in the Bam Citadel, for high height of arches the ratio of 1:3 and for low height of arches the ratio of 5:7 has been chosen. Here most of the pointed arches consist of three sections with different distance from the centre of arch; top, sides and springers.

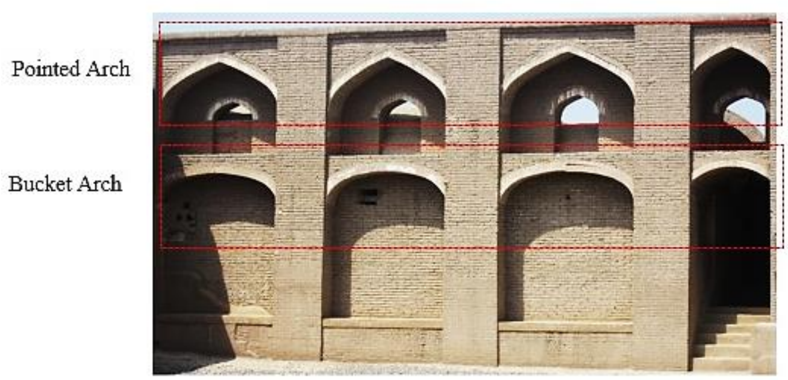


Figure 2.32- Samples of pointed arch (in upper part) and bucket arch (in lower part) in the Tekiyeh of Bam Citadel (Photo by Rouhi, 2015).

▪ **The Vaults**

Persia has created an original monumental vaulted architecture, whose morphology replies to spiritual and technical imperatives, sometimes contradictory (Chassagnoux, 1995). Vaulting became common in Persia in the 2nd millennium B.C.E.; in fact, genuine vaults of baked brick with gypsum mortar had already been introduced, for example, at the Elamite site of Haft Tepe (Negahban) (Encyclopædia Iranica). The simplest definition for vaults according to their architectural aspect is the movement of one or several arches along an axis or various axes in a surface between two load-bearing walls or at least four load-bearing pillars. Vaults usually cover places where their spans are less than their depths. In Bam Citadel, we can see a great many shapes and forms of vaults. Here, the types of vaults found in small and humble houses almost differ from those found in large and luxurious houses.

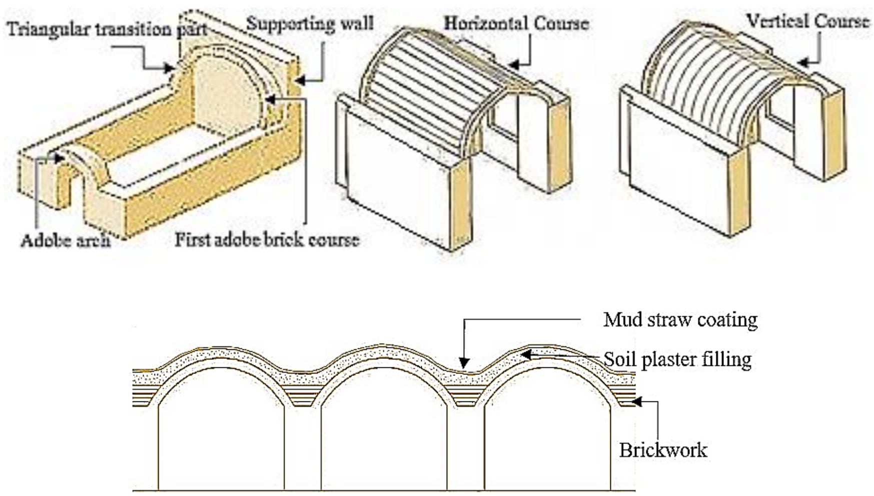


Figure 2.33- (Top) different part of vault and the quality of its courses; and (Down) the form of multi-vault arragement and the materials that cover its various parts (Designed by Author).

Surprisingly, the curved roofs (vaults and domes) have positive effects on the indoor climates, so they act as a peripheral isolator in spaces. Sometimes they are erected in double layers to benefit more from this feature so that the space between them can act as a place for heat possession and better mediation of temperature. The most common types of vault used in the Bam Citadel were in the shape of Barrel Vaults. Typically, most vaults are formed from development and combination of one or several Barrel vaults in different dimensions. Other more common types of vaults in Bam Citadel are explained in the following section.

- Barrel Vault

Barrel vaults are the simplest type of vaults which are made up from the succession of identical arches. Barrel Vaults, without needing any centrality, can have steeper or flatter profiles such as semicircular, catenary,[132] segmental, pointed, etc. Among different types of Barrel Vaults, the catenary vaults are known as a very common form, which gives maximum stability for a minimum use of material. Initially, to form a Barrel Vault, a load-bearing wall as a supporting wall with arched section is built at one end. Then, a skewed course of adobe brick towards the supporting walls is arranged. Other adobe courses are set in position up to two triangular transition segments in the form of either circular or linear shapes.

Figure 2.34- Some form of barrel vaults observed in Bam Citadel, respectively from left to right are named as pointed vault, segmental and semicircular barrel vaults (Photo by Rouhi, 2015).

- Dominical and Trought Vault

Dominical vault is a combination of two-Barrel Vaults with the same profile, which is the result of the extension of one of the two vaults. To build these types of vaults, inclined supports are provided at four corners of a room. The first adobe brick is laid at the junction of two walls; after that, the second and the third course of adobe-mud bricks are inserted on the top of the first course with an overlap of a half-brick. Then the space of roof is divided into four parts and other courses are placed layer by layer at each corner in a circular or spiral manner to complete the vault. Depending on the size of the vaults, each corner may be shortened. Here the Trought Vaults are the type of Dominical Vaults that are longer in one direction.

Figure 2.35- The quality of semi-dominical and dominical vaults in Bam Citadel (Source: archive of RPBCH).

[132] The catenary vault as a very common form of barrel vault can give maximum stability for a minimum use of material.

- Groined Vault

This type of vault like Dominical and Trought Vaults is also composed of two Barrel Vaults with the same profile; the difference is that they can be built just on spaces with square or rectangular plan.

Figure 2.36- Sample of groined vault in southern part of Governor's House during the restoration works before the 2003 Bam earthquake (Source: archive of ICHHO).

- Ribbed Vault

A Ribbed Vault is another type of Barrel Vault in which the ribs or curved twigs are rounded in the form of cones, and the vaults are built between adjacent ribs. Here the ribs are built by gypsum and are placed over the load-bearing columns or walls, it is vertically over the springers surfaces. To build a gypsum form, the arch of a gypsum is drawn on the ground. The intended land for manufacturing of the gypsum form must be completely flat and clean, and then a row of bricks along its thickness are arranged as mould to form its shape. To build a rib, two gypsum forms are needed. Since the gypsum is so fragile, in addition to gypsum, pieces of reeds are added as a reinforcer into the mixture. After drying the gypsum forms, they are placed in the position where the vaults have to be erected.

Figure 2.37- The drawing up of gypsum form within the mould of bricks (Source: archive of ICHHTO).

The installation of ribs needs a high degree of accuracy. The ribs are held vertically without any movement until workers fix them with elements like scaffold and wooden piles. Afterwards, the traditional workmans (Usta in Persian), at first starts to brickwork in space between gypsum forms and then the space between the ribs. The brickwork in spaces between gypsum forms have three models: horizontal, vertical and diagonal. In Bam Citadel, ribs have more application in the new architectural history of Bam.

Figure 2.38- The ribbed vault in the Tekiyeh of Bam Citadel during and after total reconstruction, after the 2003 Bam earthquake (Source: archive of RPBCH).

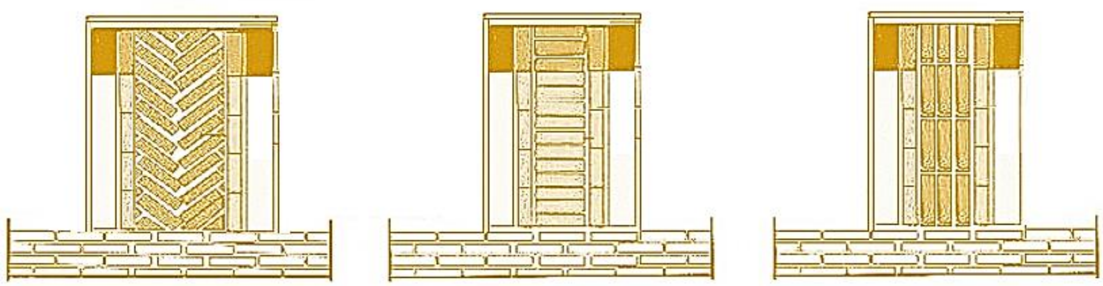


Figure 2.39- The variety of adobe brickwork for construction of a ribbed vault in the Citadel of Bam (Designed by Author).

- **The Domes**

Persian architecture most likely inherited an architectural tradition of dome-building dating back to the earliest Mesopotamian domes (Spiers, 1911).[133] This form of curved roofs is one of the main features of traditional buildings in cities and villages in the neighborhood of the Iranian desert. Although domes can cover rooms with square or rectangular plans, they are circular in plan. The roofs in such type are very thick ones (the thickness is varied from 10 cm up to 100 cm). In fact, domes are a type of vault, which are not only used for covering places with large spans, but also they are used as a symbol in the process of construction.[134] Domes with different

[133] Spiers, R.P. (1911). "*Vault*", in Chisholm, Hugh, The Encyclopædia Britannica: A Dictionary of Arts, Sciences, Literature, and General Information (11th Edition). Cambridge, England: University Press, p. 957.
[134] Domes are circular in plan. They can however, be used to cover square or rectangular rooms.

shapes and sizes were one of the main features of buildings in the Bam Citadel. Here a large number of domed roofs (48 numbers) with 2-3 m diameters commonly were used in Stable of the Bam Citadel. The simplest way to transfer loads from domed roofs are placing them directly on load-bearing walls. Since embedding of opening on domes is so difficult, Iranian architectures always used arches to transfer pressure from dome to each side of an opening. In Iran, this method of load transmission is recognized as a stage for the advent of domes with more complicated form like four arches dome "*Chaar-Sogh*". Chaar-Sogh, literally is an equilateral architectural unit consisting of four arches or short Barrel Vaults between four corner piers, with a dome on squinches over the central square; this square and the lateral bays under the arches or Barrel Vaults together constitute a room of cruciform ground plan. Chaar-Sogh is the most prominent element in traditional Iranian architecture after Iwan; an example of Chaar-Sogh in Bam Citadel can be seen in its Bazaar.

Figure 2.40- The Chaar-Sogh of the Bazaar of Ba Citadel during reconstruction works after the 2003 Bam earthquake (Source: archive of ICHHTO and Rouhi, 2015).

- Mud Mortar and Traditional Surface Coatings

Mud mortar is typically used as a bond between adobe bricks, and is merely composed of the same soil ingredients as the bricks, but it may not contain similar organic materials.[135]In adobe-mud brick structure, the quality of mud mortar has a great importance because of their direct contact with adobe bricks as materials that already absorb moisture. Mud mortar has also a significant role in limitation of the cracks of adobe-mud bricks during their continuous shrinkage and expansion. In this case, some coarse sand can be added to the mixture to make it

[135] Mortar is almost always weaker than bricks because rapid drying during building erection can lead to shrinkage and cracking of the mortar (Tolles et al., 2002).

smoother, which also will fill the cavities between the earth particles that leads to a more integrated mixture.[136] The chapped straw added to the mud mortar mixture should make it more plastic as far as it is still workable. Since cement has less elastic property, it should be avoided in mud mortar, because they can lead to cracking. Meanwhile, mud mortar mixture should not contain of a large amount of clay, because when the amount of clay is higher than the standard level, it may lead to shrinkage cracks.

Figure 2.41- Mud mortar's mixture without straw, and thatch coating's mixture with large volume of straw prepared for surface coating of the Sistani House of Bam Citadel (Photo by Rouhi, 2015).

Surface coatings are an integral element of an adobe building with direct relation to design, use, structure and building services. They give visual continuity to the interior and exterior spaces of an adobe building. Since adobe surfaces are notoriously fragile and need frequent maintenance, surface coating for their protection is necessarily essential. To protect the exterior and interior surfaces of adobe walls, surface coatings such as thatch coating, sieve coating, whitewash, lime plaster, and so on have been used. Owning to the fact that adobe coatings are exposed to different types of deteriorations, especially the exterior part of adobe construction, those deteriorated parts usually need to be reapplied periodically as much as they are unable to withstand even one season of downpours. Many times the exterior rendering of adobe buildings represents a functional, sacrificial protective coating that has been added to or replaced many times over the years (Tolles et al., 2002).

Since the final step of adobe building has a rough surface, the traditional surface coatings are felt to make it smooth. Depending on where the coating materials are used (external and internal parts), the traditional surface coatings are usually different from each other. However, for better adherence of adobe bricks and surface coatings during execution, it is necessary that all the body of adobe building be wet. During the performance of surface coatings in order to have a smooth surface throughout adobe surface, some binders are used that act as framework, and at

[136] Adobe Construction Essay - MA/ad 2011-12. Retrieved from https://maad2011.files.wordpress.com/2012/03/adobe-construction-essay.pdf

the end, all surfaces are leveled by metal or wooden trowel. In following part, some common types of traditional surface coatings seen in Bam Citadel are described:

- **Thatch Coating (Kahgel in Persian):** the same mixture for mud mortar is used for thatch coating, composed of clay, water and chopped straw. They are usually used for exterior surfaces which are subject to deterioration. Sometimes cow, horse or camel dung is added to mixture to repel insect and decrease cracks in the surfaces.
- **Sieve Coating (Simgel in Persian):** the soil in this mixture should be sieve as far as all gravels and pebbles are removed to obtain a soft soil. It is usually used for interior space. Some lime or cement is added to the mixture to have a smoother surface.[137] Sometimes partially dry dung is applied to sieve coating to help stop the development of cracks.
- **Whitewash (Sefidkari in Persian):** whitewash surface coating consists of gypsum, water and soil. Coloring materials may of course be added. This coating is inexpensive, easy to apply and just used for interior spaces.
- **Lime Coating (Ahakari in Persian):** lime coating is composed of lime, sand and water. It is less flexible, cracks easily and is used to protect a surface from the rainfall erosion.

Figure 2.42- Wetting the external and internal parts of walls during thatch surface coating (Left), and mud mortar surface coating (Right) (Photos by Rouhi 2015).

Figure 22.43- Finished part of adobe walls respectively from left to right by thatch coating, sieve coating and white wash, (Photos by Rouhi, 2015).

[137] One of the facts that should not be neglected is not using cement in the coating mixture, because the adobe-mud brick construction needs to breathe.

2.5 Deterioration Mechanism of the Adobe–Mud Brick Structures

"*[...] our eyes wander over the ruins which, now smoothed by the rains of many years, look as if they are about to melt.*" (Gaube, 1979).[138]

Decay or deterioration is an alteration of material that usually leads to a reduction in resistance, increased brittleness, porosity and a loss of material that usually begins from the outside and works inward; it is mainly related to physical or chemical actions (Croci, 1998).[139] Earthen materials are subjected to several types of degradation, likely to other building materials, but the degradation rate is faster, especially if compared to modern materials (Warren, 1999). In an ideal condition, these structures can last for hundreds of years. These structures throughout their lifetimes are under the exposure of some common causes of deteriorations. However, to obtain the best possible methods to control and limit negative causes of deterioration, it requires an in-depth analysis of deterioration factors, even qualitative predictions of future damage can help focus planning on the mitigation of critical deterioration mechanism in specific geographic areas (Brimblecombe et al., 2008). Therefore, to determine the causes of deteriorations in adobe structures, we need to look at these structures in a different way with different eye. These considerations point the necessity of taking in account diagnosis techniques with the objective to evaluate the state of conservation of the earthen built heritage and adopting methodologies of intervention in order to preserve these constructions (Lombillo & Villegas, 2013).

During the 26 December 2003 of Bam earthquake, the Citadel of Bam (Arg-e Bam) as an outstanding example of a fortified medieval town in southeast of Iranian desert experienced a sever destruction. As said before, this Citadel was entirely built by traditional construction techniques of adobe. In Iran, many culturally significant adobe-mud brick structures are located in an area with high seismic risk, where the future earthquakes will threaten the existence of this vulnerable type of Iranian national heritage. Therefore, the protection of these ancestral heritages due to their local, national and international importance is a solemn duty.

In most of previous studies carried out in various fields related to damage analysis of Bam Citadel during the earthquake, little attention has been given to the secondary causes of deterioration; factors that have had an important contribution to further destruction of Bam's architectural patrimonies during the earthquake. In this earthquake, different deterioration factors together with earthquake have had roles in severity of damages; consequently, their complications could be reduced with more considerations and more protective and preventive measures (Rouhi et al., 2016a).

[138] Gaube Heinz, *Iranian cities*, p. 110.
[139] Croci, G. (1998). *The Conservation and Structural Restoration of Architectural Heritage*. Southampton: WIT Press, p.41.

In the case of deterioration mechanism of adobe-mud brick structures, different authors and researchers have classified the causes of adobe's deterioration in different categories. Warren (1999) reported that the general agencies of failure in adobe structures are as follows: (1) water penetration; (2) plant growth; (3) human agencies and animals; and (4) wind. Tolles et al. (2002) argued that, "The extent of basal erosion can be increased by the abrasive action of wind and sand, burrowing by insects or animals, and plant growth. Gamarra (2008) in his paper published in terra 2008 mentioned, "The monument exhibits four levels of deterioration. These are associated with environmental impact and vulnerability of the building, fragility and fatigue of the earthen structures and architectural surfaces, poor adhesion of the plasters and reliefs on the walls, and extreme fragility and fatigue of the paint. The geographic and topographic location of the archaeological complex (in the desert plateau near the sea and without trees and being exposed to strongly abrasive and contaminated winds from the south) plays a decisive role in the site's complicated pathology, as doing the harsh meteorological agents (wind and sunlight) and human activities (tourism, industrial activities and livestock)." Silva et al. (2009) divide the decay of the earth constructions to:(i) material deficiencies; (ii) foundation problem; (iii) structural defects; (iv) thermal movements; (v) water; (vi) biological activity; (vii) natural disasters; and (viii) wind.[140] As it is understandable by the aforementioned classifications, while each of them has differences in title but they have close views so they share a common means of deterioration factors of adobe structures. In following chart, according to more comprehensive form of classification of deterioration factors, all observed causes in Bam Citadel are categorized in a series of four primary causes, encompassing each a number of secondary factors, see Table 2.6.

Table 2.6- The category of primary and secondary causes of deterioration in Bam Citadel (Designed by Author).

Primary causes of deterioration	Secondary factors
Human Effects	War and vandalism
	Disrespect to the value of cultural heritage and passage of time
	Pervious intervention
Biological Effects	Animals
	Plants
Inherent Effects	Low quality of material and poor composition
	Nonexistent design and construction errors
Natural Effects	Wind
	Temperature fluctuations
	Water interaction
	Earthquake

[140] Silva, R.A., Jaquin, P., Oliveira, D.V., Miranda, T.F., Schueremans, & L., Cristelo, N. (2014). Conservation and New construction of Solutions in Rammed Earth. In: Costa, A., Guedes, J.M., Varum, H. (eds.), Structural Rehabilitation of Old Buildings, Building Pathology and Rehabilitation 2, Springer-Verlag Berlin Heidelberg. pp. 77-108.

- Human Effects

There were three kinds of human damage in the Citadel:

(I) War and vandalism: Bam Citadel is considered as one of the most important military bases in the southeast border of Iran. Throughout history, this Citadel endured many wars for its logistic location. However, its defensive function has threatened its existence during insecurities in the region.

(II) Disrespect to the value of cultural heritage and passage of time: apart from war and vandalism, man's own activities represent the next major threat to cultural heritage properties. There are thus two categories of monuments which can fall into disrepair: those which deteriorate through age and weathering; and those which (often in addition) suffer from clumsy attempts at restoration that give an illusion of rehabilitation, but frequently accelerate decay because of the unforeseen reactions of some of the materials used (Gazzola, 1972). On a chemical level after time, deteriorated adobe becomes weak. The clay platelets, which are flocculated and aligned, become more dispersed, and so the volume of the pores are increased. This causes the weakening of the weathered surface and leads to destruction of the wall and consequently the building (Agnew et al., 1990). In the case of pre-earthquake physical condition of the buildings inside of Bam Citadel, according to available photos, it is revealed that by the passage of time they have become ruins. Once the Citadel of Bam was haunted, not enough attention has been to its protection and conservation. During this period, the Citadel was the subject of some raped, for instances; the people of Bam city had been used the rotten soil of roofs as fertilizer for their date palm and citrus trees, and there were also traces of illegal excavations to dig out antiques. In this case, Tohidi (2014) in his book "*Argname*" brought a document about of unauthorized removal of soil from the Bam's site, so that the mayor of Bam city wrote a letter by No. 2530 on 1956/09/27 to the officer of Bam Citadel about its inadvertence about the removal of soil from Bam Citadel. The mayor also insisted that if it be repeated again he would consider a heavy fine for his irresponsibility.

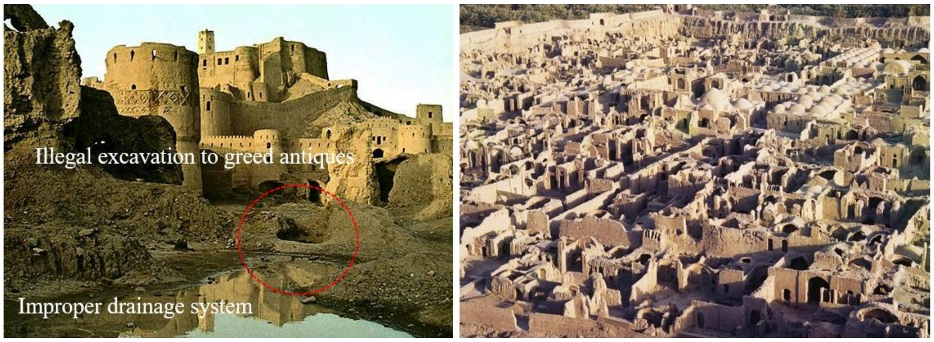


Figure 2.44- (Left) as can be seen, there was not a competent protection in the Citadel before the earthquake, there were signs of illegal excavations and lack of a proper drainage system (Source: archive of ICHO, in the late 20th century); and (Right) ruins of Bam Citadel before the earthquake (Photo by Susumo, 2001. Source: archive of Bam3DCG).

(III) Pervious intervention: as Croci (1998) noted, both lack of scientific knowledge and lowering of the strength are important factors in intensifying the erosion of historical buildings. Besides this, local geographical conditions and pathologies of the structures can also contribute to the acceleration of deterioration if they are not properly maintained (Correia & Fernandes, 2006). During the last few decades before the 2003 earthquake, most of the restoration works had just dealt with respecting the remaining properties and restoring their previous glory, which was the basis of restoration ethics. Hence, attempts had been made mostly to get back the moumnts as close as possible to their former natural aspects. Thus, during this period the engineering knowledge of restoration and dynamic behavior of the structures have not been thoroughly considered. Based on surveys conducted in Bam Citadel for recognizing the causes of damages, it was observed that some changes in the original plans of structures had increased the side effects of the earthquake loads. Therefore, because of applying unsuitable new elements, those structures that had been recently maintained or restored sustained with significantly more damage than those that had not been restored and even strengthened in recent years.

Figure 2.45- (Left) the ruins of the Caravanserai of Bam Citadel after the earthquake shows that the domed rooms along the non-buttressed wall, east side of Caravanserai, survived with partial destruction (Source: Langenbach, 2004), while the ones along the buttressed wall, west side of Caravanserai, embedded during restoration works (1978-2001 AD) mostly collapsed; and (Right) the buttresses in west side of Caravanserai have suffered partial damages (Photo by Chopin, 2007. Source: archive of Bam3DCG).

- Biological Effects

In Bam Citadel damages caused by birds, animals, creepy creatures and plants are identified as the main biological effects of deterioration in adobe properties. In general, the biological effects can be divided into two categories: (I) Animals such as termites, pigeons, snakes, foxes, chameleons and so on; and (II) The impact of the plants including root growth of plants and trees, and the spread of mosses, lichens and fungi in the site.

(I) Animal: the action of living organism can be responsible for the loss of original material and deformation of the original form (Correia & Fernandes, 2006). Even though the scarcity of trees around the city of Bam delimits the use of woods for the buildings, in the center of the Citadel, there are large and beautiful traditional houses made by high quality and luxury materials, including even wood. Moreover, in some parts woods had been used as a tensile element in the higher level of the walls and towers. Hence, protecting the woods from desert termites was a major task for people in Bam. In the Takyieh of Arg-e Bam a large Muller was found, which was probably used for oil extraction. It can be precisely shown that the people of Bam used oil on the surface of woods to prevent termite damages. In addition, adobe brick seem to be the natural house of insects. Some vegetable fibers like straw can increase the probability for termite attacks, thereby weakening them. Termites can survive in places with sufficient water and organic matter. In this case, even after earthquake, during his observation from the ruins of Bam site along the “International Workshop on Bam” (17-20 April 2004) sponsored by UNESCO, ICOMOS, and the Iranian Cultural Heritage Organization (ICHO), Langenbach (2004) drew his attention to the evidence of some infections caused by termite penetration into the walls. In addition to termites, pigeons can cause physic-chemical corrosion on the adobe structures by creating holes in the walls and their excrements. Elsewhere, there are other animals such as foxes, snakes and chameleons that fit their underground activities contribute to the decay of adobe structures by walls subsidence.

Figure 2.46- (Left) bird’s nest on the Barrack of Bam Citadel (Photos by Rouhi, 2015); and (Right) the evidence of termite’s attack on removed palm tree from debris of Bam Citadel after the earthquake (Photos by Rouhi, 2015).

II) Plants: vegetation also has a contribution to the deterioration of adobe structures. In this case, the roots must be removed as soon as possible since sometimes by growth of the plants, this cannot be lifted without causing extensive damage. Meanwhile, living plants provide food to animals, and the holes provided by plants’ roots attract animals searching for shelter. These animals can also develop further damage to adobe structures by drilling new holes and feeding from the organic matter composing the earth. However, because of hot and arid weather condition and low humidity in the city of Bam, deterioration factors caused by mosses, lichens and fungi is so rare.

- Inherent Effects

The Inherent effects of adobe’s deficiency come from low quality of material, poor composition and bad or nonexistent design and construction errors as follows:

(I) Low quality of material and poor composition: naturally, adobe buildings have a severe inherent weakness against deterioration factors. The property of adobe material in the Arg-e Bam was quite scattered and their values principally depended on the type of soil used for the fabrication of the adobe blocks. In the city of Bam, traditional architectures through a consequence of experience-based knowledge have acquired an ideal formula for adobe mixture. Sometime this mixture has been composed of some error in using the right combination of materials. For example if the soil mine lacks enough clay content, besides reducing the compressive and tensile strength of adobe bricks, it would also result in inadequate resistance to excess moisture effects, and if in contrast, the mixture contains a very high clay content, excessive cracking may occur due to shrinkage and swelling problem.

(II) Nonexistent design and construction errors: structural defects caused by incorrect or nonexistent design and due to construction errors can also result in severe destruction to adobe constructions. Regardless of the strength of the building materials, the form of the structure has a direct effect on its seismic resistance (Vatandoust et al., 2008). As stated by Cancino et al. (2009), "The geometry of a building is a critical function of its ability to withstand a seismic event. It is now accepted that thick adobe walls perform more adequately than thinner ones during a seismic event, because the thick adobe wall even after sever cracks can stay stable. Furthermore, adobe walls connected to other walls perpendicularly or those reinforced with buttresses also perform more adequately than those with no reinforced elements. Limited openings along the walls reduce patterns of weakness and increase seismic resistance." [141] Although adobe-mud brick structures have such simple construction methods, some faults in execution of structural elements besides the poor design of plan may have terrible consequences to their structural integrity, so that it can lead to collapse or the formation of large cracks. Therefore, having symmetric plan and a proper-fixed ends can have major effects on reduction of earthquake consequences in adobe structures.

- Natural effects

The remaining original earth fabric must be given maximum protection, as it is highly susceptible to deterioration from exposure and weathering (Matero, 1999). Environmental conditions and natural disaster are among the factors influencing the extent of destruction, erosion and deterioration of the structures in the Citadel. Adobe-mud bricks are very delicate and sensitive to moisture, temperature fluctuations and wind; they can greatly reduce the dimensions of the walls and roofs or cause further defects and cracks.

(I) Wind: it is a dynamic action which accelerates the speed of deterioration in adobe structures. The extent of basal erosion can be increased by abrasive action of wind and sand (Tolles et al., 2002). Studies have been conducted in 2002 show that about 676,000 hectares in eight cities

[141] Cancino, C., et al. (2009). Damage Assessment of Historic Earthen Buildings after the August 15, 2007 Pisco, Peru Earthquake. Los Angeles (C.A): The Getty Conservation Institute, p. 47.

of the Kerman province are zones at risk of wind erosion. Bam is one of these cities, with 166,000 hectares considered to be at high risk and 39,000 hectares considered to be at medium risk. After Kahnouj city, Bam contains the highest percentage of wind erosion zones (Ghafory-Ashtiany & Mousavi, 2005). In the city of Bam we confront with three different types of winds; prevailing wind, dusty wind and sand storm. In the meantime, wind-driven sand and water depend on their acceleration and frequency, which have aggressive effects and inflict severe damage or even lead to the collapse of an adobe structure. In the city of Bam, the speed of seasonal winds and sand storm is sometime up to 130 km/h where they cause massive surface evaporation and mechanical abrasion of adobes.

(II) Temperature fluctuations: rapid changes in climate exacerbate matters and accelerate decay due to the crystallization of salts. Daily and seasonal alterations in temperature and the corresponding cycles of swelling and contraction may create or increase previous cracks that can trigger or accelerate deterioration (Croci, 1998).[142] These movements normally result in vertical cracks, found through the walls length and spaced in regular intervals, and in walls junctions, which diminish the earthen structures monolithic behavior and stiffness. In the city of Bam the winters with moderate temperature is very short, while the summer with hot temperature is so long. According to I.R.OF Iran Meteorological Organization, the average temperature in Bam is about 22.6° C. However, its high average is 39.5 ° C and low average is 4.9 ° C. The temperature has risen to a maximum of 46 ° C in the summer and fallen to a minimum of -9° C in the winter (I.R.OF Iran Meteorological Organization).

(III) Water interaction: careful examination of earth structures all over the world reveals the skills of their conservators in solving the serious problem involved in preserving the durability of structures exposed to water risks, as those built with earth soil are particularly vulnerable to water action. When water stands close to a building or penetrates it, the building runs the risk of rapid deterioration (Correia & Fernandes, 2006). Water is the worst source of deterioration in adobe structures, if the walls become wet their strength will drastically be reduced, sometime due to high moisture of walls they might erode or even fail completely, and the seismic vulnerability of the house increases accordingly. The moisture susceptibility and friability of earthen building materials makes them highly prone to damage by abrasive processes (Brimblecombe et al., 2008). When we are speaking about the impact of water caused by rainfall in cities such as Bam with very low level of rainfall, it might be precise that rainfall according to its low number and short duration has little impact to mud wall. But in contrast, it should be noted that the problem is not the number and duration of rainfall events, so the intensity of rainfall in even short duration can have a deleterious effect. The moistures can enter in the body of an adobe building through large crack in the plaster, roof leaks, gaps at roof (wind towers, chimneys and etc.) and opening (doors and windows) and unwelcome

[142] Croci, G. (1998). *The Conservation and Structural Restoration of Architectural Heritage*. Southampton: WIT Press, p. 46.

aggregation of water in the base of adobe walls. The penetrated waters into the walls behind the plasters by capillary action can saturate adobe walls and cause damage to the dwelling. Then after the volume is decreased only occurs until the moisture content reaches the shrinkage limit of the soil. Whereas long before adobe has reached saturation, its compressive and tensile strengths may have been reduced from 50%to 90% (Tolles et al., 2002). This diminution in load bearing capacity can led to the disintegration of adobe materials even under normal loads. It is also feasible that an adobe wall could become sufficiently unstable as a subject for overturning if significant volume of materials is eroded from its exposed parts. In its current degraded state, the Arg is highly vulnerable to water damage, and additional deterioration is virtually certain, unless steps are taken immediately to protect the complex (EERI, 2004). In the ruin of Bam Citadel, this impact can be seen as bulges at the base of adobe walls. On the other hand, while water is certainly a part of the process, moisture alone doesn't begin to account for the damage seen in affected structures. Instead, the salt cycle involves an intricate interaction between moisture and salts (Liefeld et al., 2014):

- Ground moisture dissolves naturally occurring salts in alkaline soils.
- Capillary action draws salt-laden moisture upward through wall bases, where it evaporates on the surface of the wall, typically just above ground level.
- Crystalizing salts form on the surface (efflorescence) or with microscopic pores of the adobe (sub-florescence).
- As sub-florescing crystals outgrow the surrounding pore structure, they exert enormous crystallization pressures on pore walls (e.g., Sodium Chloride has a crystallization pressure of 56 MPa, or 8,122 pounds per square inch!).
- As the substrate gives way, salt crystals fall to the wall base where they dissolve and increase the salt concentration, driving a viscous cycle.

(IV) Earthquake: earthquakes are a complex societal problem, because they have a low annual probability of occurrence, but high probability of causing significant damage to the structures.[143] The greatest potential problem with adobe buildings is their vulnerability to earthquake ground shaking. However, earthquakes pose a very real threat to the continued existence of adobe buildings because the seismic behavior of mud brick structures, as well as that of stone and other form of unreinforced masonry, is usually characterized by sudden and dramatic collapse (Tolles et al., 2002). Adobe structures among other construction techniques are intrinsically vulnerable to earthquakes. As shown in Table 2.7, the vulnerability classes of adobe structure is included in class A with a probable range of B. However, the problem certainly seem to be more serious when these types of structures are located in seismically active areas. Generally, this type of structure, due to their heavy weight, attracts a large inertia forces during an earthquake, and because of their mechanical properties (low tensile strength,

[143] Benouar, D., Foufa A.F. (2002). *Reducing seismic risk to cultural heritage (medinas and casbahs) in the Maghreb countries*. Retrieved from http://www.geoter.fr/APS/articles/article19.html

low compressive strength and fragile behavior of the material) and their informal construction method (improper link between structural elements), every time an earthquake occurs, they are unable to resist, and often fail abruptly. Nevertheless, when the stresses exceed the tensile capacity of the adobe walls, shear and flexural stresses will cause them to crack more, cracking leads to the loss of the monolithic character of the earthen wall (Iyer, 2014). As mentioned by Randolph Langenbach (2004) about seismic resistance of adobe structures in Bam city, "[…] The buildings are, by definition, of weak construction, and the shaking at the ground level was, as shown by the seismographs, severe. This is particularly the case when the traditional construction involved unfired clay – either of pre - cast masonry or built-up directly as monolithic walls. To many observers, this is the end of the story. Nothing more needs to be said." (Langenbach, 2008). While different factors are arguably the effective factors in developing decay and loss on cultural assets, seismic risk can be named as the main result from the nature that can cause irreparable damages. Apart from the earthquake as significant-based damage on an adobe building, there are other factors influencing the decay and destruction of adobe architecture, not less important than the seismic risks. Unlike those who believe otherwise, to assess damages on adobe buildings, it is possible to consider the earthquake's ground shaking itself before considering any secondary factors. There are several negative factors together (human, biological, inherent and environmental sources of deterioration), with earthquake causing the most massive destruction. These factors, although deemed to have negligible effects on adobe buildings, can gradually contribute greatly to reducing the sustainability of the structures. In addition, these negative factors on cultural heritage for their age are much more important. Therefore, being familiar with the secondary causes of deterioration can help us to better control their destructive effects at the time of an earthquake.

Table 2.7- Attribution of vulnerability classes to different building typologies (Source: Giovinazzi & Lagomarsino, 2004).

Type of Structures		**Vulnerability Class**					
		A	**B**	**C**	**D**	**E**	**F**
Masonry	Rubble stone						
	Adobe (earth bricks)						
	Simple stone						
	Massive stone						
	Unreinforced M (old bricks)						
	Unreinforced M with R.C. floors						
	Reinforced or confined masonry						
Reinforced R.C	Frame in R.C. (without E.R.D)						
	Frame in R.C. (moderate E.R.D.)						
	Frame in R.C. (high E.R.D.)						
	Shear walls (without E.R.D)						
	Shear walls (moderate E.R.D.)						
	Shear walls (high E.R.D.)						
Steel	Steel structures						
Wood	Timber structures						
Situation	Most Possible Class		Possible Class		Unlikely Class		

CHAPTER 3

The 2003 Bam Earthquake and Inscription of Bam and its Cultural Landscape in WHL

3.1 The 2003 Bam Earthquake and its Damages upon the Bam and its Cultural Landscape

-The Seismicity of Iran and Its Effect on Iranian Adobe Cultural Heritage

The history of the formation of Iran, which is known as one of the oldest countries in the world, goes back to 3200 BC.[144] Subsequent to historical background of Iran, adobe-mud brick structures with their glorious and sustainable architecture have constituted the majority of construction technique in most urban fabric of country's historic cities, more specifically in the Central Iranian Plateau. Even today, this type of construction technique is remained as the dominant architectural form in villages and rural areas. In the meantime, due to the inherent seismic deficiency of adobe buildings, earthquakes have posed one of the greatest threats and challenges to this vulnerable type of buildings. The damage caused by the past earthquakes in Iran proves that the adobe buildings are the most vulnerable infrastructure at the time of earthquakes. Recent and historic data clearly show that not only large-scale earthquakes but also even minor to medium rate of earthquakes striking adobe buildings can result in catastrophic destruction, dismal tragedies, high death toll and high loss of cultural heritage properties (Rouhi, 2016b).[145]

Iran is located at high risk of natural hazards (WHO, 2011). A tragic statistics in a nation already ranked Iran as the world's 4th most disaster prone country (IFRC, 2004). In term of seismic hazard, catastrophic earthquakes have frequently struck the Iranian plateau, characterized by active faulting, active folding and recent volcanic activity (Berberian, 1997), so they made Iran as the world's third catastrophic country in the world (NDRI, 2010). The present active tectonics, deformation and seismicity in Iran are mainly because of its location in the Alpine-Himalayan seismic belt, as one of the most active tectonic region of the world, and its convergence with Arabian plates.

The overall convergence of the two Eurasian and Arabian plates is estimated to be about 30 mm/year at 50°E or 40 mm/year at 60°E (De Mets et al., 1994; Jackson, 1992). However, based on the relative risk of earthquake zonation map of Iran, most of the provinces in Iran are located within the high and very high relative risk areas. A study on distribution of Iranian seismic faults reveals that more than 70 percent of the big cities in Iran are situated in the vicinity of seismic faults, and in some cases the active faults pass through the cities (Izadkhah & Amini Hosseini, 2010).[146]

[144] International Ranking of Iran, History and Culture, list of sovereign states by formation date, 2010.
[145] In the time of earthquake, the mortality rates remain appallingly high in societies which are more involved with adobe buildings.
[146] Based on the seismic macrozonation hazard map of Iran, most of the provinces are located within the high and very high relative risk areas (BHRC).

Iran as an earthquake prone country has experienced more than 130 strong earthquakes with a magnitude of 6.5 or more on the Richter scale in past centuries (Ghafory-Ashtiany & Eslami, 1997; Mehrabian et al., 2005; Tabassi & Bakar, 2009), where at least one has the magnitude of 7.0 on the Richter scale every seven years, and one has the magnitude of 6 to 6.9 on the Richter scale every two years. According to Table 3.1, since the beginning of the 20th century, around 32 huge earthquakes in Iran have killed more than 150,000 people.

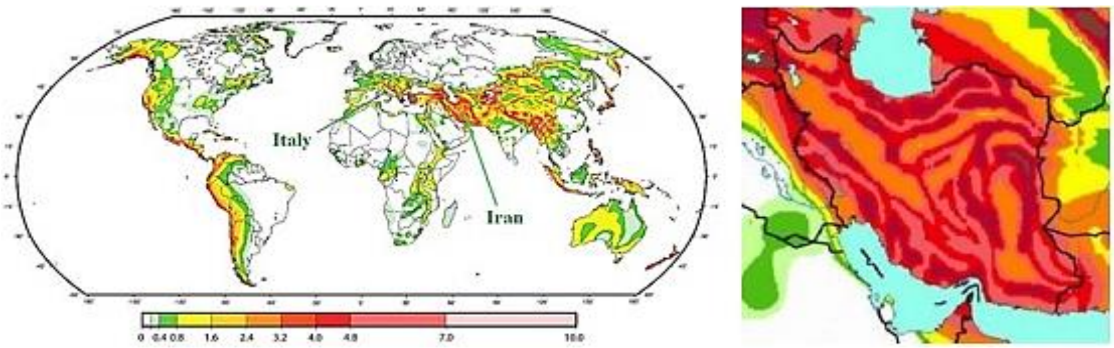


Figure 3.1- Iranian location in world seismic hazard map with peak ground acceleration (m²) with 10% probability of exceedence in 50 years (Source: USGS).

Table 3.1- List of major earthquakes happening in Iranian territory with high casualties (Source: http://earthquake.usgs.gov/earthquakes/world/historical.php).

Earthquake's Name	Mg	Fatalities	Earthquake's Name	Mg	Fatalities
Apr 2013 Saravan	7.8	35	**Apr 1972** Qir	7.1	5,054
Apr 2013 Busher	6.3	At least 30	**Aug 1968** Ferdows	7.3	12,000
Aug 2012 Tabriz	6.4	306	**Feb 1965** Bostanabad-e Bala	5.1	20
Jun 2011 Kahnooj	5.3	2	**Sep 1962** Bou'in-Zahra	7.1	12,225
Dec 2010 Hosseinabad	6.5	11	**Dec 1957** Sahneh	7.1	1,130
Aug 2010 Damghan	5.9	4	**Jul 1957** Māzandarān	7.1	1,200
Sep 2008 Qeshm	6.1	7	**Feb 1953** Torud	6.5	970
Mar 2006 Borujerd	6.1	70	**Aug 1947** Pasni	7.3	500
Nov 2005 Qeshm	6.0	13	**May 1930** Salmas	7.2	2,500-4,000
Feb 2005 Zarand	6.4	At least 602	**May 1929** KoppehDagh	7.4	3,800
May 2004 Mazandaran	6.3	At least 35	**May 1923** T-Heydariyeh	5.7	2,200
Dec 2003 Bam	6.6	~30,000	**Jan 1909** Silakhor	7.3	6,000
Jun 2002 Qazvin	6.5	262	**Jan 1895** Quchan	6.8	1,000
Mar 1998 Golbaf	6.6	5	**Nov 1893** Quchan	6.6	18,000
May 1997 Birjand-Qaem	7.3	1,567	**Jun 1755** Kashan	?	40,000
Feb 1997 Ardabil	6.0	1,100	**Nov 1727** Tabriz	?	77,000
Jun 1990 Manjil-Rudbar	7.4	40-50,000	**Apr 1721** Shebli	7.3	~80,000
Jul 1981 Southern Iran	7.3	1,500	**Aug 1042** Tabriz	7.6	40,000
Jun 1981 Souther Iran	6.9	3,000	**Mar 893** Ardabil	?	150,000
Sep 1978 Tabas	7.8	15,000	**Dec 856** Damghan	7.9	200,000

Records of devastating earthquakes in the regions of Iran dates back to the beginning of writing in the form of clay tablets of the 4th - 3rd millennium BC, and later to the Assyrian, Babylonian and Persian clay tablets and stone slates. During this recorded history by historians and travellers, some Iranian historical cities have been extremely stricken by several earthquakes, and such cities will continue to be encounter with stronger earthquakes in the near future. The decline of civilization in the following cities seem to have been partly, if not largely, due to large-magnitude earthquakes, so some of which were associated with long surface faulting. At least nine destructive earthquakes in 'Nishapur' have reduced the size and changed the location of the city several times. 'Ray', another historical location, has been devastated at least six times in its recorded history. Almost all monuments in 'Tabriz' were destroyed or severely damaged by at least eight large-magnitude earthquakes, especially by the one on 7 January 1780, which reduced all buildings to rubble. Unfortunately, except the 'Blue Mosque' (Masjed-e-Mozaffariya), built in 1465, the city now has very few historical monuments (Berberian, 1997). In many instances, an earthquake would put an end to the life of a city or a town. The survivors would abandon the city and immigrate to other parts. In other instances, it would take decades or even a century before the city recovered from the devastation (Maheri, 2003).

Throughout history, these earthquakes not only have killed thousands of people, but they have also resulted in irreparable damage to a huge number of Iranian cultural heritage properties. In this regard, symptom of Iranian art and culture always have been at risk by an earthquake or sometimes by several scattered earthquakes. In the meantime, the monuments which suffered partial or total collapse were usually subjected to abandon. Among them, we can point to the city of 'Tabas', which was struck by a major earthquake on 16 September 1978, and almost no signs of its culture and history have remained. In the reconstruction program of 'Tabas', which was implemented in the late seventies, the city was particularity reconstructed in such a way that now we cannot find any traces of its historical past, and the characteristic of its urban fabric today is almost like all new cities that have been constructed in recent decades in Iran. However, there is still a major concern over both types of Iranian cultural heritage properties, which have so far not faced or succumbed to strong earthquake. Monuments are an important part of the historical and cultural identity of the Iranian Plateau. Hence, these historical monuments as treasures in local and national communities need to be protected from future earthquakes and the non-periodical nature of the earthquakes would not promote the culture of ignorance and acceptance of such earthquakes and their consequences. This goal is not easily achieved unless by cooperation and participation of architects, engineers, seismologists and restoration specialists of monuments.

In Iran, unlike the abundance of adobe buildings, there is no official regulations for this type of buildings. Nowadays because of the relatively high cost of modern construction techniques, Iranian people in remote areas are primarily interested in employing traditional construction methods. In the meantime, due to lack of proper construction material, lack of sufficient supervision and lack of qualified workmanships, the quality of the newly constructed traditional buildings have not met the current standards and minimum requirements for such buildings. On the other hand, this problem is much more critical for the existing traditional adobe-mud brick structures and cultural heritage properties, which have not followed any standards in any levels for their construction, even in their later conservation and restoration.

Considering the high seismicity of Iran, a comprehensive hazard reduction program was launched in the country by conducting Iranian Code of Practice for Seismic Resistant Design of Buildings which known as "*Iran National Standard No. 2800*", edited in 1988, 1993, 2007 and 2015. Contrary to what was expected, the only existing seismic regulations and codes in Iran did not meet the traditional adobe buildings. In paragraph 1-2-2 (b) of current standard, in the case of mud and adobe buildings, it is mentioned that, "These buildings do not have adequate seismic resistance due to the inherent weakness of their constituting materials. Special provisions shall be observed to ensure relative safety of such buildings against seismic actions. For buildings constructed in remote areas where suitable material may not be easily available, special provisions and technical guidelines shall be developed and implemented to ensure the relative safety of these buildings such as use of wood, steel or concrete resisting elements or any combinations of them or any other suitable material." Accordingly, the case of Bam city, stricken by the earthquake of 26 December 2003, was a glaring example of this absence which resulted in the highest cultural and human losses in recent history in a city of historical importance.[147]

- The 2003 Bam Earthquake

On Friday 26 December 2003 at 01:56:52 GMT (05:26:52 local time at epicenter), a disastrous earthquake leveled the historical city of Bam within few seconds, and put Bam in the headline of all news and press throughout the world.[148] According to data recorded, Bam earthquake was one of the largest earthquakes which occurred in southeast of Iran during the last century. The bulk of damage in Bam occurred in the center of an urban area where besides considerable destruction of man-made constructions, lifeline infrastructures such as hospitals, the water supply system, power lines, educational buildings etc., the earthquake caused the tragic loss of many lifes and the destruction of an overwhelming part of its cultural heritage properties. According to the 'Iranian Building and Housing Research Center' (BHRC), the strong ground motion in this event was accompanied by more than 90 aftershocks, all of which occurred in the vicinity of the main shock up to January 7th, 2004 and caused the re-activation of the Bam fault (BHRC, 2004) (APPENDIX. III). In this case, the U.S Geological Survey (USGS) estimated that the main earthquake with a magnitude around 6.6 on the Richter scale and a focal

[147] Some studies revealed that the high rate of destruction by the previous earthquakes in Iran was mainly due to poor construction techniques and lack of sufficient supervision (Berberian, 2004; Mehrabian et al., 2005; Mehrabian & Haldar, 2005; Tabassi & Bakar, 2009).
[148] The 2003 Bam earthquake occurred very early in the morning, when most of the inhabitants were asleep, which can be recognized as one of the causes for the extraordinarily high death tolls in this event.

depth around 10 km (6 miles) happened at 29.004°N and 58.337°E (USGS, 2004).[149] However, the preliminary investigation of the region has tentatively shown that the earthquake occurred on the Bam fault where it passed from the vicinity of the Bam city (1 km in the east of the city of Bam, between Bam and Baravat[150]). Before this earthquake, the Bam fault was mapped on the geological maps of Iran as a reactivated fault. It was not known whether Bam fault had been active in historical times or not, but the existing records on historical seismicity of the region indicate that Bam fault has been silent for the last two millennium. Based on this, there are some scholars who believe that the earthquake of 26/12/2003 has ended a seismic gap along the Bam fault, so they assume that this seismic gap is equal, in age, to the construction of Bam Citadel, dating back to 2000-2500 years ago, so the Citadel has not been demolished by recorded earthquakes until this recent earthquake. Unlike these assumptions, Manuel Berberian, an Iranian-Armenian earth scientist (2005), states another assumption by which he challenged the history of Bam Citadel: "It has been incorrectly assumed that no major earthquake has taken place in Bam over the past 2,000 to 2,500 years (see Zare & Hamzehloo 2004; Ghafory-Ashtiany 2004; Fu et al., 2004; Askari et al., 2004; Munich Re Group 2004). This assumption is based on the mistaken belief that the present Citadel of Bam is between 2,000 and 2,500 years old. A minimum return period of 2,000 to 2,500 years for a medium-magnitude earthquake along the western margin of the Lut block has not been substantiated." However, through bringing some documents, Berberian proved that the city of Bam has a very old history and so we cannot say anything more about it, but his goal of raising these issues was to reject the aforementioned assumptions.

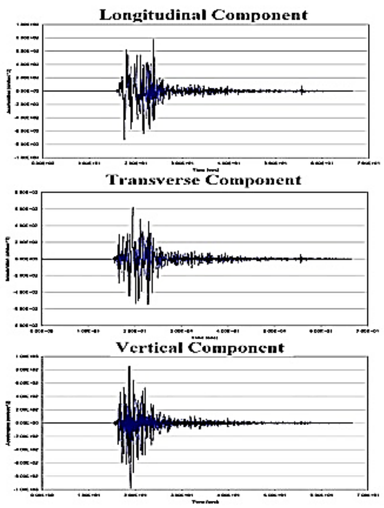
Based on data obtained from 'Bam's Accelerograph Station', the strong motion accelerometers registered shown that the vertical component of the motion has a higher peak ground acceleration (V= 0.999g) than other longitudinal components (fault-parallel motion T= 0.636g and L= 0.781g). In addition, the effective duration of the earthquake was also estimated between 7 and 10 seconds. The response spectra of all three components of motion show a peak in the period range of 0.5 to 1.5 seconds. This is either due to the effects of the local soil response or related to the earthquake source function (ICG, 2004).

As macroseismic intensity map prepared by the IIEES earthquake reconnaissance team (Eshghi et al., 2003) in EM 98 scale, the maximum intensities of Bam earthquake were estimated to be IX in Bam, VIII in Baravat, VII in New-Arg (Arg-e Jadid) and the airport area, and around IV-V in Kerman and Mahan, see Figure 3.3. However, the impact of such a moderate sized earthquake was unexpected rather than a major earthquake on the Richter scale, because of the adobe-mud brick architecture of the city of Bam, the earthquake was particularly destructive.

[149] A detailed report on this earthquake can be obtained from the International Institute of Earthquake Engineering and Seismology (IIEES), online at http://www.iiees.ac.ir/English/bank/Bam/Bam_report_english.html.

[150] Baravat is a city, 5 km to the east of the Bam, which suffered much less extensive or serious damage at the time of earthquake.

In term of financial losses, the damage was estimated at 32.7 million U.S. dollars (USGS, 2004), and from the view of human casualties, the earthquake was ranked as the worst recorded disaster in Iranian history (Teimouri et al., 2008). The earthquake damages were mostly in Bam, where the total number of people directly affected was approximately 200,000 (Manafpour, 2008).[151] However, reports indicated that the main shock killed approximately 31,000 people, left more than 75,000 homeless and 30,000 injuries (USGS, 2004).[152]



Peak Acc. (g)	0.781
Peak Vel. (cm/s)	123.17
Peak Dis. (cm)	34.50
Peak Response Acc. (g) (5%)	2.79
Predominant Frequency (Hz)	5

Peak Acc. (g)	0.636
Peak Vel. (cm/s)	59.68
Peak Dis. (cm)	20.80
Peak Response Acc. (g) (5%)	2.47
Predominant Frequency (Hz)	4.54

Peak Acc. (g)	0.999
Peak Vel. (cm/s)	39.63
Peak Dis. (cm)	8.62
Peak Response Acc. (g) (5%)	3.65
Predominant Frequency (Hz)	10

Figure 3.2- Main shock accelerographs recorded at Bam's station, and unique set of strong motions acceleration recordings during the 2003 Bam earthquake (Source: BHRC, 2004).

During the Bam earthquake, the majority of houses were destroyed (Gharaati, 2006). Based on the reconnaissance visit by the United Nations damage assessment team, 90% of buildings in the city sustained 60-100% damage (WFP, 2003), some 25,000 of the 29,500 structures within the city center and surrounding villages (UN Flash Appeal, 2004), and over 250 villages suffered damage (HFIR, 2009). The remaining 10% of building stock recorded 40-60% damage (Adam et al., 2004). According to static proposed by Ghafory-Ashtiany & Hosseini (2008), taken from the census of 1996, there were 62,364 buildings in Bam prior to the December 2003 earthquake, 34,531 of which were residential. Few homes were steel-framed or constructed of reinforced concrete (20 steel-framed, 11 reinforced concrete); most were constructed of brick

[151] At the time of the earthquake the population of Bam region was about 120,000, among them 80.000 of population were residence in suburban area of the city of Bam.
[152] "Definitive data are not available. Officially, the initial death-toll estimate was 43,200 to 45,000, which was later lowered to 40,000, then 30,000, 26,500, and finally apparently fixed at 31,500. On March 29, 2004, the head of the Statistical Center of Iran _SCI_, announced that: "*Some victims were counted more than once in the chaotic aftermath of the disaster; the earthquake killed 26,271 people and that 525 people were still missing*" _Iranian Newspapers, March 29, 2004, Tehran; irna.ir; SCI, 2004; news.bbc.co.uk_. However, a few months after the event, local inhabitants estimated a possibly exaggerated death toll as high as 79,000. More than 100,000 residents were trapped under collapsed buildings" (Berberian, 2005).

and steel (40.6%), brick and wood (1.9%), brick only (3.5%) and adobe (sun-dried brick and clay, 53.2%) (Ghafory-Ashtiany & Hosseini, 2008). Meanwhile, about 84% of the buildings (including 93.1% of adobe buildings) were built prior to the implementation of seismic codes "*Standard No. 2800*" in Iran (ISC, 2004). However, poor construction techniques together with lack of supervision were found to be the major reasons for the destruction of many newly designed and built buildings.

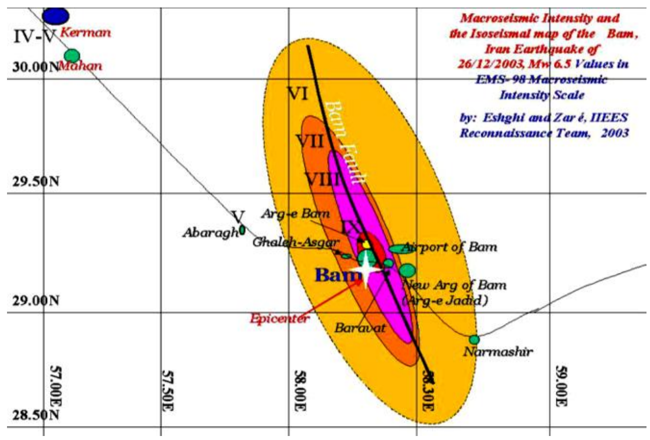


Figure 3.3- The isoseismal map prepared by the IIEES earthquake reconnaissance team (Source: Eshghi et al., 2003).

Figure 3.4- According to Damage Zonation Map from satellite data (Source: Sertit, 2003. Retrieved fromhttp://sertit.u-strasbg.fr/SITE_RM/Archives/16_iran_2003/iran_2003.html) and report presented by International Institute of Earthquake Engineering and Seismology (Source: IIEES, 2004), sever damages were concentrated in the city of Bam, and that in the olden parts, i.e. northeastern and southeastern part of the city more than 80 percent of the buildings were collapsed completely. The Citadel of Bam located within the area was also thoroughly damaged.

The population in the city of Bam was inhabited in four dominant structural system as following (Manafpour & Halcrow Group Limited, 2004):

- Adobe buildings: built from adobe materials and unfired mud bricks. Most of these building have a vaulted roof system.
- Masonry buildings: built from fired bricks or concrete block work as the main load bearing system and normally combined with a jack-arch roof system.
- Steel structures: Typical construction includes frame structures with steel beam and columns and sometimes a braced framing system to resist the lateral loads.
- Reinforced concrete structures**:** Only a limited number of these structures exist in Bam, mostly used for public buildings or government offices.

In general, here the order of new construction system is not that of adobe-mud bricks, which have entirely been displaced by modern materials of steel and concrete, but the evidence shows that traditional buildings in the city of Bam were usually made of adobe bricks. Bam's residents always copied the adobe construction technique from their predecessors and inspired from those technique used in the Citadel of Bam. In fact, these methods not only were not forgotten by the people of the region, but also by passing of time they developed them by a combination of modern and traditional techniques. In this way, the roofs were constructed with steel beam supporting jack-arches of fired brick masonry. These roofs were resting directly onto the unfired brick walls, with no anchors or ties to the walls (Langenbach, 2008). In this case, because of heavy weight of roofed adobe structures by vaults and domes, the walls of these structures were usually thinner than those in adobe supporting roofs.

Figure 3.5- Damage to traditional jack arch slab during Bam earthquake (Source: Manafpour & Halcrow Group Limited, 2004; and Mehri, 2003).

In addition to all of those claims, the devastating earthquake of 26 December 2003 in its subsequent complications also tragically damaged most of the cultural perspectives of the city of Bam and its surrounding areas. In this case, one of the finest and most ancient adobe-mud brick cities in the world, the Citadel of Bam recognized as the architectural jewel of Iranian desert suffered extensive damage ranging from severe damage to total collapse, which can be attributed to the common features of adobe structures and their improper protection. Generally, Bam's cultural landscape covers an area of approximately 20,000 hectares. Bam Citadel is the only part of it, which consisted of set of orchards, cisterns, Qanats and many historic buildings. Before the earthquake in Bam region, there were 23 historic monuments (see Table 3.2), which were legally designated and protected by the ICHO as important cultural heritage. Most of those monuments within the city experienced severe damage and destruction, ranging from 80 to 100% damage, and in other cases, the monuments out of the city were damaged to a lesser degree.

Table 3.2- Some of the main national heritage of Bam city damaged during the 2003 Bam earthquake (Designed by Author).

Site Name	Reg. No	Owner	Date of Reg.	Historical period	Core zone (Ha)
Bam Citadel (Arg-e Bam)	519	S.P	03/1966	Sassanid	73.16
Ansāri Residence	1495	P.P	10/1977	Qajar	0.35
Naderi House	1496	P.P	10/1977	Qajar	0.567
Vakil Ensemble	1729	S.P	06/1987	Qajar	0.76
Ameri House	1835	S.P	02/1997	Zand	0.66
Kushk Rahimabad	2099	S.P	08/1998	Ilkhani	0.115
Vakil Mosque	3506	S.P	03/2001	17-18th Century	P.V.E
Hazrat-e Rasul Mosque	3508	S.P	03/2001	Islamic	0.3867
Shrine of MirzāEbrāhim	3509	S.P	03/2001	Safavid and Zand	0.0308
Bam old Bazaar	4602	P.P	01/2002	Safavid and Qajar	1.08
Soroush Zabolestani House	6136	P.P	08/2002	Pahlavi	0.1068
Ice-House (Yakhdan)	6759	S.P	12/2002	Safavid- Qajar	P.A.B
Stable	9565	S.P	08/2003	Ilkhani to Safavid	P.A.B
Qal'eh Dokhtar	9566	S.P	08/2003	Sassanid	3.71
Emād School	9567	S.P	08/2003	The late of Qajar	0.1785
Jewish Hose (West Sabat House)	9568	S.P	08/2003	Ilkhani to Qajar	P.A.B
Ahmadiyeh School	9570	S.P	08/2003	First Pahlavi	0.09
Friday Mosque of Bam Citadel	9571	S.P	08/2003	Islamic to Qajar	P.A.B
Mirza Naem School	9572	S.P	08/2003	Qajar	P.A.B
Bam Old Hospital	9588	S.P	08/2003	First Pahlavi	1.9300
Hana Sai	14309	P.P	03/2006	early of Pahlavi	0.4

Notes: P.A.B: Part of Arg-e Bam - P.V.E: Part of Vakil Ensemble - S.P: State Property - P.P: Private Property

Figure 3.6- Vakil Ensemble before and after the earthquake (Source: (Left) archive of ICHHTO, before the 2003 Bam earthquake; and (Right) Rouhi, 2015).

Figure 3.7- Mirza Ebrahim Shrine before and after the earthquake (Source: archive of ICHHTO).

Figure 3.8- East part Ameri House before and after the earthquake (Source: Andaroodi, 2013).

Figure 3.9- Hana Sai before and after the earthquake (Source: (Left) archive of ICHHTO; and (Right) Rouhi, 2015).

Figure 3.10- Bazaar of Vakil before and after the earthquake (Source: (Left) archive of ICHHTO, before the 2003 Bam earthquake; and (Right) Rouhi, 2015).

Figure 3.11- Satellite photo from Bam Citadel before and after earthquake (Source: archive of RPBCH).

Figure 3.12- Aerial photo from Bam Citadel before and after the earthquake (Source: archive of RPBCH).

According to damage zonation map prepared by Keramat (2008), it can be seen that the intensity of damage caused by the earthquake varied widely from one point to another point of the Citadel. Such variation was caused by several factors and their combination, including building material and construction method, geological and seismic issues.[153]

Bam Citadel before earthquake has V= 295932.10 m^3, 70145.70 m^3 of which collapsed by the earthquake, and 225789.39 m^3 of it remained.[154] After the earthquake, the volume of buildings before and after the earthquake was calculated to assess the percentage of damage in each part of Bam Citadel. Despite the massive structural changes that occurred at the time of earthquake, the plan of buildings remained fixed. In this case, to estimate and compare conditions of buildings before and after the earthquake, aerial and satellite photos, pre-earthquake maps and other available documents were used. In the process of data records, the following formulas were used (Keramat, 2008):

Volume before earthquake (B. E volume (m^3)) = Width (m) × Length (m) × B.E Height (m)
Volume after earthquake (A.E volume (m^3)) = Width (m) × Length (m) × A.E Height (m)
Ruined volume (m3) = B.E volume (m^3)) – A.E volume (m^3)
Destruction (%) = Ruined volume (m^3)) ÷ B.E volume (m^3) × 100

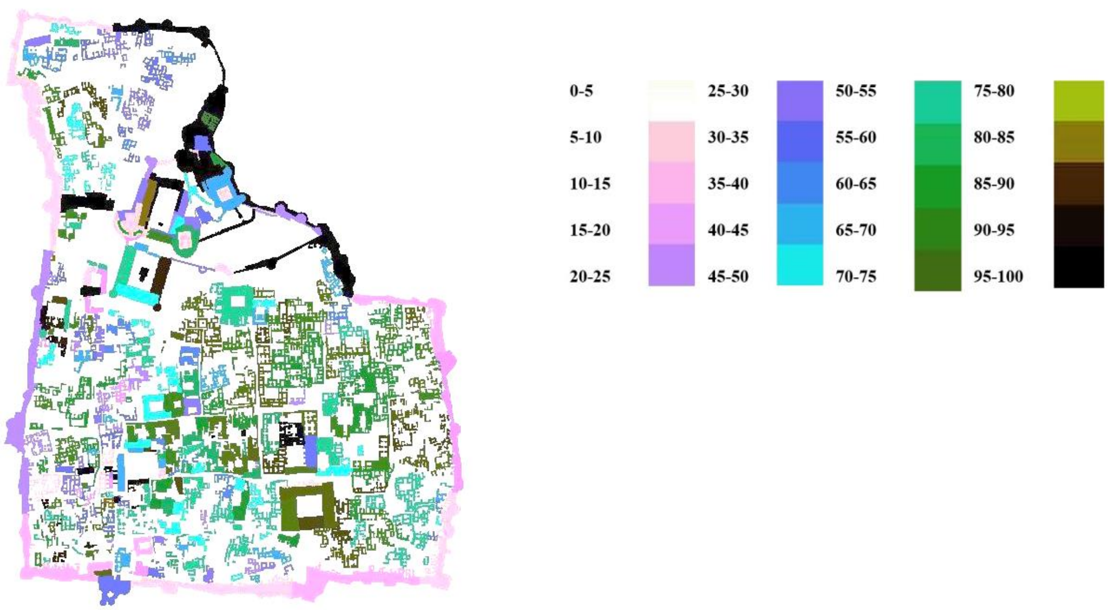


Figure 3.13- The percentage of seismic damage in different parts of Bam citadel (Source: Keramat, 2008).

153 According Author's site visitation from Bam Citadel the current damage zonation map in some parts is not correct like Caravanserai.
154 Here the means of Volume (V) before earthquake is parts of the fabric which were upper than the adjacent land and were built by the intervention of architects (Keramat, 2008).

In Vol.1 - No.2 issued in 2007 of the special serial publication, "*Annual Report of Arg-Bam Research Foundation*", commenced after the earthquake. Mr. Nejati, vice-director of Bam recovery project, described the influential factors and their types recognized in the series of building damage of Bam as follows:[155]

▪ Vulnerability to seismic damage: analysis of earthquake proved that the unevenness of ground could have caused difference of vulnerability, and that even in the same building, a variety of building materials and construction methods of previous restoration as well as time difference of restoration stage could have affected the condition of damage.
▪ Effect of previous restoration work: restoration work carried out in Iran so far has always sought for the authenticity of structures and spaces, but it has not been prepared for earthquake and other disasters.
▪ Effect of lack of seismic design: the facts of earthquake are very often ignored in Iran due to considerably long intervals between earthquakes; therefore, architects and other building craftsmen have no experience of seismic disaster.
▪ Effect of faults of building materials: substantial weakness of mud-brick adobe was an important cause as well as low seismic resistance of mud-brick structure.[156]
▪ Effect of faults in architectural plan and foundation design: the difference of damage might have been suggested by confirming the presence of accurate design of dome and arch by means of precise measurement; besides, lack of foundation in many of the buildings could have made a worse loss.[157]
▪ Effect of other natural factors: damage done to timber by termites is an example of this category; damage by wind like sandstorm cannot be also neglected. Neither of them needs to be emphasized in comparison with seismic damage.

Apart from points noted by Mr. Nejati, there are other factors contributing to the diversity and severity of damage in Bam Citadel, which are as follow:

▪ As mentioned before, in the city of Bam since 26 December 2003 earthquake, there have been more than 90 aftershocks. The aftershocks also in their own turn have caused additional damage to some of the fragile parts of Bam's adobe cultural heritage prperties.

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[155] Kokushikan University. (2010). Focused on the Case of Bam. Research Report on International Cooperation in the Recovery Process of Disaster-affected Cultural Heritage, Japan Consortium for International Cooperation in Cultural Heritage (JCIC-Heritage), pp. 110-111. Retrieved from https://www.jcic-heritage.jp/doc/pdf/2010Report_disaster_eng.pdf
[156] As bonding strength tests conducted by Kiyono & Kalantari (2004) on 12 samples of adobe mortar extracted from adobe buildings of Bam city, after the 2003 Bam earthquake, they proposed that "improper" bonding strength of mortar had been the main cause of damage for Bam's adobe buildings. It should also be noted that the results of the bonding strength tests (tension and shear) show considerable variation.
[157] In Bam Citadel, most of the structures lacked foundations, and with the exception of the Governor's Quarters (built on a stone bed), most of the structures were constructed on a bed of secondary soils.

▪ The relatively long duration of the Bam earthquake (almost 13 sec.) has a significant role in sever destruction of adobe monuments.
▪ The strength of peak ground acceleration (nearly 1g PGA) and its high intensity in the vertical direction, as Tolles et al. (1996) mentioned, ground shaking levels between 0.1 and 0.2 g PGA are necessary to initiate damage in well-maintained, but otherwise unreinforced.
▪ The adobe structures are composed of a variety of form, such as vaults, domes, wind towers, walls, etc. Naturally, each of those parts responds differently during an earthquake, and by their collapse might cause damage to the other stable parts of an adobe building.
▪ The values of the earthquake ground acceleration components in Bam region, based on distance from earthquake's epicenter and fault, is another reason for diverse levels of damages in the city, so the damages were more in areas closer to the epicenter and fault.
▪ In an earthquake, resonance, the behavior of site soils and the relation between the frequencies of the foundation and the soil, can be one of the most destructive factors. When those frequencies are similar, exaggerated movement and failure can occur (Vatandoust et al., 2008). In Bam city, the oldest part was built over the rock base and the later parts had been built on the soft alluvial soil, and rock base in its turn has the characteristic of amplifying the seismic potentials.[158]

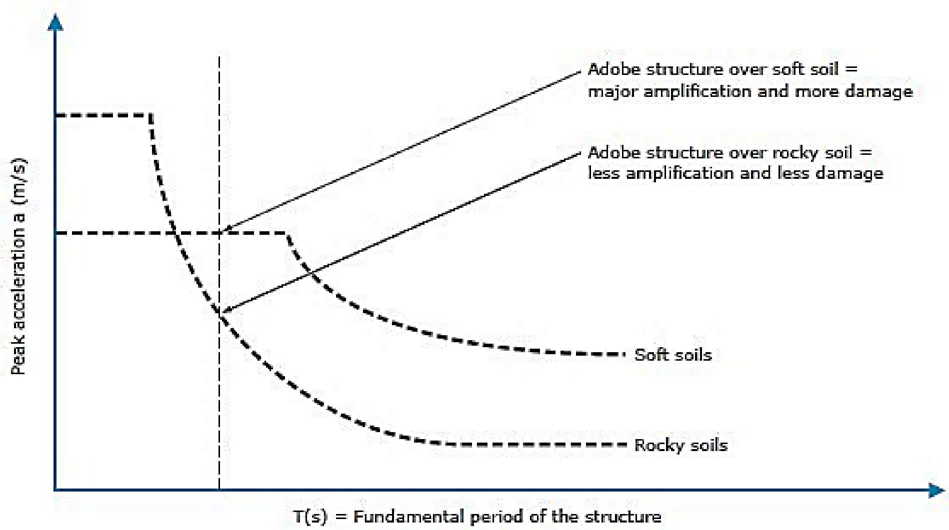

Figure 3.14- The diagram shows the theoretical response spectrum of an adobe building over rocky vs. soft soil (Source: Cancino et al., 2009).

[158] The severity of the ground motion is impossible to control or prevent and is conditional to the soil type on which the structure is built. Soft soils will amplify the energy frequency or the ground motion acceleration generated by the earthquake while firm or rocky soils will absorb them, producing less damage to still standing structures and allowing more time for occupants to leave the building before sudden collapse occurs. Buildings over soft soils suddenly collapse in less time than the ones built over rocky soils and, in most of the cases, fall with occupants still inside (Cancino et al., 2009).

Apart from all of those damages, the agro-economic losses to Bam were also significant since the Qanats were severely damaged, and the water in many of them was no longer conducted. The rupture of Qanats as an important part of Bam's urban landscape has intensified regional water management problem in both agricultural (Bam's world-famous date trees) and residential contexts. So seismic rehabilitation of the Qantas is a comprehensive project and technically strong rehabilitation plans should be designed for this purpose (Mehrabian et al., 2005). Before the earthquake, there were more than 374 Qanats in Bam region. Among 64 Qanats supplying water to Bam's world-famous date gardens, 30 experienced heavy damage and need urgent restoration. The remaining Qanats suffered damage approximately 40 to 50% (JICA & TDMMC, 2005). According to Pellet et al (2005), "Most of the sinkholes were related to the collapse of shallow qanats of 3-10 m in depth, but a few cases of deep sinkholes can also be observed in the area. The size of sinkholes varied with the dimensions of underground openings, any enlargement process that may have occurred, and erosion of shaft and tunnels. In some locations, because of existing close parallel galleries, very large sinkholes were formed at the ground surface." He also mentioned that, "Near the Bam fault, the damage was more severe and several small and large sinkholes were observed. Far from the fault, the effects of earthquake on qanats were less intense, and only some fissures and cracks were observed along the galleries and shafts that were related to the small settlement or partial collapse of some parts of the qanats."

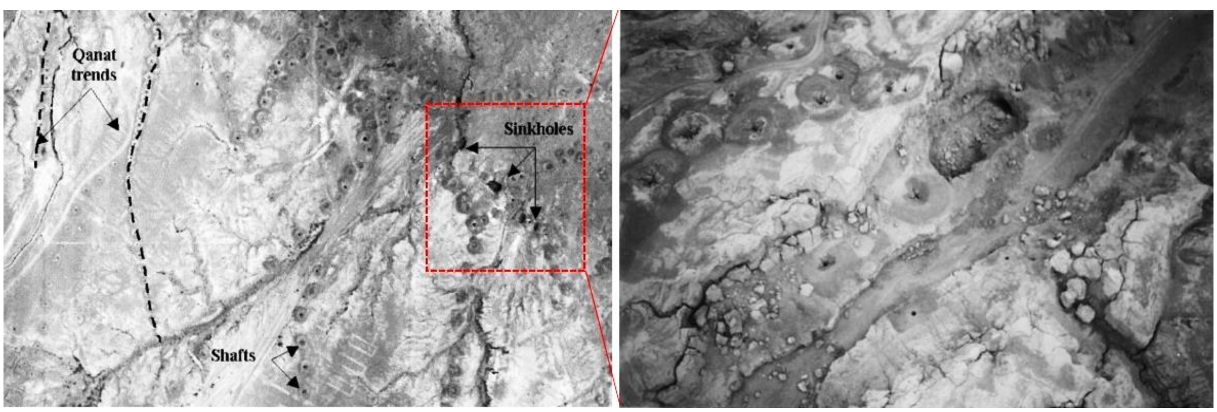

Figure 3.15- Location of some sinkholes west of Baravat (Source: Pellet et al., 2005).

After the earthquake, the government with the help of NGOs tried to facilitate the repair of qanats by investing in equipments, techniques and tools which created substantial changes in qanat knowledge in the area; however, insufficient work done by inexperienced workers sometimes resulted in further damages and destruction (Semsar-Yazdi et al., 2005).[159]

[159] "According to Dehghan Manshadi, the manager at department of soil in Agricultural Jihad office in Bam, almost all of the qanats existing before the earthquake have been restored up to the extent that the water is flowing in them. He states that the rate of restoration was not equal for all qanats, and the percentage differs from 10 to 100% restoration. But the biggest challenge is lowering the water level in

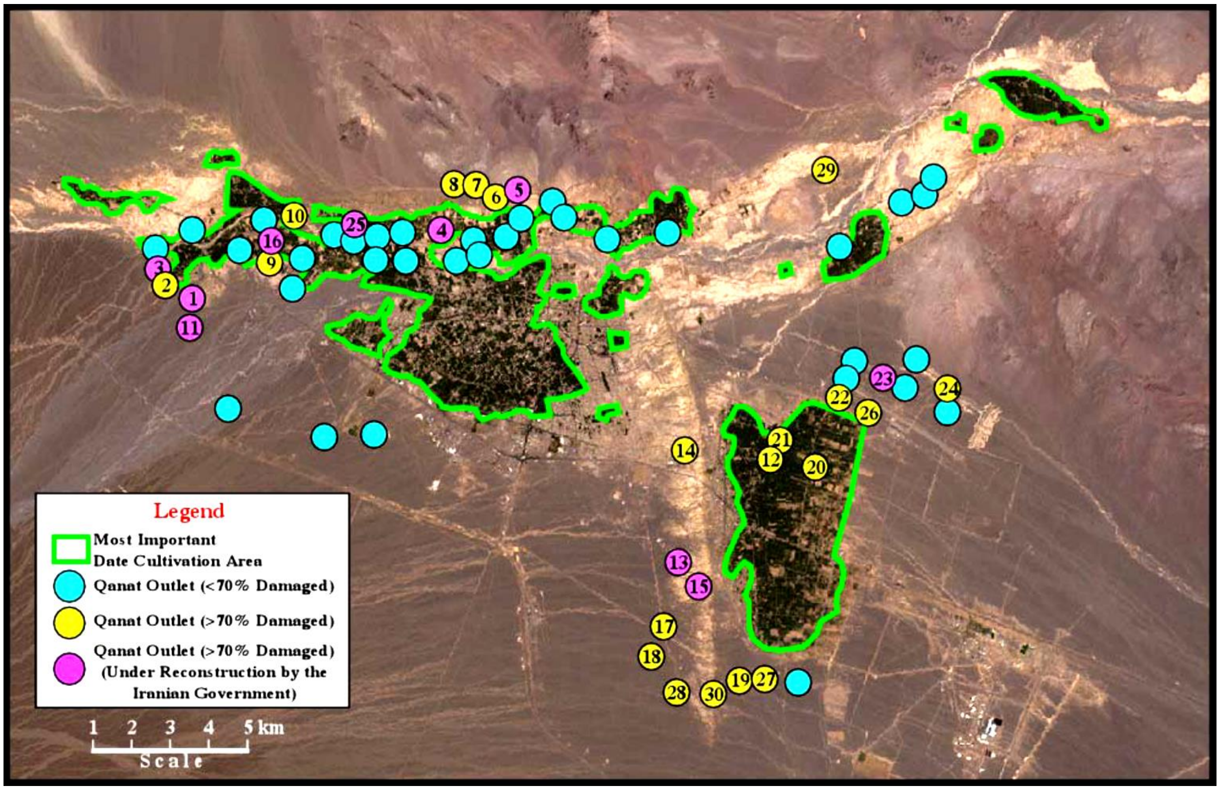

Figure 3.16- Damaged Qanat Distribution Map in Bam region, and those, which are under reconstruction (Source: JICA Study Team).

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the area, due to excessive use by qanats and deep wells. One major problem for water resource management in the area is that two different organizations are in charge of qanats and the deep wells, and many times they fall short in communication while issuing permission for new diggings. The impacts of such mismanagement have to be further discussed and analyzed" (Sabetian, 2014).

3.2 Typology of Seismic Damages Observed in Bam Citadel

The tragedy of Bam earthquake and what happened over the Bam Citadel, as a result, entails the need to evaluate the seismic vulnerability of adobe structures. Therefore, documentation of the actual damages resulting from strong ground motions are essential to understand how historical adobe buildings perform, or in fact behave at the time of earthquakes. In this case, survey about structural behavior of the adobe masonry constructions, analyzing their seismic vulnerability, which may help in preventing social, cultural and economic losses (Varum et al., 2014). During an earthquake, adobes are exposed to extreme tensile strength, so they are unable to function well structurally. As Cancino et al. (2009) stated, "Adobe, typically used to build thick and massive walls, is a low-strength building material that is able to resist compression, but is weak in response to tensile forces. The stresses absorbed by an adobe wall during an earthquake normally exceed the wall's tensile strength. The building dissipates the energy released by the earthquake through crack formations that divide the wall into isolated blocks that pound against each other until the structure suddenly collapses."[160] About the extent of earthquake damage to an adobe structure, Tolles et al. (1996) pointed out, "it is a function of (a) the severity of the ground motion, (b) the geometry of the structure, i.e., the configuration of the adobe walls, roof, floors, openings, and foundation system, (c) the existence and effectiveness of seismic retrofit measures, and (d) the condition of the building at the time of the earthquake." Elsewhere, Dowling (2004) also expressed that, "the seismic capacity of an adobe house depends on the mechanical properties of the materials (blocks and joints), on the global structural system (structural geometry, connections, etc.), on building foundations, and also on the quality of the construction and maintenance." Generally, adobe structures have a brittle behavior and may collapse without warning (Blondet et al., 2006); even there is not enough time for evacuation. That's why, adobe structures, the only earthen structures listed in the 1998 European Macroseismic Scale (Grunthal, 1998), according to which, together with rubble stone, are the most vulnerable structures to earthquakes (NIKER, D3.1, 2010).

The term 'damage' is used to describe a situation in which a structure has lost some or all of its bearing capacity, a condition that can lead to failure and collapse (Croci, 1998).[161] To address the damage typology of a special type of structures, there are different vulnerability assessment methods, which are presented in various published technical literatures. These methods can be divided into four groups; empirical methods, judgment-based methods, mechanical methods and hybrid methods. Among these methods, the first two are qualitative, whereas the last two are quantitative methods. Although the use of known numerical and modeling analysis techniques would approximately estimate the dynamic behavior of individual adobe structures

[160] Cancino, C., et al. (2009). *Damage Assessment of Historic Earthen Buildings after the August 15, 2007 Pisco, Peru Earthquake*. Los Angeles (C.A): The Getty Conservation Institute, p. 46.
[161] Croci, G. (1998). *The Conservation and Structural Restoration of Architectural Heritage*. Southampton: WIT Press, p.41.

in an ideal condition, but they cannot exactly show the real seismic function of an adobe building.[162] The main reason for this can be that the earthquake can significantly increase the internal reactivity of the adobe materials, which have been exposed to many deterioration factors over time, but for those numerically or experimentally analyzed there are no considered deterioration factors (Rouhi, 2017b).

For centuries, lessons learned from earthquakes and other natural disasters have been used to advance construction techniques, and more recently, such lessons have fostered the development of the engineering and historic preservation disciplines, as well as the testing and review of current building codes and disaster management policies and procedures (Cancino et al., 2012).[163] Generally, post-earthquake damage assessments will offer an opportunity to understand why buildings fail, and will provide information that can serve as the basis for the seismic improvement of buildings. For describing and comparing the relative damage rates sustained by buildings following Bam earthquake, it is useful to have a definite set of categories that describes the intensity of damage in different classifications. Owing to abnormal seismic behavior of adobe buildings and their non-compliance behavior to a certain principle, as well existence of differences in their construction practices from region to region, it is so difficult to render a general standard for their seismic behaviors. Therefore, studies about these types of structures are region specific. Since in Iran, there is no comprehensive standard for adobe structures, in order to denote how strongly the 2003 Bam earthquake affected monuments in Bam Citadel, two international standards are used, which can be referred to:

- **The Earthquake Engineering Research Institute (EERI 1994)**: In this division, the building damages are categorized into five grades from “A= None to E= Complete”.
- **The European Macroseismic Scale (EM-98)**: In this classification, the building damages are categorized into twelve grades from “I= Not felt to XII= Completely devastating”.

Based on the observed damage data from the Bam earthquake, the result indicated that damages on Bam Citadel were initiated at an earthquake intensity of VIII on EM-98 intensity scale and were classified into Grade D and Grade E on EERI 1994 standard.

Table 3.3- Standard damage states by EERI 1994 (Source: Tolles et al., 1996).

Damage state	EERI description	Comments on damage to historical adobe buildings
A None	No damage, but contents could be shifted. Only incidental hazard.	No damage or evidence of new cracking.

[162] The determination of earthquake size on macroseismic intensity scale is based on human observations which are made during an earthquake regarding the damage of natural and built environment (Kramer, 1996).
[163] Cancino, C., et al. (2012). *Seismic Retrofitting Project: Assessment of Prototype Buildings*, Volume 1. Los Angeles (C.A): The Getty Conservation Institute, p. 7.

B Slight	Minor damage non structural elements but probably could be reopened after cleanup in less than one week. Only incidental hazard.	Pre existing cracks have opened slightly. New hairline cracking may have begun to develop at the corners of doors and windows or the intersection of perpendicular walls.
C Moderate	Preliminarily non-structural damage but there could be minor, non-threatening structural damage. Building probably closed for 2-12 weeks.	Cracking damage throughout the building. Cracks at the expected locations (openings, wall intersections, slippage between framing and walls). Offsets at cracks are small. None of the wall sections are unstable.
D Extensive	Extensive structural and non-structural damage. Long term, closer should be expected, due either to amount of repair work or uncertainty of economic feasibility of repair. Localized, life-threatening situations would be common.	Extensive crack damage throughout the building. Crack offsets are large in many areas. Cracked wall sections are unstable. Vertical support for the floor and roof framing is hazardous.
E Complete	Complete collapse or damage that is not economically repairable. Life-threatening situations in every building in this category.	Very extensive damage. Collapse or partial collapse of much of the structure. Due to extensive wall collapse. Repair of the building requires reconstruction of many walls.

Table 3.4- Standard damage states by EM-98 (Source: Grunthal, 1998).

Damage state	EM-98 description
I. Not felt	Not felt by anyone.
II. Scarcely felt	Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.
III. Weak	The vibration is weak and is felt indoors by a few people. People at rest feel swaying or light trembling. Noticeable shaking of many objects.
IV. Largely observed	The earthquake is felt indoors by many people, outdoors by few. A few people are awakened. The level of vibration is possibly frightening. Windows, doors and dishes rattle. Hanging objects swing. No damage to buildings.
V. Strong	The earthquake is felt indoors by most, outdoors by many. Many sleeping people awake. A few run outdoors. Entire sections of all buildings tremble. Most objects swing considerably. China and glasses clatter together. The vibration is strong. Top-heavy objects topple over. Doors and windows swing open or shut.
VI. Slightly damaging	Felt by everyone indoors and by many to most outdoors. Many people in buildings are frightened and run outdoors. Objects on walls fall. Slight damage to buildings; for example, fine cracks in plaster and small pieces of plaster fall.
VII. Damaging	Most people are frightened and run outdoors. Furniture is shifted and many objects fall from shelves. Many buildings suffer slight to moderate damage. Cracks in walls; partial collapse of chimneys.
VIII. Heavily damaging	Furniture may be overturned. Many to most buildings suffer damage: chimneys fall; large cracks appear in walls and a few buildings may partially collapse. Can be noticed by people driving cars.
IX. Destructive	Monuments and columns fall or are twisted. Many ordinary buildings partially collapse and a few collapse completely. Windows shatter.
X. Very destructive	Many buildings collapse. Cracks and landslides can be seen.
XI. Devastating	Most buildings collapse.
XII. Completely devastating	All structures are destroyed. The ground changes.

To survey the damage typologies of adobe monuments in Bam Citadel, it has been tried to provide descriptions, figures, and photographs of damage failures observed in adobe walls, arches, vaults, and domes after the December 26, 2003 earthquake in Bam city. The more common types of damages can be summarized in four groups, each of which has been surveyed separately: (I) Damage on Adobe Surface Coating; (II) Damage on Adobe Walls; (III) Damage on Adobe Roofs; and (IV) Damage on Adobe Towers.

At first, to survey the damage typologies of adobe-mud brick structure, it would be worth to have a glance at the origins of cracks in adobes, and the mutual impact of their dimensions on the structural damage. In adobe structures, cracks may be caused by the expansion and contraction of materials, inadequate foundations or differential settlement, moisture invasion, wall movement from a collapsing roof structure, lateral loads from pitched roofs and openings, removal of an earthen roof, or by poorly constructed walls and more seriously with seismic motions.[164] However, it is important to determine the structural integrity of the wall (Cornerstones Community, 2006).[165] In 1992, Weaver in his book entitled "*Conserving Buildings, Guide to Techniques and Materials*", generally categorized structural cracking into two groups: first, no effect on the structure, other than aesthetic and second, effect on use and serviceability of the building.[166] The first category, which includes four classes (between 0.1 mm (very difficult to see) to 2.0 mm (can be seen in clear light from a few meters), is one in which the cracking has no serious effect on the structure, or at least only with an aesthetic effect. These cracks can be caused mostly by natural expansion/contraction cycle that is daily and seasonal. The second category also consists of four classes (between 2.0 to 5.0 (visible) to more than 25.0 mm (easily discernable from distance), in which the first three classes are related to serviceability and the fourth class is in a dangerous condition.[167]

Table 3.5- The origins of cracks in adobes, and the mutual impact of their dimensions on the structural damage (Source: Weaver, 1992)

Categories	Originate of cracks	Cracks size (mm)	Visibility of the faults or cracks	Effects of cracks on the structure
First Category	These cracks caused by initial shrinkage in new materials or thermal expansion	Less than 0.1	Very difficult to see	No effect
		0.1 to 0.3	Hairline cracks	Not serious
		0.3 to 1.0	Can be seen closely	In large numbers will have aesthetic effect

[164] During earthquakes, the ground shakes in all directions and generates inertial forces that earthen materials should be able to withstand. Since the compressive strength of adobe is much higher than its tensile strength, significant cracking starts in the regions subjected to tension (Blondet et al., 2006).

[165] Cornerstones Community. (2006). Adobe Conservation: A Preservation Handbook. New Mexico: Cornerstones Community Partnerships, p. 67.

[166] Weaver, M.E. (1992). *Conserving Buildings, Guide to Techniques and Materials*. New York: John Wiley & sons, p. 5.

[167] The best tool for measurement of cracks dimensions is using an Avongard-type crack monitor.

	and contraction over a long period	1.0 to 2.0	Can be seen in clear light from a few meters	Aesthetic effect
Second Category	Penetration of water, serious or extremely serious structural damage, structural movement, settlement of columns, footings or bending of beam or trusses	2.0 to 5.0	Visible	Cracking of arches
		5.0 to 15.0	Easily discernable	Jamming of doors and windows, cracking of walls, shear diagonal cracking in ceilings, falling plaster, collapsing arches, breaking of plumbing and pipes
	Sudden change or removal of the supports, mining subsidence, collapsing excavations	15.0 to 25.0	Easily discernable, Cracks are grouped, Visibility of distortions with naked eye	Collapse of masonry arches, walls, chimneys Distortions of bearing elements
		More than 25.0	Easily discernable from distance	Dangerous structure, structural collapse without warning

(I) Damage on Adobe Surface Coating

Crack is a typical feature of historic adobe buildings, and occurs constantly throughout the life cycle of an adobe building. Due to the expansion of adobe materials after drying and their exposure to environmental changes, as a reaction to accommodate by surrounding changes, cracks occur both at the macro and micro levels in the adobe materials.[168] Generally, cracks in adobe buildings can be characterized to be reversible or irreversible in character. However, in areas where the material strength is exceeded in either shear or tension, earthquake will produce more superficial cracks on adobe façades, so sometimes the result as the reversible crack's damages would appear as distortion and failure in adobe surface coatings. In addition, it should be noted that adobe surface coatings have a large thickness, and the gravity of these materials and the quality of their mortars have a main roles in the level of damage during an earthquake.

(II) Damage on Adobe Walls

In this case, to survey the incurred damages on adobe walls of Bam Citadel, the studies of Tolles et al. (1996), which was conducted on 20 historic and 9 older adobe buildings in California after the Northridge earthquake (Mw 6.7, 60 fatalities) in 1994, and Dowling (2006), who has a damage survey on adobe buildings after El Salvador earthquake (Mw 7.7, 825 fatalities) in 2001 are referenced. In this way, after being familiar with possible damage typologies, which during an earthquake may happen on adobe walls, the damage typologies observed in Bam Citadel

[168] There are some generic reasons, which can cause movement and lead to the development of different types of cracks in adobe materials, such as foundation failure, thermal movement, decay of superstructure, moisture movement, inherent defects, deflection under loads and ground movement.

were identified. Seismic damage patterns characteristic of historic adobe structure are summarized in Figure 3.19.

Figure 3.17- Damage on adobe surface coating in the Mirza Na'im School of Bam Citadel (Source: personal archive of Prof. Luigi Marino, 2007).

Table 3.6 provides details of the damage typologies on adobe walls along with life safety and historical fabric concerns for each type of damages. As referred in this table, some damage types are usually slight, but they may become serious if the structure is subjected to greater displacements resulting from an earthquake with a longer duration together with a large number of aftershocks, or repeated earthquakes, particularly when no intermittent corrections and repairs have been carried out. It should be considered that in most cases, different types of damages do not act independently, but rather in combination. In fact, the combination of several damage typologies can cause other types of damages. In general, although there are simple relationships between some type of damages, but in other cases they might have a very complex relation.

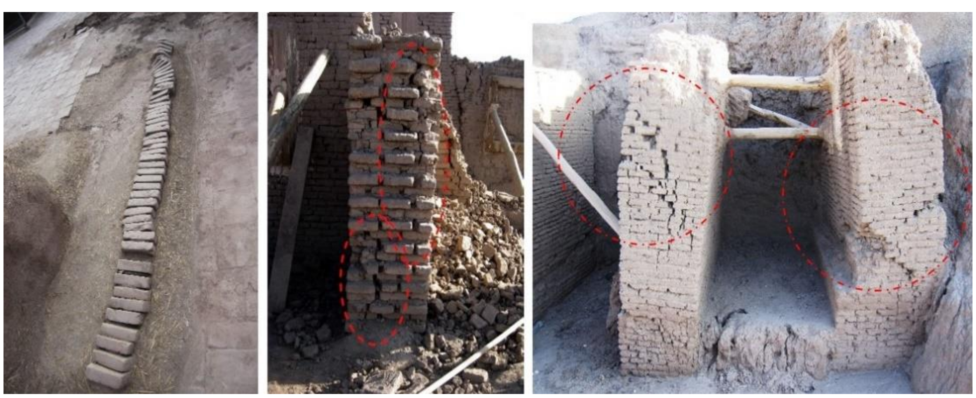

Figure 3.18- The effect of vertical and horizontal components acceleration of the 2003 Bam earthquake on the walls of Bam Citadel (Photos by Rouhi, 2015).

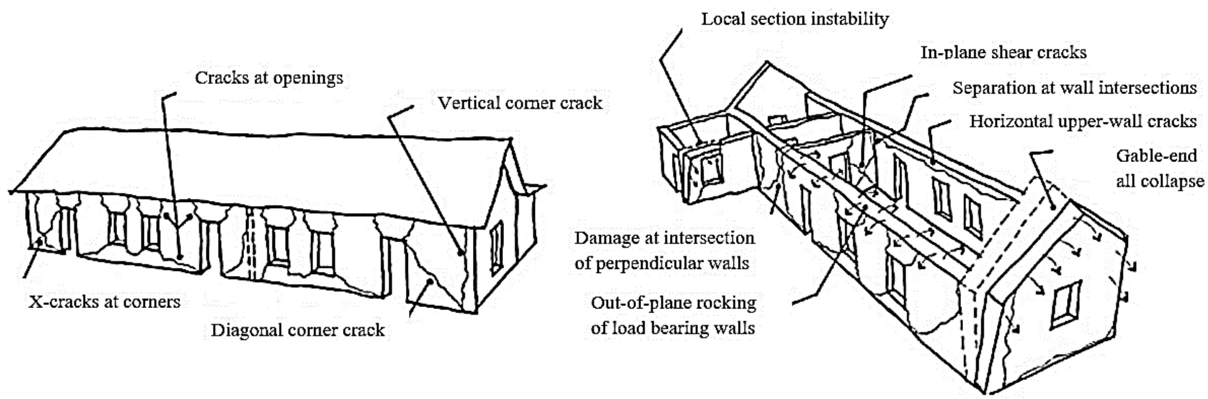

Figure 3.19- Seismic deficiencies of adobe buildings (Tolles et al., 1996).

Table 3.6- Seismic damage typologies of adobe walls (Tolles et al., 1996).

Type		**Description**	**Life safety and historic fabric**
Out of plane	**Gable end failure**[169]	Gable-end walls suffer severe cracking that often leads to instability. Gable-end walls are tall, poorly attached to the building, have large slenderness (height-to-thickness) ratios, and carry no vertical loads.	Collapse of gable-end walls is a serious life-safety threat and causes extensive loss of historic fabric.
	Flexural cracks and collapse	Flexural cracks begin as vertical cracks at transverse walls, extend downward vertically or diagonally to the base of the wall, and extend horizontally to the next perpendicular wall. <u>**The existence of cracks does not necessarily mean that a wall is unstable.**</u> Walls can rock without becoming unstable. After cracks have developed, the out-of-plane stability of a wall is dependent on the slenderness ratio, connection to the structure, vertical loads, and the condition of the wall at its base.	When walls only develop cracks and are stabilized at the top to prevent overturning, this damage type is not severe. Many load-bearing walls in extensively damaged adobe building were stable throughout the Northridge earthquake. In the case of overturning, the life-safety danger is serious because not only do the walls collapse, but the roof or ceiling structure may collapse.
	Mid-height cracks	Long, tall, and slender single-wythe walls, or long, tall, double-wythe walls with no header courses interconnecting the wythes are susceptible to mid-height horizontal cracking from out-of-plane ground motion.	Damage represented by mid-height horizontal cracking is not serious in and of itself. However, the potential for much greater damage is significant. During further ground shaking, out-of-plane movement of the wall could make the upper or lower sections of the wall unstable and collapse, thus becoming a life-safety threat.

[169] Gable-end wall collapse is specified because, where they exist, gable-end walls are the most susceptible part of a building to collapse.

In-plane shear cracks		Classic X-shaped or simple diagonal cracks are caused by in-plane shear forces.	In-plane shear cracks generally do not constitute a life-safety hazard. Nevertheless, this type of damage can cause extensive damage to the walls and the attached plaster which may be historic. When large horizontal and vertical offsets occur at these cracks repair costs may be significant, and result in a loss of historical integrity.
Corner damage	**Vertical**	Vertical cracks can develop at corners in one or both planes of intersecting walls.	Life-safety hazard is minimal. The collapse of an entire corner can occur when vertical cracks occur in both planes of a corner, resulting in loss of historic fabric and a costly repair.
	Diagonal	Diagonal cracks that extend diagonally from the bottom to the top of a wall at a corner may be caused by in-plane shear forces or out-of-plane flexural forces.	Life-safety hazard is minimal. Slippage can occur along diagonal cracks that slant downward toward a corner. If much vertical slippage occurs, the wall may be very difficult to repair, compromising historical integrity.
	Cross	A diagonal crack extending from the bottom corner can combine with a diagonal crack from the top corner forming a wedge-shaped section.	Life-safety hazard is minimal. A complex pattern of cracks can lead to significant offsets of sections of the walls. Damage may be difficult to repair if these offsets occur, compromising historical integrity.
Cracks at openings		Cracks often begin at the tops of doors and openings and propagate upward vertically or at a diagonal. Cracks can also develop at the lower corners of windows. These cracks may be caused by in-plane or out-of-plane motion.	Life-safety hazard is minimal. The cracks that occur at the tops and bottom of openings are typically not severe except to the extent that they affect the plaster over and around the cracks, which may be historic.
Damage at intersection of perpendicular walls		Perpendicular walls can separate from each other and cause damage by pounding.	Life-safety hazard is minimal, unless other problem occur as a result of this damage. Damage to historic fabric is minimal, unless historic renderings spall.
Local section instability		Local wall sections can become unstable as the result of cracks that develop at corners of buildings and/or window and door openings.	In the immediate area, life-safety hazards and loss of historic fabric may be significant.

▪ Out-of-Plane Wall Damage

During an earthquake, one of the most typical failure mechanism in adobe building is due to out-of-plane flexural damage. The adobe walls are very susceptible to cracking from flexural stresses where the cracks initiate as vertical cracks at the intersection of perpendicular walls, and later extend vertically or diagonally and running horizontally along the base between the transverse walls (Tolles et al., 1996; Varum et al., 2014). Then over time the wall rocks out-of-plane, outward and inward, rotating round the horizontal cracks at the base. If adobe walls by embedding such elements as buttressed walls have been prevented from overturning, the extent of damage will be reduced.

▪ Gable-end Wall Collapse

In historic adobe buildings, the gable-end wall collapse is a specific type of out-of-plane failure. For long adobe walls without intermediate lateral restraint, this type of damage occurs when the wall panel is inadequately connected with lateral structural elements. In this typology of damage, the wall-foundation interface behaves as a pin connection, which has little resistance to overturning when an out-of plane force is applied (Dowling, 2006). Then by detachments that occur in the wall-wall connections and wall-roof connection, because of lack of edge resistant on three sides, the wall panel will generally overturn outward due to the outward force exerted by the roof in the absence of an adequate roof diaphragm. This type of failure frequently results in collapse of building, as commonly observed in Bam Citadel in 2003.

▪ Out-of-Plane Flexural Cracks and Collapse

During a seismic event, one of the first cracks that appear in the freestanding adobe wall, without any lateral restraints and supports along its length, is out-of-plane flexural cracks. During prolonged ground motions, because gravity is constantly working in combination with earthquake forces, the bending about the vertical axis first causes a splitting-crushing cycle generating vertical cracks, and then by bending about the horizontal axis, the upper part of wall panel will overturn. In fact, the probability of out of plane flexural cracks and collapses in non-load-bearing walls are more than load-bearing walls due to lack of fixed ending. In Bam Citadel, numerous examples of out-of-plane flexural damages have been observed in Citadel's surrounding fortification.

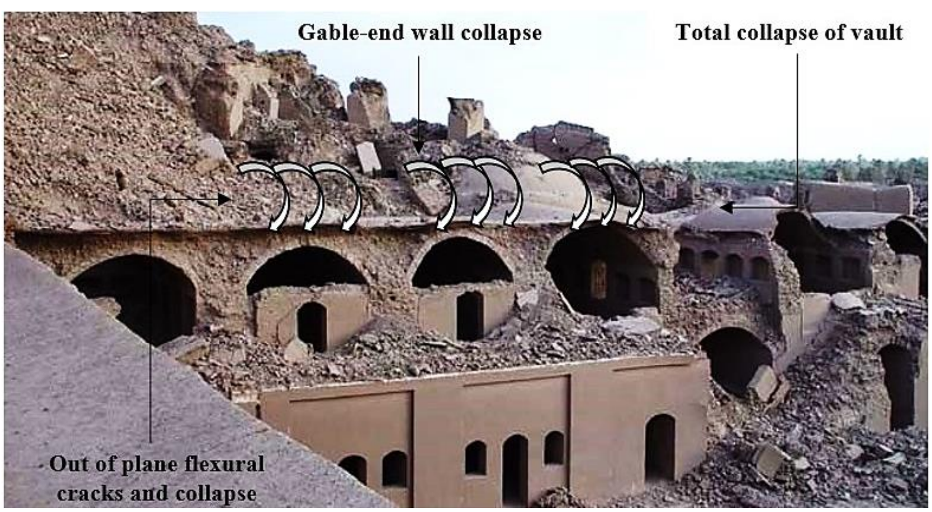

Figure 3.20- Different types of out-of-plane damage on the Barrack of Bam Citadel (Source: archive of ICHHTO, 2003, designed by Author).

▪ **Mid-Height, Out-of-Plane Flexural Damage**

A particular case of out-of-plane flexural damage occurs when the adobe wall have low thickness ratios (L= $\frac{\text{l = length}}{\text{d = width}}$). When the load-bearing and non-load bearing adobe walls are long and slender, by development of horizontal cracks along the base and their combination with vertical cracks, the mid-height, out-of-plane flexural damage might occur.

Figure 3.21- Mid-height, out-of-plane flexural damage in second wall of Bam Citadel (Source: archive of Gettyimages, 2004. Source: http://www.gettyimages.it/immagine/bam-citadel?, designed by Author).

Figure 3.22- Mid-height, out-of-plane flexural damage without collapse in third defensive wall of Bam Citadel. Fortunately as can be seen, the horizontal and vertical cracks across the length of wall could not cause to detachment of wall, if the seismic motion had been more prolonged, the total collapse of wall might have occurred (Source: archive of ICHHTO).

▪ **In-Plane Shear Cracks**

Lateral seismic forces acting within the plane of the walls generate shear forces that produce diagonal cracks, which usually-but not always-follow stepped patterns along the mortar joints (Varum et al., 2014). The diagonal cracks are typically the results of in-plane shear forces which often start at the corners of openings, such as doors and windows, and develop in walls between openings where the concentration of tensile stresses cause cracks with approximately 45° relatively to the horizontal. The X-shape in-plane cracks occur when the sequence of ground motions cause the shear forces to go in one direction and then go in the opposite direction. In this case, later when the adobe walls have cracked, the continuation of seismic movement might exacerbate the damage and cause independent collapse of the walls in an out-of-plane mode. More severe damage to the structure may occur when an in-plane horizontal offset occurs in combination with a vertical displacement (i.e., when the crack pattern follows a more direct diagonal line and does not stair-step along mortar joints) (Tolles et al., 1996).

Figure 3.23- The in-plane shear cracks in Bam Citadel after the 2003 Bam earthquake (Photos by Rouhi, 2015).

▪ **Intersection of Perpendicular Walls**

This damage often occurs as vertical cracks or gaps appear in the wall connections at the intersection between the façade walls and the perpendicular walls, where the connections between components are too weak to withstand against the earthquake demands. In this case, while the perpendicular wall remains very stiff in plane, one of the connected walls rocks out of plane. During large ground motions, this process triggers the walls to the post-failure overturning of the wall panels. This type of damage is one of the most inevitable collapse mechanism of adobe walls under seismic motions. Observations made after the Bam earthquake have shown that the magnitude of damage suffered by the monuments in Bam Citadel was directly related to quality of the connection, and the damages had been more significant where large cracks were associated with damages that occurred in roofs.

Figure 3.24- Intersection of perpendicular walls in Bam Citadel after the 2003 Bam earthquake (Photos by Rouhi, 2015).

▪ **Corner Damage**

Cracks caused by seismic motions often occur in locations with high stress concentrations. Cracks in corners of an adobe building are very common because relative response is largest at the wall's interfaces. That is why the probability for occurrence of cracks at the corners of buildings during an earthquake is more than other parts. A thin adobe wall may become unstable soon after the initiation of cracks through the wall. However, a thick-walled adobe building is still a long way from losing its stability after the first cracks develop (Tolles et al., 1996). The extent of damage caused in a building will depend on the width of the crack generally characterized as hairline cracks, fine cracks, moderate cracks, extensively damaged cracks and structural cracks (Varum et al., 2014). It should be noted that, since adobe materials have high adhesion properties, any cracks could not cause serious damages.

Figure 3.25- High adhesion of seismic damaged adobe wall in the Bazzar of Bam Citadel (Photos by Rouhi, 2015).

As Tolles et al. (1996) cited, corner cracks in adobe walls can be categorized in three sections:

- Vertical cracks at corners: Vertical cracks often develop at corners during the interaction of perpendicular walls and are caused by flexure and tension due to out-of-plane movements. This type of damage can be particularly severe when vertical cracks occur on both faces allowing collapse of the wall section at the comer.
- Diagonal cracks at corners: Diagonal cracks that start at the top of a wall and extend downward to the corner are caused by in-plane shear forces. This type of crack results in a wall section that can move laterally and downward during extended ground motions. This type of damage is difficult to repair and may require reconstruction.
- Combinations with other cracks or preexisting damage: The combination of diagonal cracks and vertical cracks can leave an adobe wall severely fractured with several sections of the adobe wall susceptible to large offsets and/or collapse. The diagonal cracking at that location is at the southwest corner of the buildings leaving the cracked wall sections free to move outward. Corners may be more susceptible to collapse if vertical cracks develop and the base of the wall has already been weakened by previous moisture damage.

Figure 3.26- Different types of cracks in Mirza Naem School of Bam Citadel after the 2003 Bam earthquake (Photo by Rouhi 2015).

▪ Cracks at Openings

An opening in a frontage constitutes a vulnerable point in the event of deformation of the adobe frame. The cracks of the front walls are found in the contours of the openings, where the stresses are most significant and in particular close to the re-entrant angles (NIKER, D3.1, 2010). Since more often during seismic motions, cracks occur in locations that stress concentrations are high, the openings are deep interested in cracks phenomena. Usually, these cracks start at the top or bottom corners of openings and develop vertically, diagonally and horizontally to the tops or bases of the walls. In adobe building, cracks over the openings may be hazardous to occupants if they are dislodged. The best way to control cracks at openings is keeping the openings in the walls small and well-spaced.

Figure 3.27- Crack at opening of Bam Citadel after the 2003 Bam earthquake (Source: (Left) personal archive of Prof. Luigi Marino; and (Right) Auroville Earth Institute "BAM AND ARG-E-BAM", after the 2003 Bam earthquake).

III) Damage on Adobe Roofs

▪ Damage Analysis of Vaulted Roofs

As a general remark, the vaulted roofs system have limited stability under static conditions, so when the stability of this type of roofs is satisfied that the line of thrust (LT) remains in the middle third of the side's roofs and walls. In term of LT's placement in vaults, when LT goes to the intrados side and/or outside the extrados side of the middle third, the tension stress will increase in the vault. On the other hand, in term of LT's placement in walls, when LT goes to the outer middle third, the bending and shear tension might cause severe damage to the adobe walls. During the 2003 Bam earthquake, due to the dynamic character of the seismic motions, most of LT went outside of inner third. However, surviving vaulted roofs could be seen all over the Citadel even in areas where the greatest damages were observed. However, there were some vaults that showed good behavior even when the direction of the movement was perpendicular to their generators. Apart from some cracks, minor failure and separation from side's walls, this type of roofs performed satisfactorily. In this case, the observed damages and failures were mainly concentrated in areas in the vicinity of the intersection line of the vaults with the end of their triangular transition sections where the roofs are connected to adobe wall. Although it is difficult to know the main reason for good dynamic behavior of still standing adobe vaults in Bam Citadel, it can be noticed that differences in the thickness of roofs and the quality of the site's soil may also be responsible for this behavior. In most cases, the vaults in Bam Citadel together with other structural components of adobe buildings have suffered complete collapse. The sequence of such failure usually starts with excessive deformation of load bearing walls, and later separation of roofs from walls in buildings without adequate wall-to-roof connections often lead to complete building collapse. However, in some cases, the failure of roofs did not follow wall's destruction, while the walls remained relatively intact, the roofs faced total collapse. The reason for such failure can be found in heavy weight and weak connection of adobe vaults. Apart from that, the high vertical acceleration component of this earthquake also increased the probability of complete collapse of the adobe roofs.[170]

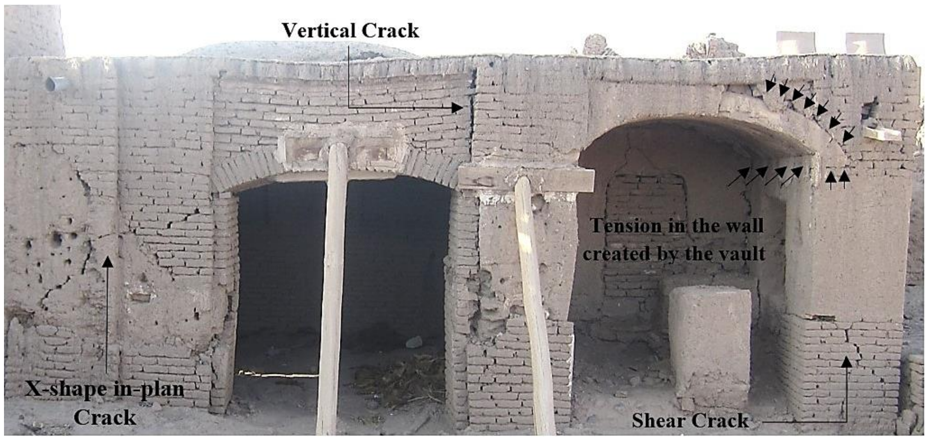

Figure 3.28- Damages on vaulted structure in the east part of Bam Citadel after the 2003 Bam earthquake (Photo by Rouhi, 2015).

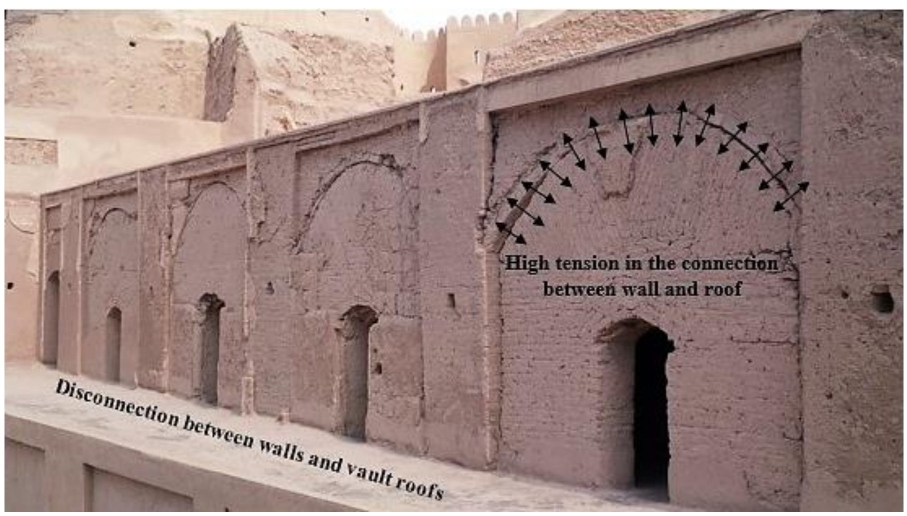

Figure 3.29- A set of vault roofs survived during the 2003 Bam earthquake in the Barrack of Bam Citadel (Photo by Rouhi, 2015).

[170] Some people of the city of Bam who survived from 2003 Bam earthquake, in their description about earthquake said that at the time of earthquake it seemed that all of the buildings were exploding from their upper parts.

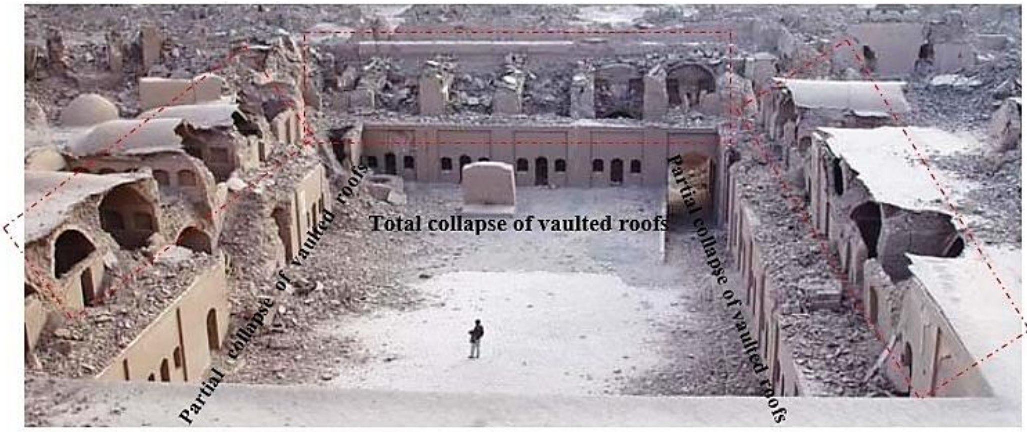

Figure 3.30- Total and partial collapse in the Barrack of Bam Citadel after the 2003 Bam earthquake (photo by Ahmadi and Boroomandi, 2003. Source: archive of ICHHTO, designed by Author).

▪ **Damage Analysis on Domed Roofs**

Unlike the vaulted roofs that have shown variable damage typologies by the earthquake, most of the domed roofs in Bam Citadel faced complete destruction, and a small number of domes faced low failure in their façade. An example of such total destruction can be seen in the Stable of Bam Citadel, where almost all of its domes totally collapsed. As Langenbach (2004) pointed out, "the collapse of the domes throughout the complex, many simply may have followed their bursting supporting walls to the ground. Others that collapsed inwardly, such as the icehouse, probably suffered from the effect of the intense vertical vibrations on the weak unfired brick masonry. The momentary doubling of the weight of the domed structures was probably more than they could handle. The bricks themselves were simply too small and weak to form enough of a resisting arch."

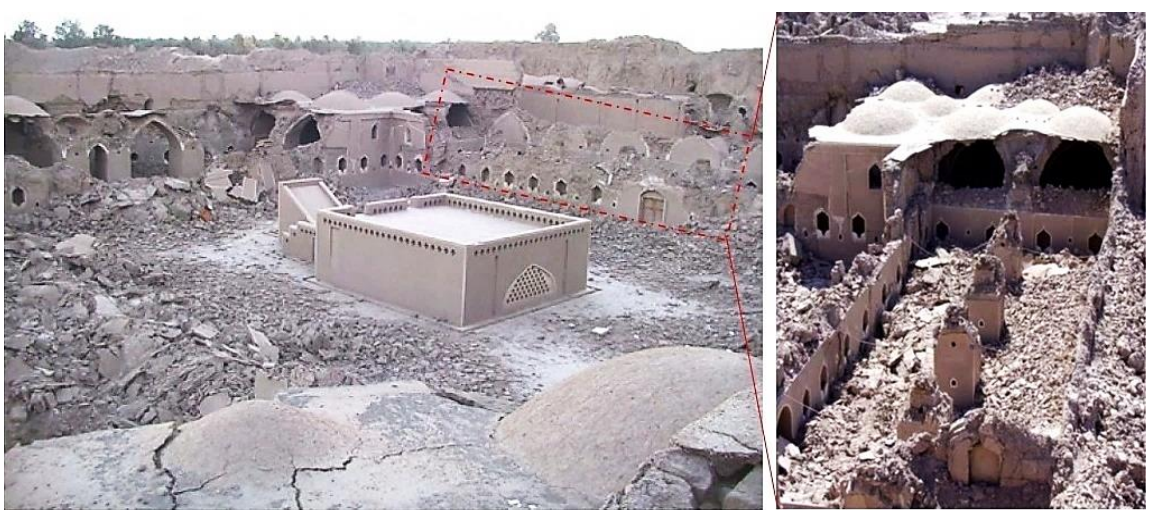

Figure 3.31- Damage on domed roof in the Stable of Bam Citadel after the 2003 Bam earthquake (Source: archive of RPBCH, designed by Author).

(IV) Damage on Adobe Towers

During the earthquake, the Citadel's towers with their destruction marked one of the greatest cultural heritage losses, even 13 years after earthquake and with all the efforts made, the absence of towers in the first gate, stable, governor's house and etc. is largely felt. The circular structures, such as the turrets on the ramparts, fared worse than the long straight walls and rectangular structures (Langenbach, 2004). Bam Citadel was composed of a set of 49 towers, in which by the 2003 earthquake, most of them suffered a severe range of damage from 70% to tottal collapse.

Because of long height and insufficient strength of their materials, adobe towers are extremely unstable to the earthquake. However, seismic motions by moving over the body of adobe towers can cause failures in their different parts. In Bam Citadel, the horizontal, vertical and diagonal cracks and rupters could be seen on the façade of towers. In most cases, by development of cracks, the towers were subject to detachment in their connection with side walls. Here due to the large vertical acceleration of the earthquake, the upper portion of most towers were substantially damaged.

Figure 3.32- The condition of east-south tower of the Stable of Bam Citadel in different periods before and after earthquake (Source: archive of ICHHTO, before the 2003 Bam earthquake; and Rouhi, 2015).

3.3 Definition of Cultural Heritages and their Values

- Cultural Heritage and its Definition by the Past

"*We do not inherit the Earth from our Ancestors, we borrow it from our Children*" (Ancient Indian proverb).

Understanding the history is possible by knowing the human thoughts. One way to know the human thoughts is possible by objective manifestation of the subjective structures. In other words, the objective manifestation of the human mind is specifically evident in the value of cultural heritage and more specifically is demonstrated in the historical monuments and sites.

Archaeologists are the ones who by scientific studies have tried to open new windows to the origins of humankind. However, their records encompass all areas in the world that have been occupied by early humans. A museum is an institution that tries to represent the essence of cultural significance remaining from ancient times, and through exhibits make them available to the visitors to be able to understand the values of the past in the shortest possible time. However, a fundamental question arises here regarding **what is the dependency between man and past while we are facing the future?** It seem completely irrational to spend our time in any way researching the subjects that are related to the past.

The past is the period of time that has already happened, it is known as a generator that can outreach our future in the present. The past is opposite to the future and in contrast to the present. It is also regarded as the conglomerate of events that happened in a certain point of time within the space-time continuum. The aforementioned concept is closely related to Albert Einstein's relativity theory. Albert Einstein, in his theory of special relativity, determined that the laws of physics are the same for all non-accelerating observers, and he showed that the speed of light within a vacuum is the same, no matter at what speed an observer travels. As a result, he found that space and time were interwoven into a single continuum known as space-time. Events that occur at the same time for one observer could occur at different times for another (Redd, 2016).[171] In a more detailed study, the present tense in its turn is associated with the past or in continuation with the future. In this way, the present and future cannot be understood without fully understanding the experiences acquired from the past. As Carr (1961) writes, "But, as we all know, the present has no more than a notional existence as an imaginary dividing line between the past and future."[172]

In fact, without any accurate conception of these three dependent tenses (past, present and future), we cannot evaluate our present. Even all our decisions about the future are influenced

[171] Redd, N.T. (2016). "*Einstein's Theory of General Relativity*", SPACE. Retrieved from http://www.space.com/17661-theory-general-relativity.html
[172] Carr, E.H. (1961). *What is history?*. London: Cambridge University Press, p.126.

by the accumulation of factors that have shaped our present being. Meanwhile, there is a dependency between past, present and future tenses. Lessons that can be gained from the past would be meaningful for us in the future. Indeed, the ignorance of the past can conduct to the ignorance of the future, so without the past a person would be unable to figure out what is going on in the world around him, and to navigate it successfully. As Hewison (1987) writes, "[…] **you** do not know where you are unless you know where you have been […]"[173]

In his doctoral dissertation, Mehdi Hodjat (1995) analyzed the approach to heritage and history as proposed in the Qur'an and in the Islamic societies. As Hodjat mentioned, "by presenting particular examples and suggesting certain interpretations, the Holy Quran invites us to travel around the earth and investigate the deeds of past nations." He also added, "[…] Historical remains are not just the agents of reports; they are also medium with which human beings are able to make an emotional contact with their ancestors, a role that perhaps nothing else can play. This role provides a unique place for cultural heritage in the psyche of human beings."[174]

Generally, our perceptions of the past determine the direction of our cultural heritage activities. This will assist us to make the ground ready to find out an appropriate definition for our cultural heritage from the view of **why cultural heritage needs more attention**?

Studying the value of the past is not only particularly essential for those who are involved with cultural heritage, but also for humankind as a whole. As Boito (1893) stated, "Considering the fact that the architectural monuments from the past are not only valuable for the study of architecture but contribute as essential documents to explain and illustrate all the facets of the history of various peoples throughout the ages."[175] However, cultural heritage is very important in fostering the quality of life with values and pride in all civilizations. It comes together with an historic message and information that the cultural materials transmit from the past to the present and the future (Fallahi, 2008).

Facing the question, "**why should we care about the importance of cultural heritage?**", the answer to this question is that cultural heritage implies a shared bond, our belonging to a community, and it gives us a better knowledge about who we are and where we come from, as well as our history and our identity, our bond to the past, to our present, and the future. In this

[173] Hewison, R. (1987). *The heritage industry*. London: Methuen London Ltd. p.10.
[174] Hodjat, M. (1995). CULTURAL HERITAGE IN IRAN: policies for an Islamic country (Dissertation for a Philosophy Degree, Institute of Advanced Architectural Studies, The King's Manor University of York, England). Retrieved from etheses.whiterose.ac.uk/2460/1/DX193597.pdf
[175] Jokilehto, J. (1986). A History of Architectural Conservation: The Contribution Of English, French, German And Italian Thought Towards An International Approach To The Conservation Of Cultural Property (D.Phil. Thesis, The University Of York, Institute of advanced Architectural Studies, England. Retrieved from https://vk.com/doc277688559_437435201?hash=204ac4f1d4c699116f&dl=39b65a8b182586a0cd

case, as John Feather (2006) mentioned, "the driving force behind all definitions of Cultural Heritage is it is a human creation intended to inform."[176] In 2005, Simon Thurley, an English academic and architectural historian, proposed a heritage diagram, as shown in Figure 3.33, which gives us an idea how we can make the past part of our future (Thurley, 2005).[177] In fact, the "*Heritage Cycle*" proposed by Simon Thurley helps us to realize the process of finding and incorporating.

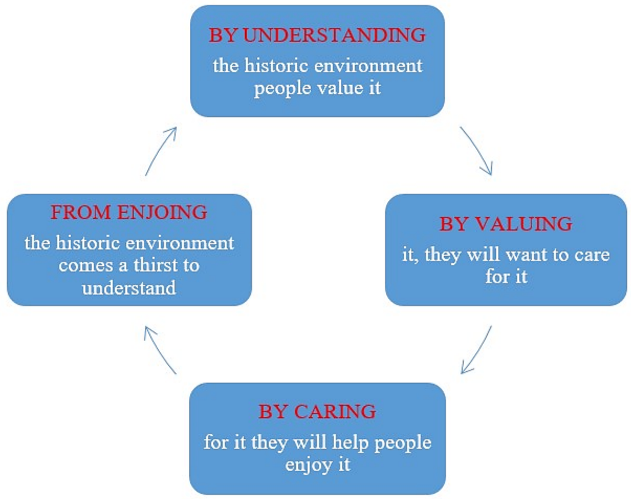

Figure 3.33- The Heritage Cycle diagram (Source: Thurley, 2005).

However, when we are talking about the importance of respecting the cultural heritage, it is not related to a group of people in a specific geographic location, but it means all cultural significances belonging to different cultures in different geographic locations of the world. In fact, to give an international character to our cultural heritage, it would be better, as a part of whole, to name them "World Cultural Heritage". World Cultural Heritage can created connections between different social values, beliefs, religions, histories and customs. They have also provided conditions to share our mindsets and historic backgrounds with others throughout the world. In this process, the world cultural heritage forms a veritable sense of unity and belonging within a group and opens a new avenue to know ourselves.

Nowadays, the role of historical remains is so obvious that in almost every country, the large budget is allocated to the preservation and presentation of ancient remains, so millions of people visit them enthusiastically. These concepts show that the role of cultural heritage in our societies

[176] Feather, J. (2006). Managing the documentary heritage: issues for the present and future. In: Gorman, G.E. and Sydney J. Shep. (eds.), Preservation management for libraries, archives and museums. London: Facet, pp. 1-18.
[177] Thurley, S. (2005). Into the future. Our strategy for 2005-2010. In: Conservation Bulletin [English Heritage] (49). Retrieved from https://content.historicengland.org.uk/images-books/publications/conservation-bulletin-49/cb4926-27.pdf/

is extremely important. But when we want to address a complete definition of the cultural heritage, we will face two important questions: first, **what is cultural heritage?** and second, since the nature of cultural concepts usually causes ambiguities, **what values encourage us to take efforts for their conservation?**. In the next parts, according to the process followed, it has been tried to find a comprehensive respond to these two fundamental questions.

- Philological Meaning of the Cultural Heritage

Raymond William once remarked that 'Culture is one of the two or three most complicated words in the English language' (1983). He never said what the other ones were, but had he been writing today, one of these might well have been 'heritage' (Les, 2014).[178] Since knowing where and when a word can be used plays an important role in revealing its hidden meanings. In order to have a better definition of "***Cultural Heritage***" it may be worth taking a look at the etymology of the terms of 'Culture' and 'Heritage'. According to the Oxford English Dictionary on historical principles (1893),[179] the notion of '***Culture***' means: "Worship; reverential homage". "The action or practice of cultivating the soil; tillage, husbandry". "The cultivating or rearing of a plant or crop". "The cultivating or development (of the mind, faculties, manners, etc.); improvement or refinement by education and training". "The training, development, and refinement of mind, tastes, and manners; the condition of being thus trained and refined; the intellectual side of civilization" and "The prosecution with special attention or study of any subject or pursuit". However, there are two famous anthropologists, Tylor (1832-1917 AD) and Geertz (1926-2006 AD), who have argued for a purely cognitive definition of culture. As an anthropologist, Edward Burnett Tylor in his "*Primitive Culture*" (1871) stated, "Culture, or civilization, taken in its broad, ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society."[180] Geertz (1973) provided a classical "cognitive" definition of culture, as, "[...] a historically transmitted pattern of meanings embodied in symbols, a system of inherited conceptions expressed in symbolic form by means of which men communicate, perpetuate, and develop their knowledge about and attitudes toward life."[181]

On the other hand, as Lord Charteris, the Chairman of the National Heritage Memorial Fund, and former private secretary to the Queen, has said, the heritage means "anything you want"

[178] Les, R. (2014). Talkin bout my generation: popular music and the culture of heritage, International Journal of Heritage Studies, Routledge; 20(3): 262-280.
[179] A New English Dictionary on Historical Principles. (1893). In: Murray, J.A.H., Bradley, H., Craigie, W.A., and Onions, C.Y. Retrieved fromhttp://onlinebooks.library.upenn.edu/webbin/metabook?id=newenglishdictionary
[180] Taylor, E.B. (1871). *Primitive Culture: Researches Into the Development of Mythology ...*, Volume 1. London: Bradbury, Evans, and Co., Printers, Whitefriars. p. 1.
[181] Geertz, C.J. (1973). *The Interpretation of Cultures*. New York: Basic Books, Inc. p. 89.

(Hewison 1989).[182] According to the Oxford English Dictionary on historical principles (1901),[183] "***Heritage***" or other form: *eritage, erytage, heiritagie,* etc., all come from the Latin root *hereditagium,* which means, "[…] that which has been or may be inherited: any property, and esp. land, which devolves by right of inheritance". "The fact of inheriting; inheritance, hereditary succession". "Anything given or received to be a proper and legally held possession" and "That which comes from the circumstances of birth; an inherited lot or portion; the condition or state transmitted from ancestors". In this case, Hewison in Uzzel's Heritage Interpretation (1989), about the word of heritage pointed out, "the word *Heritage* has been in existence for a long time', though, 'its usage in the present context is relatively recent […] subject to a variety of presentations and interpretations […]." However, all of these definitions show that the objects are inherited from the past.

If we want to give a full definition of "***Cultural Heritage***" based on the above meanings, "Heritage" is a property, something that is inherited from past, transferred from previous generations. Moreover, the concept of 'culture' denotes a lot of meanings, but we can understand it to mean "social organization, custom and traditions, religion, language, arts and literature, form of government, economic system". However, cultural inheritance therefore would concern all these different aspects of culture, traditionally handed over from generation to generation (Jokilehto, 2006).

In the first glance, it might be precise that the definition of cultural heritage is sufficiently obvious and does not need any more definition. However, for the professionals and individuals that are actually involved in different aspects of this issue, this is not identically true. As Robert Hewison (1987) in his book entitled "*The Heritage Industry*" stated, "Two things are clear about this word: it is of relatively recent usage- an important date was the designation of 1975 as European Architectural Heritage Year - and it is a word without definition, even in two Acts of Parliament."[184] David Lowenthal (1985) also has mentioned that, "Those who drafted the National Heritage Act confess they could no more define the national heritage than we could define, say, beauty or art [...]. So we decided to let the national heritage define itself."[185]

In this case, the aim of Hewison and Lowenthal have not been that the concept of cultural heritage is left without definition, rather they meant that the aggregation of different points of view can lay different definitions for cultural heritage where they can make it difficult to reach a common consensus. However, depending on the individual country's interpretation of cultural

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[182] Hewison, R. (1989). Heritage: An Interpretation. In: D. Uzzell (ed.), Heritage Interpretation 1, London: Belhaven Press, pp.15-23.
[183] A New English Dictionary on Historical Principles. (1901). In: Murray, J.A.H., Bradley, H., Craigie, W.A., and Onions, C.Y. Retrieved fromhttp://onlinebooks.library.upenn.edu/webbin/metabook?id=newenglishdictionary
[184] Hewison, R. (1987). *The Heritage Industry*. London: Methuen Publishing Ltd. p.31.
[185] Lowenthal, D. (1985). *The past is a foreign country*. London: Cambridge University Press. p. 37.

heritage, in every region of a country there is also difference on cultural heritage interpretation with criteria vary from country to country.

At the global level, approaches to the past are different from country to country, through each country, particular aspects of the past and special concepts of cultural heritage are being noticed. The concept of the past values can be under various reasons. Throughout history, a review of the cultural heritage approaches of a country can demonstrate how different epochs, regional authorities, social conditions and ideologies, etc., have affected the current perception of the past values. For examples, in Iran to find a way for urban development, municipalities have considered old urban textures as distressed textures that would be demolished. Somewhere else, according to the Iranian Cultural Heritage Organization (ICHO), the courts will summon only those buildings that have been registered in the national world heritage list. In this case, the concern arises when non-listed historic buildings might face to the demolition. The case of Iran shows that lack of any inclusive and applicable definition of cultural heritage can be associated with disrespect to cultural heritage. However, any approaches should rely on a correct definition of cultural heritage.

- Definition of World Cultural Heritage by the UNESCO: "Outstanding Universal Value"

In examining the reasons for the respect to the past, it is understood that the study and interpretation of history can create motivation for the main means by which human beings can communicate with other eras, cultures, religions, histories and customs, as well as various attitudes to respect the past. Concerning the concepts of "Cultural Heritage", or more in general, definitions that can create mobility to respect our past and history are particularly relevant to UNESCO's programmers. Making our peace with nature, UNESCO has defined 'nature', in its "*Draft Medium Term Plan 1990-1995*" (UNESCO, 1989), as a tool for creation of peace in national and international levels:

"*A world at peace with itself will be viable only if it is reconciled with nature. The fact is that peace today must also be seen in term of the interactions, in space and time, between human beings and their environment as well as in term of intergenerational relations. This means responding fully to present needs while making sure that we do not jeopardize the world we bequeath to future generations.*"[186]

Since the Convention concerning the Protection of World Cultural and Natural Heritage was adopted by the General Conference of UNESCO on 16 November 1972,[187] the criteria for

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[186] UNESCO. (1989). Draft Medium Term Plan 1990-1995, 25 C/4, p.13. Retrieved fromunesdoc.unesco.org/images/0008/000825/082539eb.pdf

[187] Heritage is our legacy from the past, what we live with today, and what we pass on to future generations. Our cultural and natural heritage are both irreplaceable sources of life and inspiration. Places as unique and diverse as the wilds of East Africa's Serengeti, the Pyramids of Egypt, the Great

definition of cultural heritage have constantly been evolving to meet different aspects of World Cultural Heritage properties. In the meantime, the basics of the Convention is necessarily immutable, its Operational Guidelines, but the provisions through which the Convention are implemented make it possible for the integration and evolution of new concepts and processes. The last revision of the Operational Guidelines (July 2015) addresses not only these new ideas, but also reflects our growing collective experience.[188]

According to "*Operational Guidelines for the Implementation of the World Heritage Convention*", the World Heritage List is based on the definition of the Outstanding Universal Value (OUV). In defining "**Cultural Heritage**", Article 1 of the World Heritage Convention notes that "**monuments**" and "**groups of buildings**" should have Outstanding Universal Value (OUV) from the point of view of **history**, **art**, or **science**, while the "**sites**" are also seen from the **ethnological** or **anthropological** points of view. In addition, in defining "**Natural Heritage**", Article 2 of the World Heritage Convention notes that "**natural features**" should have Outstanding Universal Value (OUV) from the point of view of **aesthetic** or **scientific**, while the **natural sites or precisely delineated natural areas**" are also seen from the **science**, **conservation** or **natural beauty** points of view. In Table 3.7, different categories of World Cultural Heritage with Outstanding Universal Value are presented.

Table 3.7- Definition of the categories of the world cultural heritage properties (Source: UNESCO-WHC).

Category of World Cultural Heritage "OUV"	Definition
Cultural Heritage (Article 1)	**Monuments:** architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of Outstanding Universal Value from the point of view of history, art or science;
	Groups of buildings : groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of Outstanding Universal Value from the point of view of history, art or science;

Barrier Reef in Australia and the Baroque cathedrals of Latin America make up our world's heritage. What makes the concept of World Heritage exceptional is its universal application. World Heritage sites belong to all the peoples of the world, irrespective of the territory on which they are located. The United Nations Educational, Scientific and Cultural Organization (UNESCO) seeks to encourage the identification, protection and preservation of cultural and natural heritage around the world considered to be of outstanding value to humanity (Convention concerning the Protection of the World Cultural and Natural Heritage, adopted by UNESCO, 1972).

[188] In all cases, the Convention and Operational Guidelines remain the primary references. The text of the World Heritage Convention (available in Arabic, Chinese, English, French, Hebrew, Portuguese, Russian and Spanish) and the Operational Guidelines (in English and French) are available from the UNESCO World Heritage Centre and on its website (http://whc.unesco.org/).

	Sites: works of man or the combined works of nature and of man, and areas including archaeological sites which are of Outstanding Universal Value from the historical, aesthetic, ethnological or anthropological points of view.
Natural Heritage (Article 2)	**Natural features** consisting of physical and biological formations or groups of such formations, which are of Outstanding Universal Value from the aesthetic or scientific point of view;
	Geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of Outstanding Universal Value from the point of view of science or conservation;
	Natural sites or precisely delineated natural areas of Outstanding Universal Value from the point of view of science, conservation or natural beauty.
Mixed Cultural and Natural Heritage (Paragraph 49)	Properties shall be considered as “mixed cultural and natural heritage” if they satisfy a part or the whole of the definitions of both cultural and natural heritage laid out in Articles 1 and 2 of the Convention.
Cultural Landscapes (Paragraph 47)	**Type 1:** Landscapes Designed and Created Intentionally by People.
	Type 2: Organically Evolved Landscapes.
	Type 3: Associative Landscapes.

According to the UNESCO World Heritage Centre, the signatory States Parties are divided into five regions: (1) Africa, (2) Arab States, (3) Asia and the Pacific, (4) Europe and North America, and (5) Latin America and the Caribbean. As of 2016, the World Heritage List includes 1052 properties, which consist of 814 cultural, 203 natural and 35 mixed properties in 165 States Parties.

Table 3.8- Distribution of world cultural heritage properties in different regions (Source: UNESCO-WHC).

Regions	Cultural	Natural	Mix	Total	%	States Parties with inscribed properties
Africa	48	37	5	90	9	33
Arab States	73	5	3	81	8	18
Asia and the Pacific	172	62	12	246	23	36
Europe and North America	426	62	10	498	47	50
Latin America and the Caribbean	95	37	5	137	13	28
Total	814	203	35	1052	100	165

Since each culture has its own ways to represent its values, the concept of “Outstanding Universal value” has been much discussed with specialists from all around the world, so each has their own interpretation of the concept. In this case, diversity of views on interpretation of

Outstanding Universal Value does not mean that there is nothing common for definition of the OUV of World Cultural heritage properties; rather it means that it is necessary to accept that different groups and societies in different periods of time would have had their own cultural values, and ways for their expression.[189] However, as declared by UNESCO about the cultural diversity, "Culture takes diverse form across time and space. This diversity is embodied in the uniqueness and plurality of the identities of the groups and societies making up humankind." (UNESCO, 2001, Article 1).

As indicated in the *Operational Guidelines for the Implementation of the World Heritage Convention* (2015): "Outstanding Universal Value means cultural and/or natural significance, which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole. The Committee defines the criteria for the inscription of properties on the World Heritage List." (Operational Guidelines, 2015, Paragraph 49).

During the process for inscription of country's properties on the World Heritage List (WHL), and in order to identify their Outstanding Universal Value, several debates have formally raised among 'State Parties'[190] of the World Heritage Committee (WHC). In this case, only countries that have signed the World Heritage Convention can submit nomination proposals for inclusion of their properties in UNESCO's World Heritage List.[191] In the meantime, in order to avoid extensive increase of the number of sites inscribed on World Heritage List, and also to create a balance between nomination and inscription of cultural and natural heritages, WHC has considered a lot of precautions.

The first proposals for justification of the WH Criteria goes back to a meeting of the Advisory Bodies on May 1976 in Morges. In this meeting, ICOMOS adopted the first version of criteria I-VI for the OUV of cultural heritage properties with reference to monuments, groups of buildings and sites and explained them by giving examples. To achieve a better understanding of the so-called OUV concept, ICCROM had an interesting contribution in definitions of values including artistic value, historic value and typological value. Then, in 1977 and 1978, the

[189] The same relicts that are considered valuable for a society in a specific period might be not necessarily important or precious for another or same society in another period of time.

[190] States Parties are countries, which have adhered to the World Heritage Convention. They thereby agree to identify and nominate properties on their national territory to be considered for inscription on the World Heritage List. When a State Party nominates a property, it gives details of how a property is protected and provides a management plan for its upkeep. States Parties are also expected to protect the World Heritage values of the properties inscribed and are encouraged to report periodically on their condition.

[191] Countries that pledge to protect their natural and cultural heritage.

ICOMOS's draft criteria of 1976 were revised. Finally, the results were reflected in a revised version of the Operational Guidelines of 1980.

In 13th of October 1994, the World Heritage Committee launched the Global Strategy for a Representative, Balanced and Credible World Heritage List. In fact, the aim of this expert meeting on the Global Strategy was to ensure that the WHL reflects the world's cultural and natural diversities of OUV. By adopting the Global Strategy, the World Heritage Committee wanted to broaden the definition of World Heritage to better reflect the full spectrum of our world's cultural and natural treasures and to provide a comprehensive framework and operational methodology for implementing the World Heritage Convention (UNESCO World Heritage Centre - Global Strategy). Then, during the 6th World Heritage Committee, on March 2003 in Paris, it decided to merge the ten criteria for the assessment of Outstanding Universal Value (WHC, 2003). In the following years, the debate continued and the criteria were further edited several times until the present version. With the adoption of the revised *Operational Guidelines for the Implementation of the World Heritage Convention 2005*, only one set of ten criteria exists; six cultural and four natural criteria. Consequently, the WHC considers a property as having Outstanding Universal Value that meets at least one out of ten selection criteria (Operational Guidelines, 2015, paragraph 77), see Figure 3.34 and Table 3.9.

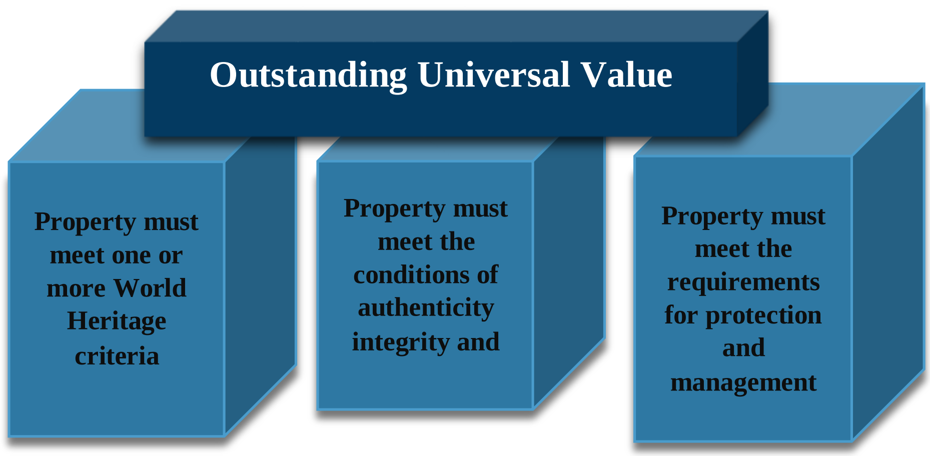

Figure 3.34- Three foundation for a property to be judged as of Outstanding Universal Value (Source: World Heritage Resource Manual, 2011).

Table 3.9- The criteria for selection as the world cultural heritage property (Source: UNESCO-WHC).

Criteria No.	Definition
(i)	represent a masterpiece of human creative genius;
(ii)	exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;

<table>
<tr><td>(iii)</td><td colspan="10">bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared;</td></tr>
<tr><td>(iv)</td><td colspan="10">be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history;</td></tr>
<tr><td>(v)</td><td colspan="10">be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;</td></tr>
<tr><td>(vi)</td><td colspan="10">be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria) ;</td></tr>
<tr><td>(vii)</td><td colspan="10">contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;</td></tr>
<tr><td>(viii)</td><td colspan="10">be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landform, or significant geomorphic or physiographic features;</td></tr>
<tr><td>(ix)</td><td colspan="10">be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystem and communities of plants and animals;</td></tr>
<tr><td>(x)</td><td colspan="10">contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.</td></tr>
<tr><td>Operational Guidelines(year)</td><td colspan="6">Cultural criteria</td><td colspan="4">Natural criteria</td></tr>
<tr><td>Operational Guidelines 2002</td><td>(i)</td><td>(ii)</td><td>(iii)</td><td>(iv)</td><td>(v)</td><td>(vi)</td><td>(i)</td><td>(ii)</td><td>(iii)</td><td>(iv)</td></tr>
<tr><td>Operational Guidelines 2005</td><td>(i)</td><td>(ii)</td><td>(iii)</td><td>(iv)</td><td>(v)</td><td>(vi)</td><td>(viii)</td><td>(ix)</td><td>(vii)</td><td>(x)</td></tr>
</table>

Until the end of 2004, World Heritage sites were selected based on two separated lists: six cultural criteria (i, ii, iii, iv, v, vi) and four natural criteria (i, ii, iii, iv). With the adoption of the revised *Operational Guideline for the Implementation of the World Heritage Convention 2005*, only one set of ten criteria exists. For the evaluation of criteria for the nomination of cultural and natural heritage, there are two Advisory Bodies: ICOMOS for cultural heritage and IUCN for natural heritage, which have the responsibility for assessment of criteria considered for each property. In addition, properties nominated as mixed cultural and natural heritage are evaluated by both IUCN and ICOMOS.

- The Relationship between Cultural Heritage, Natural Heritage, Mixed Cultural and Natural Heritage and Cultural Landscape

Cultural and natural heritage have their particular criteria, and it would not be difficult to identify each one. Nevertheless, the problem arises and might be confusing when we want to realize the difference between mixed properties and cultural landscapes. Mixed properties, according to 2005 Operational Guidelines, are inscribed independently under at least one of the criteria related to cultural heritage (i) to (vi) and at least one criteria related to natural heritage (vii) to (x), and cultural landscapes are defined under their inter-relationship between culture and nature. In fact, the natural values of cultural landscapes are a sub-value for definition of its actual value, which does not apply to justify inscription as natural heritage. However, these types of properties should be recognized as a mixed site and a cultural landscape. As Resource Manual 2011 cites, “for some mixed properties the natural values and cultural values are integrated and co-dependent. In other cases, the values may not be co-dependent but simply share the same geographic location.”

- Integrity and/or Authenticity

To be deemed of Outstanding Universal Value, a property must also meet the conditions of integrity and/or authenticity and must have an adequate protection and management system to ensure its safeguarding (Operational Guidelines, 2015, Paragraph 78). For the first time the term authenticity was introduced in the 2nd International Congress of Architects and Technicians of Historic Monuments, Venice (1964),”**Imbued with a message from the past**, the historic monuments of generations of people remain to the present day as the living witnesses of their age-old traditions. People are becoming more and more conscious of the unity of human values and regard ancient monuments as a common heritage. The common responsibility to safeguard them for future generations is recognized. It is our duty to hand them on in the full richness of their authenticity.”

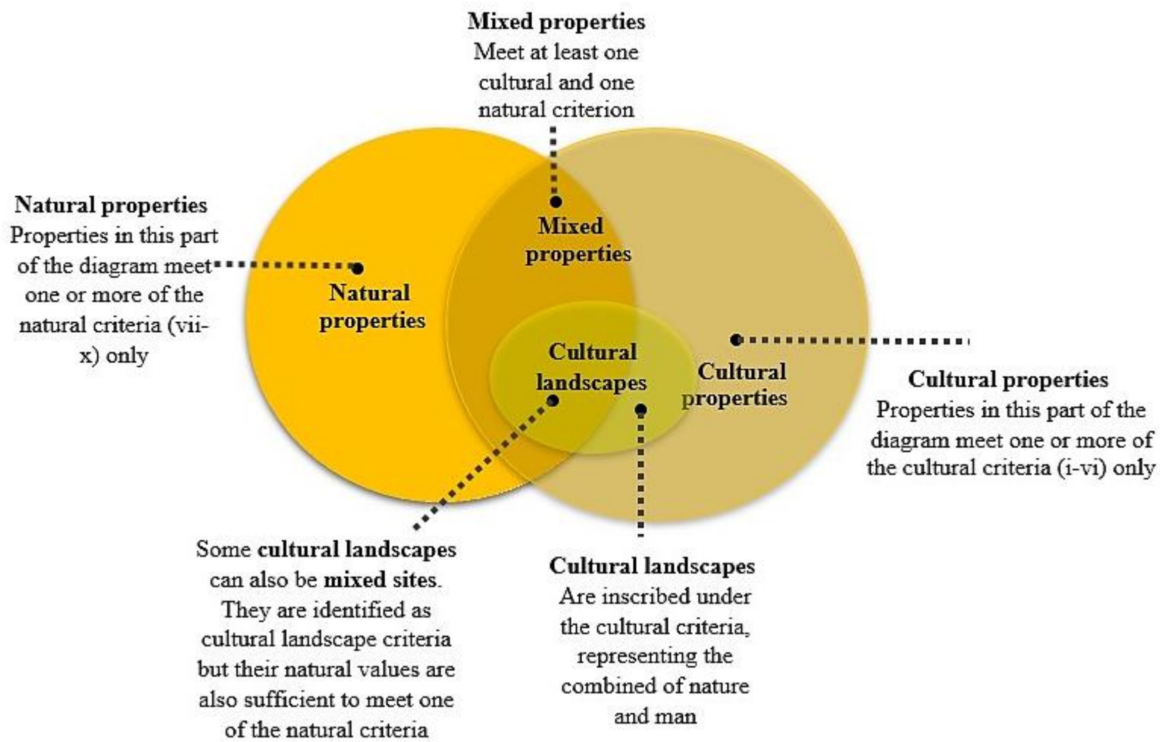

Figure 3.35- Theoretical relationship between quartet types of properties (Source: World Heritage Resource Manual, 2011).

On 20 October 1977, the *Operational Guidelines for the Implementation of the World Heritage Convention* proposed the 'test of authenticity' that referred to four parameters: **design** (form and project), **materials, workmanship** (constructive technique) and **setting** (context). In fact, the definition was basically directed to the tangible material of the heritage.

Then in 1992 to further examination of authenticity in relation to the World Heritage Convention, the Government of Japan generously offered to sponsor a major international conference of experts at the historic city of Nara, Japan. In the "*Nara Document on Authenticity*", 1-6 November 1994, which was sponsored with a preparatory workshop in Bergen,[192] participants discussed the concept of authenticity, an issue for which in some languages there is no precise word to express it gracefully. In this Conference, the revised Operational Guidelines gave a new definition for the authenticity in relation to the World Heritage Convention. As paragraph 13 of the *Nara Document on Authenticity* states, "Depending on the nature of the cultural heritage, and its cultural context, authenticity judgments may be linked to the worth of a great variety of sources of information. Aspects of the sources may include form and design, materials and substance, use and function, traditions and techniques, location and setting, spirit and feeling, and other internal and external factors. The use of these sources permits elaboration of the specific artistic, historic, social, and scientific dimensions of cultural heritage being examined."

Generally, the *Nara Document on Authenticity* followed the principle of Venice Chapter, so in addition to previous parameters, "design, material, workmanship and setting", some new parameters are to be added such as, "tradition, techniques, spirit and feeling, other internal and external factors." After Nara Conference, in synthetic report of the meeting on "*Authenticity and Integrity in an African context*", Zimbabwe 2000, other authenticity attributes are proposed: "managements system, language, and other form of intangible heritage."

Following the concept of authenticity, in the *Operational Guidelines for the Implementation of the World Heritage Convention 2015*, it is mentioned that, "Properties nominated under criteria (i) to (vi) must meet the conditions of authenticity." […] "Depending on the type of cultural heritage, and its cultural context, properties may be understood to meet the conditions of authenticity if their cultural values (as recognized in the nomination criteria proposed) are truthfully and credibly expressed through a variety of attributes (Operational Guidelines, 2015, Paragraph 79-82). In case of credibility and truthfully of World Cultural Heritage properties, Jokilehto (2006) stated that, "[…] etymologically the concept of 'being authentic' refers to being truthful, both in term of standing alone as an autonomous human creation as well as being a true evidence of something."

[192] The workshop proceedings were published by Riksantikvaren of Norway under the title Conference on Authenticity in Relation to the World Heritage Convention.

On the other hand, the second key issue that a nominated property on the World Heritage List shall meet is certainly its integrity. Integrity is a measure of the wholeness and intactness of the natural and/or cultural heritage and its attributes. Examining the conditions of integrity, therefore, requires assessing the extent to which the property: a) includes all elements necessary to express its Outstanding Universal Value; b) is of adequate size to ensure the complete representation of the features and processes which convey the property's significance; and c) suffers from adverse effects of development and/or neglect (Operational Guidelines, 2015, paragraph 88). Meanwhile, to clarify the concept of the integrity in paragraphs 89 to 95 of Operational Guidelines, in relation to the World Heritage criteria, some specific standards are proposed. With a brief review on related paragraphs, it is understandable that the purpose of decision was to show the integrity of land ownership and its nature that belongs. In the case of "Bam and its Cultural Landscape" inscribed on the World Heritage list in 2004, "the site was initially proposed as a monument but it was then redefined as a cultural landscape. As a result, its values were consolidated and extended. The core zone was defined so as to cover a large part of the most important qanat area, while the rest of the oasis, including the new town of Bam, was enclosed in the buffer zone." (Jokilehto, 2006).[193]

- Protection and Management Requirements

Protection and management of World Cultural Heritage properties should ensure that their Outstanding Universal Value, including the conditions of integrity and/or authenticity at the time of inscription, are sustained or enhanced over time (Operational Guidelines, 2015, Paragraph 96). To meet the demands for the Protection and management of World Heritage properties, in 2008, within the framework of the revision of the questionnaire of the Periodic Reporting exercise (Section II),[194] the WHC adopted a standard list of factors affecting the OUV of World Heritage properties. The list consists of a series of **14 primary factors**, each encompassing a number of secondary factors, as shown in Table 3.10.

[193] "This emergency nomination was first focused on the ancient citadel, perhaps the most visible and best-known feature of the site. Subsequently, after contact with the authorities, it was decided to extend the boundaries of the nominated area and also include the ancient irrigation system, the underground qanats, which in themselves were an important archaeological evidence of this traditional technique, as well as a vital element in the development and survival of this settlement at the crossroads of trading routes in the desert environment of central Iran. Parts of the qanats have been in use for more than two millennia and are the fundamental basis for the existence of this oasis" (Jokilehto, 2006).

[194] The Periodic Reporting on the application of the World Heritage Convention is intended to serve four main purposes: (1) to provide an assessment of the application of the World Heritage Convention by the State Party; (2) to provide an assessment as to whether the World Heritage values of the properties inscribed on the World Heritage List are being maintained over time; (3) to provide up-dated information about the World Heritage properties to record the changing circumstances and state of conservation of the properties; (4) to provide a mechanism for regional co-operation and exchange of information and experiences between States Parties concerning the implementation of the Convention and World Heritage conservation. (http://whc.unesco.org/en/periodicreporting/).

Table 3.10- The primary and secondary factors affecting the OUV of World Heritage properties (Source: UNESCO-WHC).

Primary Factors	Secondary Factors
Buildings and Development	Commercial development, Housing Industrial areas, Interpretative and visitation facilities, Major visitor accommodation and associated infrastructure
Transportation Infrastructure	Air transport infrastructure, Effects arising from use of transportation infrastructure, Ground transport infrastructure, Marine transport infrastructure, Underground transport infrastructure
Services Infrastructures	Localised utilities, Major linear utilities, Non-renewable energy facilities, Renewable energy facilities, Water infrastructure
Pollution	Air pollution, Ground water pollution, Input of excess energy Pollution of marine waters, Solid waste, Surface water pollution
Biological resource use/modification	Aquaculture, Commercial hunting, Commercial wild plant collection, Crop production, Fishing/collecting aquatic resources, Forestry /wood production, Land conversion, Livestock farming / grazing of domesticated animals, Subsistence hunting, Subsistence wild plant collection
Physical resource extraction	Mining Oil and gas Quarrying Water (extraction)
Local conditions affecting physical fabric	Dust Micro-organism, Pests Radiation/light, Relative humidity, Temperature Water (rain/water table), Wind
Social/cultural uses of heritage	Changes in traditional ways of life and knowledge system, Identity, social cohesion, changes in local population and community, Impacts of tourism / visitor / recreation, Indigenous hunting, gathering and collecting, Ritual / spiritual / religious and associative uses, Society's valuing of heritage
Other human activities	Civil unrest, Deliberate destruction of heritage, Illegal activities, Military training, Terrorism, War
Climate change and severe weather events	Changes to oceanic waters, Desertification, Drought, Flooding, Other climate change impacts, Storm, Temperature change
Sudden ecological or geological events	Avalanche/ landslide, Earthquake, Erosion and siltation/ deposition, Fire (wild fires) Tsunami/tidal wave, Volcanic eruption
Invasive/alien species or hyper-abundant species	Hyper-abundant species, Invasive / alien freshwater species, Invasive / alien marine species Invasive/alien terrestrial species, Modified genetic material, Translocated species
Management and institutional factors	Financial resources, Governance High impact research / monitoring activities, Human resources, Legal framework, Low impact research / monitoring activities, Management activities, Management system/ management plan
Other factor(s)	Any additional factor not already covered by the list above.

Since the earthquake (2003) affected “Bam and its Cultural Landscape”,[195] a review on the World Cultural Heritage Properties shows that since 1979, 32 properties from 25 State Parties

[195] Earthquake in the list of factors affecting the properties categorize as a ‘sudden ecological or geological event’.

have been threatened by the earthquake, where 94% of them have been related to Cultural Heritage, 3% Natural Heritage and 3% Mixed Heritage.

When a State Party inscribes a property in World Heritage List, as Article 4 of the World Heritage Convention about inscribed properties on the World Heritage List indicates “each State Party to this Convention recognizes that the duty of ensuring the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage referred to in Articles 1 and 2 and situated on its territory, belongs primarily to that State, ([…] and) will do all it can to this end […]” (Paris, 1972). Furthermore, Paragraph 169 of the *Operational Guidelines for the Implementation of the World Heritage Convention 2015* provides a detailed definition of the reactive monitoring process (“SOC process”) as being the “reporting by the Secretariat, other sectors of UNESCO and the Advisory Bodies[196] to the Committee on the state of conservation of specific World Heritage properties that are under threat […].” The State of Conservation (SOC) for both WHL and WHLD provides exceptional reports on the present state of conservation of intended properties, and World Heritage Committee examines this information each year. The reports that are provided by SOC have significant importance for the future of a site, as far as the collected information have a very important role for World Heritage Committee to decide whether to move a property from the WHLD to the WHL or the contrary.

- Nomination of Properties in World Heritage List

A review of all nomination files of properties inscribed on World Heritage List at the end of 1990s can reveal the deficiency of the Convention. Essential elements of the inscribed property were often unknown or unclear; nomination was with fairly generic information, and there had not been sufficient accuracy for the protection and management of inscribed properties. In 1999, a comprehensive scrutiny was conducted to improve the nomination process of World Cultural Heritage Properties. Until then, the responsibility of properties’ nomination was laid to Advisory Bodies without an initial check of their content by the Secretariat. Subsequently in 2005, a revised version of Operational Guidelines entered into force, and a new and more detailed and annotated format for properties’ nominations had officially been approved by the World Heritage Committee. Accordingly, the evaluation of nomination documents with the Advisory Bodies turned to fundamental principles for World Heritage Committee to decide about inscription of properties on the World Heritage List. The basic purpose of nominations is to say what a property consists of, why it demonstrates a potential Outstanding Universal Value, and how this value will be sustained, protected, conserved, managed, monitored and

[196] The World Heritage Committee works in cooperation with Advisory Bodies: ICOMOS, IUCN and ICCROM, in order to make greater strides in diversifying the World Heritage List and make it truly balanced and representative of the world’s heritage.

communicated (World Heritage Resource Manual, 2011).[197] In the meantime, State Parties for nomination and inscription of properties in World Heritage List have a set of responsibilities that are divided in three sections:

- preparation of Tentative Lists;
- preparation of nominations;
- protection, conservation and management of the Outstanding Universal Values of properties that are nominated to be inscribed in World Heritage List.

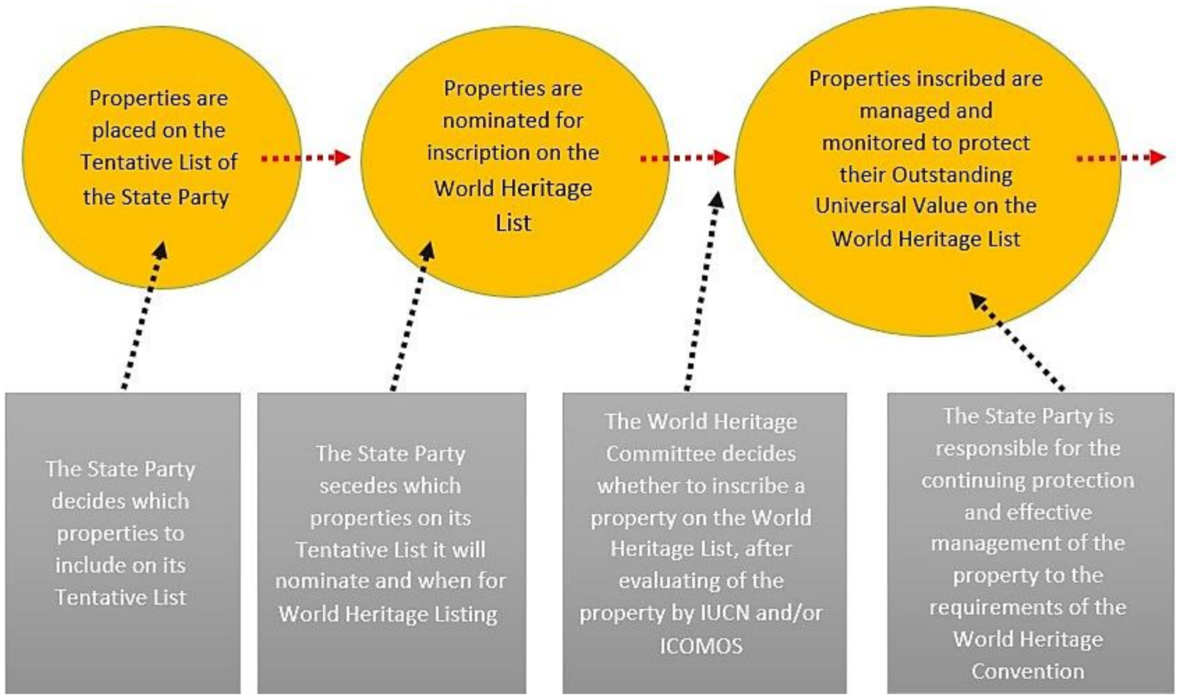

Figure 3.36- Summary of different steps in the nomination process, and the main responsibilities of the State Party and the UNESCO World Heritage Committee (Source: World Heritage Resource Manual, 2011).

[197] Some possible benefits of inscription of a property in World Heritage List are (World Heritage Resource Manual, 2011):

- providing an opportunity for the State Party and for the local community to celebrate the property as one of the most important natural and cultural places on Earth;
- the property often becomes a flagship for the national protected area / site system, including a deeper recognition and better protection for heritage in the life of the community;
- international interest in World Heritage often provides a stimulus for international cooperation and joint efforts to ensure the protection of the property;
- providing opportunities to mobilize funding and support, including from donors, and the World Heritage Fund;
- providing techniques and practices for protection, conservation and management that can be applied to national and local heritage properties.

State Parties as countries around the World that have adhered to the World Heritage Convention should make an effort to identify and nominate properties on their national territory so that they might be inscribed on the World Heritage List.[198] This agreement encourages State Parties to submit their **Tentative Lists**, as paragraph 62 of the Operational Guidelines (2015) states, "a Tentative List is an inventory of those properties situated on its territory which each State Party considers suitable for nomination to the World Heritage List. States Parties should therefore include, in their Tentative Lists, details of those properties which they consider to be of potential Outstanding Universal Value and which they intend to nominate during the following years." In fact, the Tentative List is the first step towards the nomination of properties with Outstanding Universal Value on the World Heritage List in accordance with Article 11.1 of the Convention (1972) and the corresponding provisions of the Operational Guidelines. In order to detect these potentials, various research frameworks have developed to contribute to a better understanding of the values of a property. There are two useful frameworks, one is about Cultural Heritage: "The World Heritage List: Filling the Gaps– An Action Plan for the Future (ICOMOS, 2005)"; and other is about Natural Heritage; "The World Heritage List: Guidance and Future Priorities for Identifying Natural Heritage of Potential Outstanding Universal Value (IUCN, 2006)."

Usually, for preparing of the World Heritage nomination, a minimum of 2-years work is needed. It should be noted that a well-prepared and well-organized document within minimum possible efforts will save the time spent. The official cycle for nomination of a property in the World Heritage List is that the World Heritage Committee manages the Convention, and is responsible for making decision about the inscription of a nominated property on the World Heritage List. Meanwhile, the World Heritage Committee is supported by World Heritage Centre (WHC) as Secretariat, and by three recognized Advisory Bodies – ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property), ICOMOS (International Council on Monuments and Sites), and IUCN (International Union for Conservation of Nature).

The nomination document that is prepared by State Parties should be accurate, informative and complete. In this way, to help States Parties for preparation of a good quality of World Cultural Heritage's nomination, Advisory Bodies have prepared some manuals. For each manual, depending on its particular theme, one of the Advisory Bodies act as the lead agency responsible for coordination, while the final production of each theme is ensured by the World Heritage Center.

These Resource Manuals are intended to provide detailed structure and guidance on the implementation of the Convention to the State Parties, heritage protection authorities, non–governmental organization (NGOs), local governments, site managers and local communities linked to World Heritage sites, as well as other stakeholders in the identification and

[198] Only countries that have signed the World Heritage Convention can submit nomination proposals for properties on their territory to be considered for inclusion in UNESCO's World Heritage List.

preservation process**.** In this case, as said by Kishore Rao, Director of UNESCO World Heritage Centre (2011), “As a consequence of the greater prominence and recognition according to World Heritage, there is a growing range of interests and motivation behind seeking World Heritage inscription. So, while the feasibility of new procedures like the ‘Upstream Processes’ is currently being tested, the value of this manual is evident when looking at the increasing interest of States Parties in developing nominations, which present new justifications for an Outstanding Universal Value, and the emergence of new themes to support nominations.”(World Heritage Resource Manual, 2011).

- Nomination of Properties in World Heritage List in Danger

In accordance with Article 11.4 of the World Heritage Convention (1972), “the List of World Heritage in Danger is a list of the property appearing in the World Heritage List, for the conservation of which major operations are necessary and for which assistance has been requested under this Convention. In fact, the List of World Heritage in Danger is designed to inform the international community of conditions which threaten the very characteristics for which a property was inscribed on the World Heritage List, and to encourage corrective action.”[199] This list for each category of cultural and natural heritage is divided into two groups: the first is ascertained danger that refers to specific and proven imminent threats; the second is potential danger when a property has faced threats that could have negative effects on its World Heritage values (see http://whc.unesco.org/en/158/). The duration of inscription of properties on the In-Danger List has varied from two years to over twenty (ICOMOS, 2009).

If the State Parties to the Convention observes any threat in their inscribed sites on the World Heritage List in the shortest time possible, it must draw the Committee’s attention to the existing threats. Along with this notification, if the Committee reaches to the fact that the Outstanding Universal Value of the intended property is damaged, it can decide to place the property in World Heritage List in Danger or delete the property from the World Heritage List. When a property is inscribed in the World Heritage List, the State of Conservation (SOC), which consists of the UNESCO Secretariat and the Advisory Bodies, should provide an annual report about the condition of registered sites to the World Heritage Committee, and according those reports the Committee will decide to remove the property off from the World Heritage List in danger.

[199] UNESCO, World Heritage in Danger. Retrieved from http://whc.unesco.org/en/158/

3.4 A Review on the Inscription of “Bam Citadel and its Cultural Landscape” in the WHL and WHLD until its Removal from WHLD

From the 29 November - 2 December 2003, during the 9th international ICOMOS conference on the study and conservation of earthen architecture “*Terra 2003*”, Yazd, Iran. As a predetermined program of the conference, participants visited the Citadel of Bam, one of the major earthen monuments in the national and international levels. Just two weeks after this visitation, Bam was severely damaged by a strong earthquake, where it caused serious destruction to the Bam Citadel and the surrounding areas.

During a few days after the earthquake, the devastated city of Bam was in an extraordinary situation so that all the officials and people were in shock, confusion and chaos and they did not know what to do. The extent of the disaster was such that even now, nearly thirteen years after the earthquake, the Bam’s people have not yet recovered psychologically. However, due to the emotionally close connection between the citizens of Bam and Bam Citadel, as a symbol of culture, tradition and history within Bam, and since its absence could have a negative impact on their morale, many top Iranian senior officials reiterated this to the media that the Citadel would be rebuild.[200] Although initially there was a scene of apparent disruption and emotion in the area, Iran Cultural Heritage, Handicrafts and Tourism Organization (ICHHTO) was very active from those early days onwards. As reported by Mr. Taniguchi (January 2004),[201] the Iranian Cultural Heritage Organization (ICHO) in its priority actions immediately established a temporary camp with 43 persons (5 technical experts, 17 guards, 15 craftsmen-laborers, 4 drivers, 2 support assistants). On 28 December 2003, UNESCO was formally requested by the ICHO to be the lead UN agency in assisting the Government to co-ordinate all international assistance for addressing the cultural heritage needs in the Bam, including those from other UN Agencies.[202] Following the invitation from the ICHO, and the Chief of Planning and Implementation of the Bam Task Force, as well as under the authorization of the Director of the UNESCO Tehran Cluster Office, three UNESCO-ICHO joint missions were held in Bam to prepare technical reports and to decide about the future of Bam’s cultural heritage, as follow:

- 12-14 January 2004, UNESCO-ICHO joint mission, Mission led by Mr. Taniguchi
- 22-26 January 2004, UNESCO-ICHO joint mission, Mission led by Mr. Bandarin
- 12-16 March 2004, UNESCO-ICHO joint mission, Mission led by Mr. Bumbaru

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[200] As Afshin Ebrahimi, the current manager of the Bam recovery project said. “The reconstruction drive has had a positive impact on residents of the modern city of Bam, which lies at the foot of the citadel. Survivors who lost family members in the quake are still haunted by memories of the tragedy,” Ebrahimi said. “To see the citadel being reborn has a soothing effect. This is a very special project, it is very emotional.” (Source: *Agence France-Presse* Dec 25, 2013).

[201] UNESCO Situation Report for Cultural Heritage in Bam (12-14 and 20 January 2004), section 4.2.1.

[202] Ibid.

As a follow-up to the first high-level technical mission (12-14 January 2004), the second high-level technical and advisory expert mission (22-26 January 2004) was organized with the purpose to define precise emergency measures which could be carried out immediately in order to reduce the risks of further damage to the cultural heritage properties of Bam city. In the meantime, the third mission was also an opportunity to discuss the nomination dossier for inscription of Bam and its cultural landscape on the WHL and WHLD, as well the organization of the 17-20 April 2004 Bam's Workshop.

- 12-14 January 2004 UNESCO-ICHO joint mission: the contents of this mission in their totality comprehensively records all actions taken by UNESCO Tehran Cluster Office and Mr. Taniguchi, and the information obtained before, during and soon after the mission until 20 January 2004, to assist the Iranian authorities in addressing the cultural heritage needs in Bam region.

As a review of the activities implemented during this mission, and their objectives, the committee undertook a site-visit from the Bam Citadel and as many other cultural heritage properties of Bam city to assist on an urgent basis for the conservation of Bam's cultural heritage properties. Moreover, "[…] to document, research, record, conserve, present and eventually develop the cultural heritage assets of Bam City, it undertook a consultations with the national and provincial authorities on priority actions required for both the damaged heritage assets and the new tangible heritage assets which have been revealed following the earthquake, as well as revitalization of the intangible heritage assets and cultural industries of the Bam area for social development." In addition,"[…] the committee discussed for the of preparation a broad mid to long-term action plan for appropriately addressing the conservation needs, the revitalization of intangible cultural heritage and cultural industries and tourism of Bam." Furthermore, "[…] the following points were discussed; 1) the capacity of Iranian cultural heritage stakeholders in the implementation of the priority actions and mid to long term action plan; 2) possible and appropriate international financial and technical co-operation to address the priority actions and actions within the broad mid to long term action plan; 3) the feasibility and schedule for preparing an emergency nomination for Arg-e-Bam and the Historic Monuments of Bam." Beside those,"[…] the Draft Tentative List for the Arg-e Bam and the Historic Monuments of Bam and also the Draft International Assistance Emergency Request for assisting in financing the emergency actions for Arg-e-Bam and the Historic Monuments of Bam were finalized." [203]

- 22-26 January 2004 UNESCO-ICHO joint mission: apart from previous UNESCO-ICHO joint mission, this mission was more technical. During this mission, subsequent to meetings were held between officials to survey the current conditions, and discussions took place about

[203] UNESCO. (2004). "Bam and its Cultural Landscape". Retrieved from whc.unesco.org/uploads/nominations/1208bis.pdf

the Emergency Nomination for inscription of the Cultural Heritage of Bam on the WHL and the WHLD. There was also a plan in the short, medium and long-term to be implemented for the conservation of the Bam Citadel and other cultural heritage properties of the city, which is as follows (UNESCO, 2004):

***Action I** – Emergency Measures: first half of 2004;*
***Action II** – Documentation, Assessment, Analysis and Planning: 2004-2005;*
***Action III** – Long-Term Conservation, Restoration, Rehabilitation, Presentation, and Sustainable Utilization of Bam's Cultural Heritage: 2005-2015.*

Meanwhile, it was recommended that the aforementioned actions should be undertaken in different stages, bearing in mind that the implementation of the proposed actions will necessarily overlap.

- 12-16 March 2004, UNESCO-ICHO joint mission: in this mission, focus was primarily given to the Citadel of Bam, even though several other sites located both inside and outside the city of Bam were visited. However, the main findings and recommendations of the mission was about the emergency measures needed to be taken at the citadel for the debris, still standing structures, access to the citadel, visitor track, facilities and equipments needed and so on. Meanwhile, during this mission the preparation of the nomination file for registration of the Bam site in the WHL and WHLD, and organization of the forthcoming April Workshop were discussed.

- 17-20 April 2004 Bam's Workshop: after these aformentioned missions, ICHO, UNESCO and ICOMOS on the occasion of the International Day of Monuments and Sites (18 April), co-organized a situ workshop for the Recovery of Bam's Cultural Heritage between 17-20 April 2004 in Bam.[204] The aim of this workshop was to learn from the Bam earthquake, to examine and to reflect the effects of earthquake on city's cultural heritage properties, in particular Bam Citadel, and studying and proposing measures to keep intact the integrity of Bam's tangible and intangible architectural heritage and cultural landscape. It also adopted sound guiding recommendations under the proposed timetables for the immediate, short-term, mid-term and long-term restoration actions, as well as enhanced planning and implementation of the conservation interventions required and sustainable utilization of Bam's heritage within the

[204] In this workshop 38 international and 23 Iranian expert participants and representatives of local and national authorities, and 31 ICHO members, gathered from Canada, France, Germany, Iran, Italy, Japan, Peru, Spain, the United Kingdom and the United States of America, as well as representatives the Governments of France and Italy, International Centre for Earth Construction – Ecole d'Architecture de Grenoble - (CRATerre-EAG, France), the Getty Conservation Institute, World Monuments Fund, the International Centre for the Study of the Preservation and the Restoration of Cultural Property (ICCROM), ICOMOS, the World Bank, and UNESCO (Bam Declaration and Recommendations, 2004).

overall post-earthquake development of the city of Bam. The Declaration of this workshop is listed as follow (Bam's Declaration and Recommendations, 2004):

1. *Conserving the full significance of Arg-e Bam and its setting*
2. *Conserving the character and the heritage of the city and landscape*
3. *Integrating heritage in the recovery process and the future development of Bam*
4. *Preserving and enriching the tradition of earthen architecture*
5. *Protecting and preventing damage to earthen heritage in seismic areas*
6. *Sustaining co-operation to realize the conservation goals*
7. *Recommendations*
8. *Sustaining the momentum and focus to implement the present Declaration and Recommendations*

The recommendations of the 17-20 April 2004 workshop within four actions are listed as follow (Bam's Declaration and Recommendations, 2004).

Action I – Recommendations for immediate action:
▪ *Document, identify and analyze initial risks and implement emergency stabilization treatments.*
▪ *Secure and stabilize the parts of Arg-e Bam which are vulnerable to aftershocks.*
▪ *Provide adequate, sensitively designed and safe access to conservation professionals, the general public, and to the citizens of Bam who will continue to utilize the Arg-e Bam for traditional and religious activities.*

Action II – Recommendations for short-term actions (2004-2005):
▪ *Define criteria and procedures for managing debris, taking into full consideration, on a case by case basis, the structural implications any interventions may cause on the heritage resources.*
▪ *Continue with rigor the consultation process between ICHO and the relevant authorities in ensuring that the Master Plan for the Reconstruction of Bam City respects the heritage areas of Bam, as defined within the core and buffer zones, which are being proposed for World Heritage inscription. In addition, the panoramic views and cultural landscape surrounding Arg-e Bam and its related properties must be taken into account within the Master Plan.*
▪ *Strengthen and continue the comprehensive management planning process in a short to medium time frame, for Arg-e Bam and its surrounding areas.*
▪ *Develop plans for visitor access and orientation, including exhibition of pre and post-earthquake events and heritage assets.*

Action III – Recommendations for mid-term actions (2004-2010):
▪ *Develop and implement a site management plan for Arg-e Bam and its surrounding areas. The plan must address and establish policies for conservation, archaeological researches,*

rehabilitation, cultural landscape protection, site interpretation, access, circulation and safety. Furthermore, the plan should guarantee compatibility with the General Master Plan being developed for Bam's reconstruction.

▪ *Develop a conservation program, which includes a comprehensive analysis resulting in interventions based on the identification of the complete range of values in accordance with international charters. Implement an open information management system to ensure access to information and to prevent wastes of effort. To this end, standard criteria for data collection, classification and entry must be established. These standards must take into consideration the needs of multiple disciplines.*

Action IV – Recommendations for long-term actions (2004-2015):

▪ *Assess the objectives of the site management plan of Arg-e Bam, the effectiveness of the policies within the management plan, and the compatibility with the expected outcomes from the General Master Plan.*

▪ *Conduct scientific investigations to address issues related to the long term conservation of earthen architecture in Arg-e Bam. This could contribute, in a broader national and international context, to the development of adapted use of earthen architecture techniques for seismic areas and for contemporary needs.*

- Inscription of "Bam and its Cultural Landscape" on WHL and WHLD, and Management of Bam Citadel after the Earthquake

After the 2003 Bam earthquake, both in the national and international levels, particularly amongst main international institutions and professionals involved on the issue of cultural heritage preservation, there was a solidarity to save Bam's cultural heritage properties. According to the emergency procedure foreseen in Paragraph 67, and Paragraph 178 and 179 of the *Operational Guidelines for the Implementation of the World Heritage Convention*, Bam's cultural heritage properties was qualified to be inscribe on both the WHL and WHLD. However, World Heritage Committee made ICHO incumbent to submit the dossier concerning the inscription of "Bam and its Cultural Landscape"; following the request of ICHO, UNESCO Tehran Cluster Office also assisted ICHO for the preparation of the nomination dossier. Although Bam Citadel was figured on the National Tentative List of Iran, its formal Tentative List submission had not been done before the earthquake. Therefore, ICHO with some help from Mr. Taniguchi completed the official Tentative List by name of "Arg-e-Bam and the Historic Monuments of Bam" and submitted it on 16 January 2004 to the World Heritage Centre's Director. In the debut for the preparation of nomination file by ICHO, there was a question regarding what priority should be considered in the nomination of Bam's site. However, through meetings hold and discussion made among national and international experts who had rich experience in this field, the domination of Bam site, the proposal for core and buffer zone and other related parts of its emergency nomination file was augmented. Then, for possible inscription on the WHL and the WHLD, on May 2004 it was submitted to the World Heritage Committee for examination at 28th session of the WH Committee, Jun-July 2004, Suzhou, China.[205]

Eventually, on the 7th July 2004, "**Bam and its Cultural Landscape**" as a single urgent inscription which includes Bam Citadel and the city's historic sites and monuments, gardens, Qanats,[206] under criteria (ii), (iii), (iv) and (v) was simultaneously inscribed on UNESCO's WHL and WHLD. Each criterion of "Bam and its Cultural Landscape" is defined as follow (UNESCO, 2004):

*- **Criterion (ii):** Arg-e Bam developed at the crossroads of important trade routes in the southern side of the Iranian high plateau, and it became an outstanding example of the interaction of the various influences.*
*- **Criterion (iii)**: Arg-e Bam and its related sites represent a cultural landscape and an exceptional testimony to the development of a trading settlement in the desert environment of the Central Asian region.*
*- **Criterion (iv):** Arg-e Bam represents an outstanding example of a fortified settlement and citadel in the Central Asian region, based on the use of mud layer technique (Chineh) combined with mud bricks (Khesht).*
*- **Criterion (v):** The cultural landscape of Bam is an outstanding representation of the interaction of man and nature in a desert environment, using the Qanats. The system is based on a strict social system with precise tasks and responsibilities, which have been maintained in use until the present, but has now become vulnerable to irreversible change.*

Immediately after the Bam earthquake, the Iranian Cultural Heritage Organization (ICHO) as a sub-branch of Iranian Cultural Heritage, Handicraft and Tourist Organization (ICHHTO) set up a Task Force, headed by the Director of the Organization, in order to coordinate all the works and measures related to cultural heritage of Bam. The Task Force that started its activities in Bam with a temporary camp included several committees: technical, executive, documentation, information, international relations, administration, protection and public relation (this group now is recognized as the "*Bam Base*" or "*Recovery Project of Bam's Cultural Heritage*" (RPBCH).

The inscription of Bam Citadel on the World Heritage list at the 28th session of the UNESCO's World Heritage Committee in China was a giant step towards renovating this historical site

[205] In the case of Bam city, the site was initially proposed as a monument but it was then revised as "Bam and its cultural landscape".
[206] Some of the listed buildings outside the Arg are property of other governmental institutions, but any changes are subject to permission by ICHO (UNESCO, 2004).

(Mike Corfield 2006, an interview with CHN).[207] In consequence of UNESCO-ICHO joint mission held in 2004 soon after the earthquake, an 'Action Plan' was proposed by 'Isfahan University' for the restoration of Bam Citadel, which consisted of three main parts: (a) research; (b) conservation, restoration and rehabilitation; and (c) presentation and education. The Action Plan was not aimed at complete reconstruction of the whole complex, but to conserve, restore, revitalize, present and develop the historical areas, based on clear guidelines and a strategic, realistic action plan to be implemented in the coming months and years (Hejazi & Mehdizadeh, 2015). In this Action Plan, three major phases were considered for all activities: phase I: emergency measures; phase II: documentation, assessment, analysis and planning, and phase III; long-term restoration, rehabilitation, presentation, and sustainable utilization of Bam's cultural heritage. In fact, during the early months after the earthquake, the mission of RPBCH was mainly crisis management, but after passing through the critical stage, its mission was stepped into the conservation of Bam's cultural heritage properties.

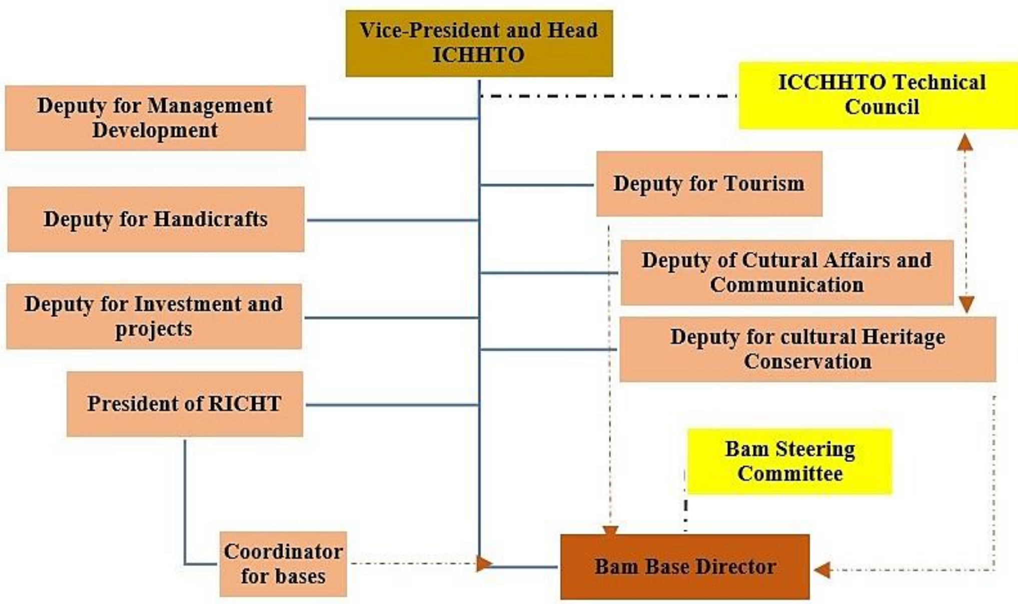

Figure 3.37- Bam base within the organizational chart of ICHHTO (Source: Comprehensive Management Plan of Bam and Its Cultural Landscape 2008-2017, designed by Author).

If we want to have a review of the management of Bam Citadel from the time of its inscription in the WHL and WHLD in 2004 until its removal from WHLD in 2013, we should survey the restoration projects, based on the proposed phases in Action Plan. In all of these phases, RPBCH tried to act in such a way that all international conservation norms and recommended criteria

[207] Sadigh, S. (2006). "*Reconstruction of Bam Citadel Needs Time and Patience*", an interview with Mike Corfield, The Circle of Ancient Iranian Studies (CAIS). Retrieved from http://www.cais-soas.com/News/2006/February2006/18-02-reconstruction.htm

by UNESCO and ICOMOS, during missions and sessions after the earthquake are to be implemented with a particular care, the three main phases are exposed in following:

Phase 1: Emergency measures:

This phase that accomplished in almost six month primarily concentrated on the urgent and immediate management of the citadel, as the most visible and best-known feature of the city, to prevent further damage to the remained structures and to provide condition for retrieving the available documents and to start research and analysis required to proceed the restoration plans.

i) Minimum protection:

As mentioned by Ahmadi Roini (2012), "After the earthquake, much of the 2000 m perimeter wall was in ruins, and the shallow slope of the rubble invited visitors to climb. Although a few of the thousands of people who came to Bam had no wish to visit the citadel, the majority chose to go there. As a result, there were thousands of visitors each day. This was a problem from a number of perspectives. There was a great concern that the uncontrolled visitors might create more damage and destroy archaeological evidence. We were also concerned about the safety of the visitors. As well as the possibility of aftershocks or collapses which could have trapped people, there were a large number of animals running wild over the site." However, the first priority action was the establishment of fences along the perimeters of the citadel, blocking the street in front of the Arg and prohibiting people to enter inside of the site, a temporary way was built that was just used by authorities and experts.

ii) Completion of documents

In this step, all documents related to the structural information such as architectural typology, building material characteristics, implementation procedure and conservation history, as well as the existing maps, aerial photos, photographs and etc., were collected.

iii) On-site inspection

▪ Evaluation of structural damages, typology and materials,
▪ Geology, including structural failures and patterns,
▪ Archeology,
▪ Safety of structures, including mapping of all potential risks to heritage assets and identifying priority security areas.
▪ Geotechnical conditions of the area.

iv) Access of visitors to the citadel

As regards the particular characteristic of the monuments inside Bam citadel and their condition after the earthquake, there were increased requests and enthusiasts for visiting, both among people and mostly among experts. And since the damage caused by the earthquake has disrupted all the visiting paths inside the Bam Citadel, a safe and flexible wooden pathway has been set up to resolve the visitor pressure for the moment. This visitor route started from the first main gate at the south of the citadel and by passing through the Bazaar ended at the second gate. Through this route, the visitors could circle around collapsed section and have a close-up view from the ruins. Here it should be pointed that in the time of pathway assembling, it was tried to use materials that have very close color similarity to the ruins and debris, so it was constructed from scaffolding pipes and Russian timber. In this respect one of the main actions after the earthquake, also praised by the participants in the April 2004 workshop, was the building of a temporary wooden passageway through the debris for visitors (Vatandoust et al., 2007).

v) Debris removal and emergency securing

Since the full extent of damage continues to emerge over time, one of the most important emergency actions was debris removal, securing the structures and preparation of site for next restoration phase. In this case, all measures were under the supervision of archeologists so that valuable heritage assets would be conserved, and adobe bricks which remained in good state were also stored for possible re-use in the future. Depending on the condition of damages and their location, different methods and equipment were used for debris removal; removal by hand, removal by hand and using mountain climbing equipment, removal by using chutes and removal by other mechanism like wagons on rails, cable wagons and etc. Besides all aforementioned measures, there were also carried out other tasks, such as physical security consisting of detection, consolidation and scaffolding of vulnerable parts; collection of related information, documents, photos etc., at national and international levels; and daily monitoring of the site and their records.

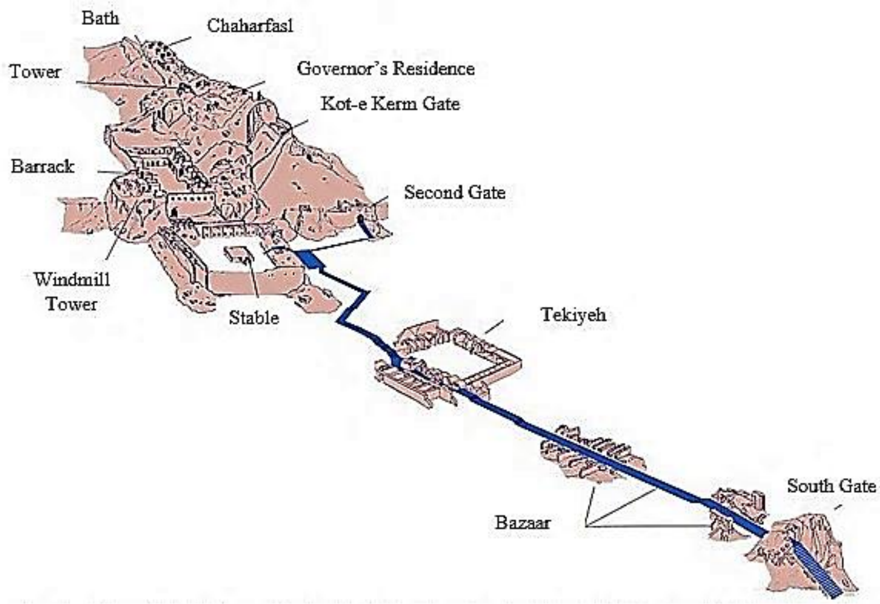

Figure 3.38- Photos and schematic picture of wooden pathway of Bam Citadel in counter between first main Gate and Second Gate (Source: (Top) Photo by Kenare, 2004. Source: gettyimages; and (Down) UNESCO, 2004).

Figure 3.39- Debris removal in Bam Citadel after the earthquake (respectively from left to right photos by fs, 2007; Marino, 2004, Cheng, 2006. Source: https://www.flickr.com/search/?text=bam%20citadel).

Phase 2: Documentation, assessment, analysis and planning:

Most of the ruins in Bam Citadel were the parts that already were added to the main body of structures or were modified during the previous conservation activities before the earthquake. Moreover, in any seismic upgrading in heritage sites there are four item, which are very important: seismology of the area, quality of the construction, function of building and cultural values. A wide variety of intervention strategies and techniques have been considered for the repair and the seismic retrofitting of the adobe buildings in the Citadel (Shad, 2015). The aim of phase 2 was mainly seize the time to do a comprehensive research and analysis for extending the archeological knowledge and enhancing the seismic performance of materials and constructions for all future conservation activities. Furthermore, Bam saving project, in this phase tried to investigate all the documents, technical maps (such as topography, seismicity, archeology etc.), and photographs of the ruins of Bam Citadel to be able to return to their past glory and greatness. In addition to all of those actions, criteria for site management and preliminaries for Comprehensive Master Plan, Draft for Conservation Program in Bam Citadel, Draft of Comprehensive Archeological Plan of Bam and its Cultural Landscape, Plans for the Introducing of Bam Citadel and its Cultural Landscape and Draft of Studies Associated with Development of Tourism Improvement in Bam were ongoing. This phase started from the second half of 2004 and finished in 2005.

Phase 3: Long-term restoration, rehabilitation, preservation, and sustainable utilization of Bam's cultural heritage:

In this phase, activities were linked to the overall reconstruction and recovery plan of Bam city to represent an opportunity to improve local and national capacities. In this purpose, many efforts have been made for registration, recognition, and legal protection of properties with cultural, historical and natural specifications within the cultural landscape zone. Meanwhile, a number of measures such as emergency conservation, restoration, protection and stabilization of the remains have been taken in order to prevent monuments from further decay. In addition, other principal measures such as reconstruction and rehabilitation of the main monuments, and their reutilization through assigning new functions to them (e.g. exhibition area, storage area, areas for production and exhibition of handicrafts, etc.) have been taken in order to promote local culture. In the meantime, the importance of Bam's people and their participation in the current phase was reviewed and was not ignored.

After the assessment of the post-earthquake situation of Bam site through national and international expertise, the all of recommendations were made to define a backup strategy for the Bam's cultural landscape. In the meantime, the declaration of Bam that was proposed at the International Workshop of April 2004, laid the principles that would define all interventions: "keeping the full meaning of Arg-e Bam and its environment", "safeguarding the character and heritage of the city and its landscape" and "integrating heritage into the reconstruction process." (Garnier et al., 2013). [208] Generally, the inscribing Bam and its Cultural Landscape on the List of World Heritage in Danger has helped the project to have a more efficient role in improving the quality of the reconstruction of the city (Vatandoust et al., 2008). Then after the inscription

[208] Garnier, P., Moles, O., Caimi, A., Gandreau, D., & Hofmann, M. (2013). Natural hazards, disasters and Local Development, Integrated strategies for risk management through the strengthening of local dynamics: from reconstruction towards prevention, CRAterre Editions. Retrieved from craterre.org/diffusion:ouvrages.../download/.../14803_natural_hazards_disasters.pdf

of Bam Citadel in World Heritage List and completion of enough available documents, UNESCO's decision prompted the then government to take planned actions to remove the Bam site from the WHLD. To achieve this purpose, in Art 3.1 of April 2004 international workshop for the Recovery of Bam's Cultural Heritage it was mentioned that, "The conservation and revitalization of intangible and tangible heritage of Bam must be integrated within the General Master Plan which should be revised, as well as complementary support programs and special projects contributing to the recovery process of post-earthquake Bam, in order to ensure that the unique identity and cultural character of Bam are retained and fully contribute to the restoration of the life of its citizens."

Since this project was not possible without a regular collaborative participation between all stakeholders either between the organizations related to the cultural heritage properties and in the urban affairs, prior to the implementation phase, several meeting with stakeholders were held in order to engage them in the planning process and ensure their contribution in conservation and capacity building (Mozafari, 2014). Therefore, the state party of Iran in addressing the concerns expressed by the World Heritage Committee in its previous decisions, as well as recommendations made by previous reactive monitoring missions,[209] for the first time in 2007 with support of a team of experts coordinated by the UNESCO Tehran Cluster Office and ICHHTO prepared a Comprehensive Management Plan, 2008-2017.[210] In the meantime, the plan which covers all areas of Bam and its cultural heritage properties was developed through a process involving the local authorities of the County, the five Districts and the municipalities of Bam and Baravat.[211]

One of the main point of Bam's Comprehensive Management Plan 2008-2017 was that for the eventual removal of Arg-e Bam and its cultural landscape from the List of World Heritage in Danger. In this plan seven benchmarks were defined which were to be meet until 2010, and the World Heritage Committee accepted it, the benchmarks are listed in Table 3.11. In this case, the second Comprehensive Management Plan was submitted to the World Heritage Centre in January 2010 (State of conservation "Bam and its Cultural Landscape", 2011). Generally, the principle aim of these Comprehensive Management Plans were to achieve sufficent balance between conservation of values of the landscape and sustainable socio-economic development of the local communities.[212]

[209] According to the definition criteria and procedures for intervention and managing the debris and remains in Bam and its Cultural Landscape.
[210] A consulting group named 'Architecture Consulting group of Bam', created by the Governor in 2008, coordinates the implementation of the MP, through the 'Office for Planning and Management of Bam and its Cultural Landscape (OPMBCL). Meanwhile, it was legally adopted in 2010, and was assigned by all related organizations and governmental bodies to cooperate with ICHHTO.
[211] Report on the joint UNESCO - ICOMOS Reactive Monitoring Mission to Arg-e Bam and its Cultural Landscape, IRAN (16 - 22 Oct. 2011).
[212] In general, a management system should contribute as a decision-making tool when addressing external threats, such as pathologies, encroachment, tourism pressure, etc. In this case, the management

Table 3.11- Benchmarks proposed by ICHO in 2007 for the eventual removal of Bam and its Cultural Landscape (Source: UNESCO, 2012).

Benchmark No.	Explanation
1	Emergency stabilization treatment and securing the parts of Arg-e-Bam, which are vulnerable to aftershocks
2	Providing adequately, sensitively designed and safe access to conservation professionals, general public, and to the citizens of Bam who will continue to utilize the Arg-e-Bam for traditional and religious activities
3	Removal of Debris from the Arg-e-Bam
4	Comprehensive Management Planning and the conservation of the Cultural Landscape of Bam
5	Preservation and enrichment of the tradition of earthen architecture
6	Completion of mapping of the archaeology and geo-morphology of the area of Bam and its Cultural Landscape and related studies
7	Protection of the heritage areas in the World Heritage property outside the Arg-e-Bam

Apart from these benchmarks, there were also considered some rules related to the local urban policies to protect cultural heritage properties of the region, which paid attention to the Citadel and all the cultural properties including those currently discovered in the town of Bam and are in the future landscape buffer zone. In the case of Comprehensive Management Plan (2008-2017 AD),[213] we can refer to some rules, which are being ratified for core zones and buffer zones:[214]

- Core Zone: consists of the Citadel and other single monuments in the region, which are a part of Bam's cultural heritage properties. Any construction activity or alteration in this zone is forbidden without the permission and supervision of the ICHO.
- Buffer Zone 1: in this buffer zone like core zone, all constructions should be under supervision and permission of ICHO; the highest point to build is considered 4.5 m; and the style and façade of the building as far as possible should be in traditional style of the architecture in Bam.
- Buffer Zone 2: in this buffer zone the construction of building is limited to three floors (maximum 10 m height); the style of building can be in any styles; the skyline and views

plan does not integrate a deep analysis on the existing site and components conditions analysis; the condition of the earthen material; the conservation state of the site; a conservation proposal; a maintenance schedule; an effective program of work, among several other issues (State of conservation "Bam and its Cultural Landscape", 2011).

[213] ICHHTO. (2008). Comprehensive Management Plan 2008-2017: Bam and its Cultural Landscape, Iranian Cultural Heritage. Tehran, Iran: Iranian Cultural Heritage Handicraft and Tourist Organization. (Published in Persian).

[214] Before the earthquake, there was no buffer zone defined for the citadel, just a limited zone around the site which was defined by the roads in the south and west sides, date gardens in the east side and the river in the north side. There were housing and private date gardens in the peripheral zone, and some plans for new road construction (Khakzad, 2011).

of Bam Citadel, other related historical monuments and surrounding mountains are protected; in agricultural context any activities is permitted as far as this will not require construction disturbing the landscape, as well as mining and quarrying.

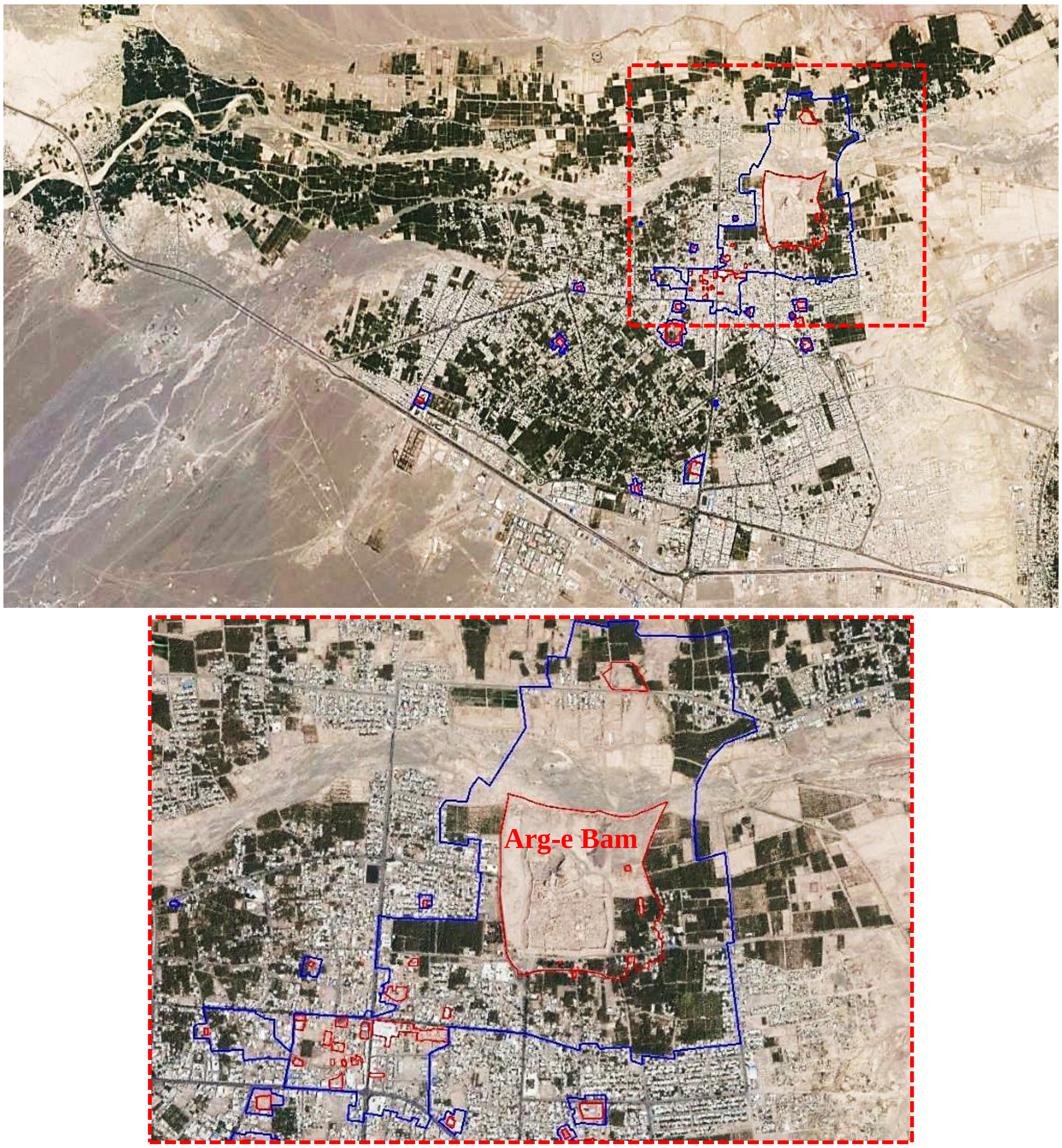

Figure 3.40- Core zone (the red one) and buffer zone 1 (the blue one) of Bam and its Cultural Heritage, other parts of city are a part of buffer zone 2, and core zones outside of buffer zone 1 have their segregated buffer zone 1 (Designed by Rouhi, based on last version of proposed boundaries).

Based on deadline considered for the State Party of Iran to remove Bam from the List of World Heritage in Danger, UNESCO dispatched a monitoring group in February 2010 to estimate the authorities' response to the proposed benchmarks and evaluate the progress regarding the desire state of conservation of the site. As regards to report on the joint UNESCO-ICOMOS Reactive

Monitoring Mission to Arg-e Bam and its Cultural Landscape (October 2011), "there were still some missing milestones to be completed. Meanwhile, the mission team drew attention to some demolitions and encroachments developed within the property that appear not to be in line with planning controls and might have an impact on the Outstanding Universal Value of the property."[215] For this consideration, a list of subsequent and relevant recommendations was suggested to be met.

Finally, during the 37th session in Phnom Penh (2013), World Heritage Committee commended the 'considerable efforts made by the State Party, with the support of the international community, to address the threats that led to the inscription of the property on the List of World Heritage in Danger and to implement the corrective measures'; remains had been sufficiently stabilized and its management was sound enough for the site to be declared safe. According to the State of Conservation "Bam and its Cultural Landscape" (2013), through Analysis and Conclusions of the World Heritage Centre, ICOMOS and ICCROM it was said that, "the World Heritage Centre and the Advisory Bodies are of the view that the State Party has addressed the work needed to complete the remaining corrective measures identified by the October 2011 reactive monitoring mission and has now met the Desired state of conservation for the removal of the property from the List of World Heritage in Danger. They recommend that the World Heritage Committee commended the State Party for the sustained efforts made in implementing the corrective measures for the property. Therefore, they recommend that the World Heritage Committee consider the removal of this property from the List of World Heritage in Danger. They note, however, that the property remains vulnerable, in particular the challenges in controlling illegal construction, effective protection of the buffer zone, achieving consistency in restoration, and ensuring continuous site security." [216]

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[215] UNESCO. (2012). Report on the joint UNESCO - ICOMOS Reactive Monitoring Mission to Arg-e Bam and its Cultural Landscape, IRAN (16 - 22 Oct. 2011). Retrieved from whc.unesco.org/document/116542

[216] In order to have a fully comprehensive overview of all the process of inscription Bam and its Cultural Landscape as WHL and WHLD, until its removal from WHLD; all working documents and Committee decisions concerning the property from the following eleven sessions can be accessed online at this address: http://whc.unesco.org/en/soc/?action=list&id_site=1208:

- 28th session of the WH committee, Suzhou, China (2004);
- 29th session of the WH committee, Durban, South Africa (2005);
- 30th session of the WH committee, Vilnius, Lithuania (2006);
- 31st session of the WH committee, Christchurch, New-Zealand (2007);
- 32nd session of the WH committee, Quebec City, Canada (2008);
- 33rd session of the WH committee, Sevilla, Spain (2009);
- 34th session of the WH committee, Brasília, Brazil (2010);
- 35th session of the WH committee, Paris, France (2011);
- 35th session of the WH committee, Paris, France (2011);
- 36th session of the WH committee, Saint Petersburg, Russian Federation (2012);
- 37th session of the WH committee, Phnom Penh, Cambodia (2013).

3.5 Significance and Issues of "Bam and its Cultural Landscape"

The aim of this section is primarily to represent a clear prospect of why cultural landscapes are important, and what constitutes cultural landscape in the World Heritage context, then to address the significance and issues of "Bam and its Cultural Landscape" and to extract its implications for future considerations. To achieve this purpose, the study is divided into two main sections. The first section gives an overview of the cultural landscape in the world heritage context, including the notion of cultural landscape and the history of the presentation of cultural landscape in the World Heritage List. The second section will address the significance and characteristics of the inscribed property of "Bam and its Cultural Landscape" in the WHL, issues on applying the convention, and current issues of cultural landscape conservation in the region. The benefits of this part would be twofold: first, simply, a clear image of how each of the values identified for Bam site are expressed, embodied, or otherwise represented in the materials of the site (ranging in scale from relics to monuments to landscapes); second, the key "anthology" of tangible resources and intangible values, and their relation with Bam cultural landscape are investigated.

- Definition of the World Heritage Cultural landscape

The word "Landscape", at the beginning of the 16th century, was originally introduced as a painters' term from Dutch 'landschap', from Middle Dutch 'landscape' which is simply taken from two words "region, from land" and "condition, from scap" (The American Heritage Dictionary of the English Language).[217] The perception of landscape was deeply established in Europe and became well known as 'English Garden' (Akagawa & Sirisrisak, 2008). It refers to the informal landscape style which was popular in the UK from the mid-18th century to the early 19th century (Akagawa & Sirisrisak, 2008), meaning "tract of land with its distinguishing characteristics." (The American Heritage Dictionary of the English Language). At the beginning of the 1990s, the concept of the cultural landscape has common property, a positive word used by researchers, planners and administrators in a variety of contexts. Then, it has become a catchword used in the media everyday life (Jones, 1991).

It was Carl Ortwin Sauer, a human geographer, who was probably the most influential in promoting and developing the idea of cultural landscapes. Sauer was determined to stress the agency of culture as a force in shaping the visible features of the Earth's surface in delimited areas (Bharatdwaj, 2009).[218] Sauer thus stressed CULTURE as a geographical agent, although the physical environment retained a central significance as the medium with and through which

[217] The American Heritage Dictionary of the English Language (4th Edition). Retrieved from http://dictionary.reference.com/search?r=2&q=landscape
[218] Bharatdwaj, K. (2009). *Physical Geography: A Landscape Appreciations*. New Delhi: Discovery publishing house PVT. LTD, p. 6.

human cultures act (The Dictionary of Human Geography, 2009),[219] see Figure 3.41. As classic definition of "Cultural Landscape" by Sauer (1925), "The cultural landscape is fashioned from a natural landscape by a cultural group. Culture is the agent, the natural are the medium, the cultural landscape is the result. Under the influence of a given culture, itself changing through time, the landscape undergoes development, passing through phases and probably reaching ultimately the end of its cycle of development. With the introduction of a different, alien culture, a rejuvenation of the cultural landscape sets in, or a new landscape is superimposed on remnants of the old one."[220]

According to Akagawa & Sirisrisak (2008), "The clear separation of cultural landscape and natural landscape as Sauer defined it is commonly practiced in landscape protection. This issue was also a major concern in Europe as addressed in the Report of the Expert Meeting on European Cultural Landscapes of Outstanding Universal Value in 1996 that Nature conservation in Europe does not often integrate the protection and development of cultural landscapes." However, the historical background of 'Cultural landscape' goes obviously back to academic world in the earlier 20th century and it was considered in field of conservation in the 1990s (Fowler, 2003).

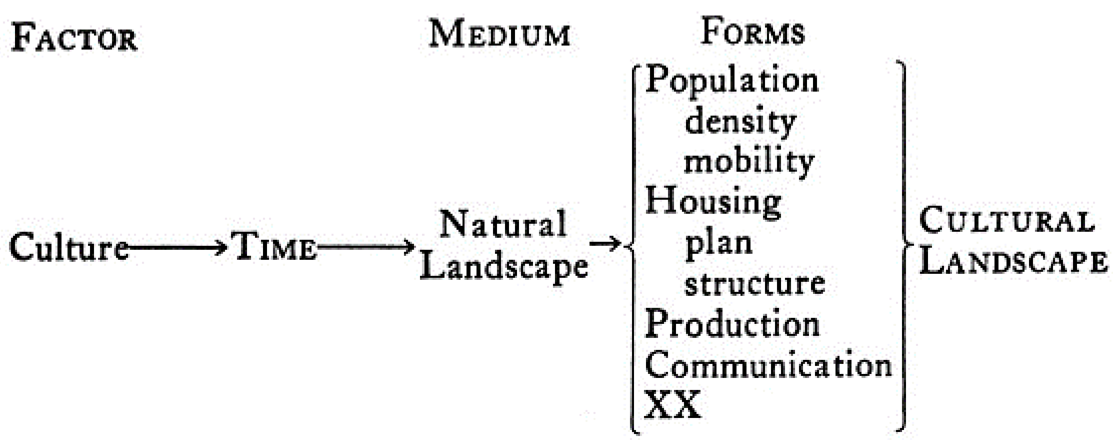

Figure 3.41- The model of Saur for Cultural landscape (Source: Sauer, 1925).

The first signs of international concern about the importance of safeguarding the beauty and character of landscapes and sites can be seen in the 12th session of UNESCO in Paris from 9 November - 12 December 1962. As the General Conference defined, "[...] the safeguarding of the beauty and character of landscapes and sites is taken to mean the preservation and, where

[219] Gregory, D.R., Pratt. G., Watts, M., & Whatmore, S. (eds.). (2009). The Dictionary of Human Geography (5th Edition). Hoboken, New Jersey: Wiley- Blackwell.
[220] Sauer C.O. 'The Morphology of Landscape', 1925. In Land and Life: A Selection from the Writings of C. O. Sauer, edited by J. Leighley. Reprinted by University of California Press, Berkeley, pp.315–50, 1963.

possible, the restoration of the aspect of natural, rural and urban landscapes and sites, whether natural or man-made, which have a cultural or aesthetic interest or form the typical natural surroundings."

The second specific international mobility on the subject of cultural landscape preservation was the establishment of the International Scientific Committee for Cultural Landscapes (ICOMOS/IFLA) and the International Federation of Landscape Architects (IFLA) in 1970. The third was the recognition of World Heritage Cultural Landscape under UNESCO's World Heritage Convention (1972) as outstanding examples of the "combined works of nature and man". Then, the next international movement was the adoption of Historic Gardens (The Florence Charter) by ICOMOS in 1982. Finally, the current notion of cultural landscapes has been variously used, applied, debated, developed and refined within academia since 1992 when the World Heritage Convention decided to give a broader definition to cover the diversity of cultural landscape in the world, hereafter, it has been possible to nominate places for their cultural landscape values to the WHL. Then in 1995, Europe Council in Recommendation No (95)9 of the Committee of Ministers to Members States on the Integrated Conservation of Cultural Landscape Areas as Part of Landscape Policies, gave a new definition about "cultural landscape area". According to Article 1 of Council of Europe (1995), "specific topographically delimited parts of the landscape, have been formed by various combinations of human and natural agencies, which illustrate the evolution of human society, its settlement and character in time and space and have acquired socially and culturally recognized values at various territorial levels, because of the presence of physical remains reflecting past land use and activities, skills or distinctive traditions, or depiction in literary and artistic works, or the fact that historic events took place there."[221]

The first time the *Operational Guidelines for the Implementation of the World Heritage Convention 1997* brought together the term of natural and cultural places into one frame (Noroozi et al., 2015). Then, World Heritage Committee in 2002, 2005 and 2008 revised the categories of cultural landscapes.

According to *the Operational Guidelines for the Implementation of the World Heritage Convention*, "Cultural landscapes are cultural properties and represent the "combined works of nature and of man" designated in Article 1 of the Convention. They are illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal" (Operational Guidelines, 2015,

[221] Council of Europe Committee of Ministers. (1995). Recommendation No. Rec (95) 9 on the integrated conservation of cultural landscape areas as part of landscape policies. Retrieved from https://search.coe.int/cm/Pages/result_details.aspx?ObjectID=09000016804fd025

paragraph 47). Refining this further, the World Heritage Convention recognizes three categories of cultural landscapes as follow (Operational Guidelines, 2015, Annex 3, paragraph 10):
(I) The most easily identifiable is the clearly defined ***landscape designed*** *and* ***created intentionally by man****. This embraces garden and parkland landscapes constructed for aesthetic reasons which are often (but not always) associated with religious or other monumental buildings and ensembles.*

(II) The second category is the ***organically evolved landscape****. This results from an initial social, economic, administrative, and/or religious imperative and has developed its present form by association with and in response to its natural environment. Such landscapes reflect the process of evolution in their form and component features. They fall into two sub-categories:*

- *a relict (or fossil) landscape is one in which an evolutionary process came to an end at some time in the past, either abruptly or over a period. Its significant distinguishing features are, however, still visible in material form.*
- *a continuing landscape is one which retains an active social role in contemporary society closely associated with the traditional way of life, and in which the evolutionary process is still in progress. At the same time it exhibits significant material evidence of its evolution over time.*

(III) The final category is the ***associative cultural landscape****. The inscription of such landscapes on the World Heritage List is justifiable by virtue of the powerful religious, artistic or cultural associations of the natural element rather than material cultural evidence, which may be insignificant or even absent.*

After preparation of cultural landscape's nomination by state parties, professionals review them, and then the WHC determine whether it has a universal example or not. If appropriate, the evaluation will be carried out by ICOMOS in consultation with IUCN (see Paragraph 146 of the Operational Guidelines, 2015). Currently, among all scientific associations, the UNESCO World Heritage Centre has a unique role in conservation of World Heritage Cultural Landscape. In this case, the inscription of a site to the WHL can help in the survival of cultural and natural heritages in the area. In recent years, the World Heritage Center has put efforts into promoting a framework and measures for evaluation and management of World Heritage Cultural Landscapes, and developing this concept by supporting a series of workshops, conferences and expert meetings among all state parties.

World Heritage Cultural landscapes are typically wide places, larger in area than the monuments and sites, which make the conservation management of these sites more challenging than other sites. The challenges related to cultural landscapes often are in applying the appropriate limits of modification without losing the character and qualities of the landscape. Generally, world heritage cultural landscapes in their protected areas play a vital role in the preservation of the world's cultural and natural heritages; there is a strong linkage and key conceptual similarities between cultural landscapes and protected areas, so world heritage cultural landscapes more often manifest spatially overlap or partially coincide with protected areas. In this way, all protected areas could be described as nesting in 'cultural' landscapes due to the impact cultural practices continuously have or once had in changing and influencing ecology (Dudley, 2008). Accordingly, each of the respective protected area categories depict landscapes that are more or less humanly modified, providing a description of the areas' character in comparison with the intensity of human-nature interaction (Dudley, 2008). Virtually all landscapes have cultural associations, because virtually all landscapes have been affected in some way by human action or perception (Singh, 2013). With a single glance at WHL, it can be perceived that over half of the cultural landscapes are identified solely in term of their historical values and cultural functions rather than their contemporary importance to the communities. This issue reveals the privileges that historical and cultural meanings of a specific area have over those of the geographically and landscape for the people.

The practice of "reading" and interpreting the landscape can prove difficult because most people are not used to taking a critical look at what they see (Keough, 2013). Therefore, each group of people within different communities with different history of civilizations interprets their living landscape differently. This issue in its turns usually may cause different perceptions about the notion of cultural landscape, where values might have meaning for a society within a particular epoch in their cultural or socio-economic contexts, not important for the other communities. On the other hand, this discrimination can also be seen between different fields of study; perception of the world heritage cultural landscape in the natural sciences (biologists, ecologists, etc.) diverges from that in the humanities (historians, archeologist, etc.). For the former, scientists are interested solely in biological and ecological aspects of landscapes, while for the latter, historians are interested in how landscapes are culturally interpreted by human and how cultures manifest themselves in the landscapes. From this viewpoint, world heritage cultural landscape has important values as guides to the actions that cause landscape changes. That is why in the 'Operational Guidelines for the Implementation of the World Heritage Convention', more broadly and disciplinary, has identified the concept of world cultural landscape as the total interaction between humans and nature in a given area.

As expressed by Kirby & Wharton (2004), "A cultural landscape may include a grouping of heritage types, such as structures, spaces, archaeological sites and natural elements, all of which have particular characteristics and unique identity and values". In this case, Fowler (2001) has also pointed out that cultural landscape is the result of interaction of people with environment. He considered the word of 'folk' to explain this sense by saying that culture means the life ways, including the artifacts, of a group of people but the essence of 'folk', as in 'folk-life', is not just people but the result of their interaction with their environment over a period of time.

In this notion, even intangible values (custom, beliefs, religious, traditions, etc.) are to be a part of cultural landscapes, so that landscape values as a combination of either tangible and intangible values or historical and emotional values stand among them. Therefore, as expressed by UNESCO World Heritage Center about Cultural Landscapes, “Certain sites reflect specific techniques of land use that guarantee and sustain biological diversity. Others, associated with the minds of the communities with powerful beliefs and artistic and traditional custom, embody an exceptional spiritual relationship of people with nature.” […] “Cultural landscapes -- cultivated terraces on lofty mountains, gardens, sacred places ... -- testify to the creative genius, social development and the imaginative and spiritual vitality of humanity. They are part of our collective identity.”[222]

Although cultural landscape studies traditionally have focused on the dispersion of human features within areas to comprehend processes affecting landscapes and culture, the gaze of cultural landscape studies has expanded to include investigating the wider political, social, and economic structures in societies that initially produced these features (Wong, 2015). Cultural landscape studies, as a result, have begun to question the meanings embedded within these features and to view the landscape as a social expression of symbols, icons, and metaphors (McDowell, 1994).

Cultural landscapes contain invaluable information about our past and our relationship with land over time. Cultural landscapes also reveal much about our evolving relationship with the natural world, and often derive their character from a human response to natural features and natural system (Birnbaum, 1996).[223] Cultural landscape is thus a site by high cultural, historical and archeological values, mirrored within people and their custom, traditions and civilizations. However, cultural landscapes are a legacy inherited from the past. These particular sites reveal aspects of our country’s origins, civilizations, development and features embodied with certain cultural preferences, as well as the evolvement of our ancestors in relationships with the natural world. The study about different aspects of these sites, by their multiple values, will provide a great opportunity helping communities to better understand themselves and deepen a sense of place and identity for future generations.

As Leader-Elliott et al. (2004) stated about this issue, “Connection with familiar landscapes form part of political and cultural identity, as people feel they belong to one place, one region and one country. This recognizes that a cultural landscape is more than just the sum of its physical places; it is equally concerned with the spaces between places and how these are given meaning, as well as the documentary and oral history stories that are woven around both. The

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[222] UNESCO World Heritage Centre, “Cultural Landscape, History and Terminology.” Retrieved from http://whc.unesco.org/en/culturallandscape

[223] Birnbaum, C.A. (1994). Protecting Cultural Landscapes: Planning, Treatment and Management of Historic Landscapes. U.S. Dept. of the Interior, National Park Service, Cultural Resources, preservation Assistance, 1994. Retrieved from https://archive.org/details/protectingcultur00birn

deeply social nature of relationships to place has always mediated people's understandings of their environment and their movements within it, and is a process which continues to inform the construction of people's social identity today. Landscape values accrue historically."[224]

However, considering the importance of the matter of cultural landscape, managing Historic Urban Landscape needs great attention. During decision-making for intervention and urban development in a historic urban landscape, where the historic city's authenticity and integrity are determined by various character-defining elements such as land uses and patterns, spatial organization, visual relationships between contemporary and historic architectures, details of construction, topography, vegetation, etc., must not be compromised. Therefore, management of the dynamic changes and developments in World Heritage historic urban landscapes encompasses precise knowledge of the territory and its elements of heritage significance identified through scientific methods of inventory, the relevant laws, regulations, tools and procedures, which are formalized in a Management Plan, according to the *Operational Guidelines for the Implementation of the World Heritage Convention* (Vienna Memorandum, 2005).

- Bam and its Cultural Landscape

The relationship between nature and culture is at the core of understanding a sustaining and flourishing desert culture with all its manifestations in Iran (Sabri, 2006). Cultural landscape of Bam reflects specific techniques of land use, which has guaranteed and sustained biological diversity of the region. About other characteristics of this cultural landscape, they are all admixed in the minds of this community with strong beliefs, artistic and traditional customs that embody an exceptional spiritual relationship of Bam's people with nature. By considering that World Heritage Cultural Landscape in its context is recognized as a mediator between culture and nature, past and present, physical and spiritual values for the sustainable development of a region by high cultural values, in Bam city, the landscape has not even survived through history but also is adapted to the modern life.

The subject of Bam and its Cultural Landscape creates much interest where the site is linked to the contemporary backdrop to reveal the great interaction between humans and its environment over the time path. It also shows different stages of the history of a region and its evolution from medieval town of Bam (Bam Citadel) to modern urban city, whereby its archaeological remains and architectural representatives are sustaining the traditional living cultures in the present era. Here we can see a continuing landscape, where the people and nature dwell together and people make their lifestyle easier, doing some interference in this harsh nature.

[224] Leader-Elliott, L., Maltby, R., & Burke, H. (2004). Understanding Cultural Landscapes: Discussion paper. Retrieved from http://ehlt.flinders.edu.au/humanities/exchange/asri/define_cl.html

Furthermore, Bam and its Cultural Landscape embody tangible as well as intangible heritage, which is a combined expression of both. Herein, various form of traditional knowledge have shaped landscape and there is a vital topic in cultural landscape research and practice. By study of this issue, it will be possible to extract layers of meaning ascribed to this landscape that have been lost or contested. However, Bam cultural landscape is not just a geographic landscape; it can be fit into different subjects related to landscape such as; living landscape, indigenous cultural landscape, agricultural landscape, ethnographic landscape, historicdesigned landscape, historic vernacular landscape, etc.

The Landscape of Bam is the products and precedents of natural and cultural interactions that began in the past and will continue into the future. Understanding the values of Bam's cultural landscape as living landscape will recast ideas of historical integrity and authenticity. Apart from the uniqueness of Bam Citadel as the greatest and largest extent adobe-mud brick complex in the world, and those monuments in the immediate vicinity of the Citadel, its intangible values and cultural landscape also influenced as a rationale for its nomination in World Heritage List. In fact, intangible heritage is also a part of Bam and its Cultural Landscape and ensuring their authenticity and integrity is essential.

The "diverse tangible and intangible" heritage resources of Bam also express values associated with the long and complex history of the city (UNESCO, Appendix 1, 2004). Meanings and memories, which reside in the minds of the residents and in their way of life start to manifest themselves in the form of a developed culture (Sabri, 2006). Therefore, any attempt for preserving spatial patterns embedded within the people and context of Bam after the earthquake, is a welcoming idea in keeping the traditional character of the city. To retain the authenticity of this relationship, the management of the buffer zone will play a critical role, as well as provisions made for the continuation of historic practices and rituals and the continuous function and use of the area (UNESCO-WHC).

As mentioned by Amirjamshidi et al. (2012), "The legends, the culture, the arts and the religious rituals are essential parts of the authenticity of Bam and its cultural heritage. These aspects are what keep the original intellectual and cultural landscape which gave rise to the architectural wonder that the Bam Citadel is, and without them the value and significance of the monument suffers a great loss." He also added, "It is, therefore, of the utmost importance for future management plans and conservation plans to consider these aspects as essential parts of what needs to be preserved for future generations. Only by doing so, the authenticity and the integrity of the monument can be maintained whilst plans that neglect these aspects will result in loss of genuineness in Bam." In the case of intangible heritage that constituted an important part of local cultural identity and community pride, after the earthquake, some measures have been taken, such as the reuse of some monuments within the Citadel for education, religious practices, historical celebrations, rituals, local festivities, manufacture of local handicrafts, etc.

Three elements of cultural landscape strongly influenced people' beliefs and their strategies of action regarding the earthquake: the Bam Citadel, the Qanats and the dates trees (Parsizadeh, 2012). After 26 December of 2003 Bam earthquakes and inscription of the cultural landscape of Bam in the World Heritage List, a growing body of research has been carried out to further develop the management plan of this endangered world heritage site within its buffer zones. Generally, the aim of this inscription was to reveal and sustain the great diversity of the interactions between humans and their environment to protect living traditional cultures and preserve the traces of those which might be disappeared after the earthquake.

Fortunately, during these years, the maintaining of the structures of the city, including monuments, land-use, Qanats, gardens and the protection of most of the scattered heritage throughout the city has been secured. In this way ICHHTO was able to include in the master plans for the city of Bam the norm regarding the protection of the cultural landscape of the city, which were approved in 2004 and later revised in 2007 (Bam's Comprehensive Management Plan 2008-2017). These norms in their turn strongly recommended that land-use must be kept as it was prior to the 2003 earthquake. Moreover, they insist the maintenance and repair of the Qanats, the protection of agricultural fields and gardens, as well as the conservation and restoration of monuments and historic sites, and that the buffer zones of historic buildings should be taken into consideration. According to the importance of the Cultural Landscape of Bam, the Comprehensive Management Plan of Bam (2008-2017) has elaborated the following themes:

- **Background 1)** Built Heritage: The territory of Bam and its Cultural Landscape carry evidence of its history in the built structures and archaeological properties. These include the entire network of forts and citadels that have been formed for more than two thousand years, as well as form the Early Islamic period (600 AD onwards). Arg-e Bam is an exceptional complex of an earthen constructed fortified settlement. It was unique in its continuous occupation and development over 2,000 years until 1932.

- **Background 2)** Agriculture and farming: Agriculture has always played a central role in Bam's economy since the earliest times, and was more diversified in the past. In the twentieth century, Bam focused on the production of dates and fruit. This has resulted in agriculture being the most dominating feature in the cultural landscape, both visually and structurally.

- **Background 3)** Trading and Industry: Bam developed at the crossroads of important trade routes linking Asia and the Persian Gulf. The history of Trade routes has left traces in the history, seen in the archaeological evidence of ancient bridge and earlier settlements and forts that still stand, and spice Routes between Europe and China, Bam was a key trading city en route from Central Asia to India and Afghanistan, while also connecting to the

Persian region and the Oman Sea in the south. It was through such contacts that the cultivation of mulberry trees and the production of silk were introduced to Bam the second century AD. Bam became renowned for the trade of high quality silk and cotton garments, marketed in Mesopotamia and Egypt, in its heyday between the 7th and 11th centuries. Today, Bam still has the potential of developing its role in trade, preferably trade that is appropriate and sustainable taking into account the overall character and universal significance of Bam's Cultural Landscape recognized as a World Heritage Property.

- **Background 4)** Intangible Cultural Heritage and Cultural Industries: The history and traditions of the cultural landscape of Bam County are the intangible heritage of the Bam people and society as a whole. There are traditional performing arts, rituals, and crafts which either continue or are being developed today.

- **Background 5)** Water Resource Management: The water management system in Bam region was based upon a sophisticated use of topography, making use of the abundant reservoir created by the Bam Fault and possibly the first use of Qanats as a means of intercepting the reservoir and conducting its water to the points of use.

- **Background 6)** Natural environment: Water resource management is closely related to the natural environment of Bam's Landscape. This landscape includes both hot and cold climates and a rich diverse fauna and flora.

"Bam and its Cultural Landscape" is nominated as belonging to the second category of cultural landscapes, notably the organically evolved landscape. Taking an overall look at the case of Bam, it can be understand that, the significance of "Bam and its Cultural Landscape" nomination was enhanced by an in-depth examination of the social functional integrity of the site in the light of its values. This nomination refers to the concept of "cultural landscape" as a whole, composed of the desert environment, open landscape (agricultural land use, gardens and built environment) characterized by extensive terracing, water springs, ancient irrigation system (an ingenious water use, management and distribution system), archaeological sites and a historic core. However, the example of Bam shows how the functional integrity of the place can enhance a better understanding and clearer definition of the outstanding universal value of a place (Jokilehto, 2006).

In the following section, in order to assess the significant values of "Bam and its Cultural Landscapes" to the contemporary society and to accentuate its cultural landscape importance while highlighting the crucial reasons for its preservation, the criteria (II), (III), (IV) and (V), by which Bam and its Cultural Landscape is inscribed in WHL are analyzed (Rouhi et al., 2016b):

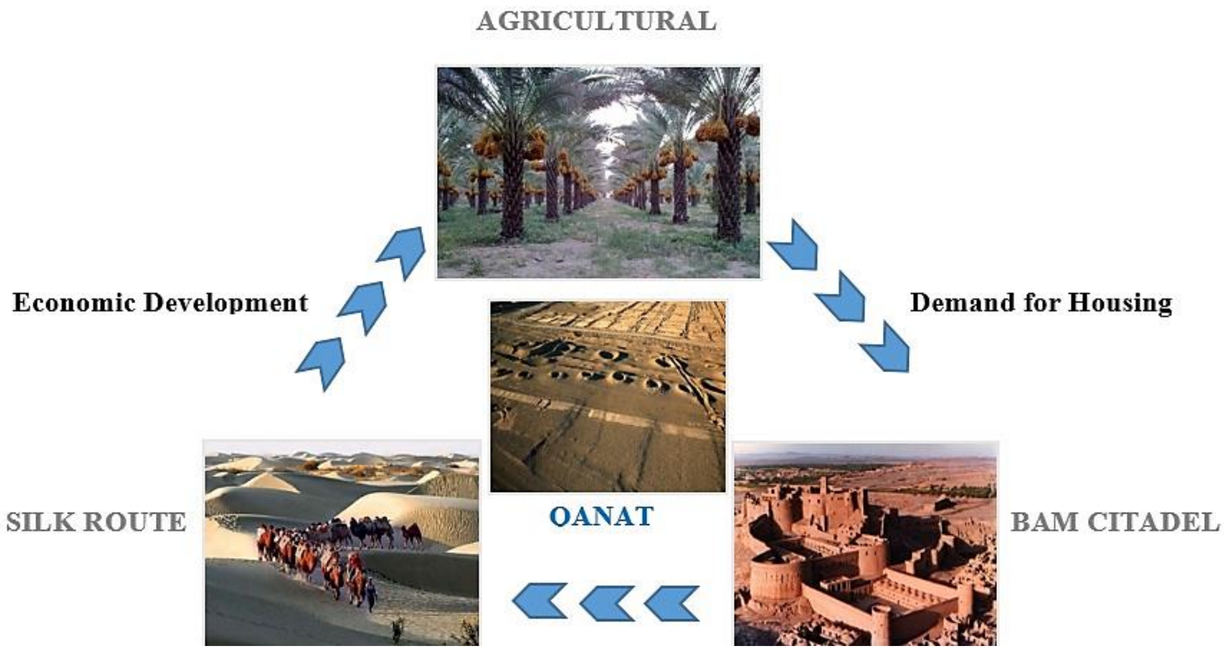

Figure 3.42. Cycle of the development of Bam City with origin of Qanat (Design by Author).

- The interpretation of criterion (II): *Bam developed at the crossroads of important trade routes at the southern side of the Iranian high plateau, and it became an outstanding example of the interaction of the various influences*

Bam is a wonderful historical landmark in eastern Iran. In Bam, accessibility to underground water by the use of Qanat system, besides Bam's genuine history can be considered as the main reasons for continuing of life and its development in the reign. The city, which has origins back to the 6th to 4th centuries BC, mainly developed during the 7th to 11th centuries, thanks to its location on the silk and cotton roads. In the middle of the historical city, the Citadel is a huge mud-brick fortified medieval complex which has been inhabited for about 2,000 years (Baize, 2015).[225] Hence, Bam based on its geographical location in trade route of Silk, an international route between Eastern and Western countries, used to be an important commercial hub in the area. The artistic and architectural remains of Bam Citadel, an important commercial centre on the Silk Road, are an exceptional testimony to the interchange of Indian, Hellenistic, Roman, Achaemenian and Sassanian influences as the basis for the development of a particular artistic fortification in the desert of Iran. Since, living in hot and dry climate region is only possible with creating a harmony between environment features and lifestyle. The associated Citadel and its cultural landscape by its sophisticated irrigation system, urban constructions, forts, mosques, caravanserai, bazaar, etc., in the crossroads of significant trade routes was the best place for traders, merchants and travelers to choose it for getting a rest.

[225] Baize, S. (2015). The cultural landscape of Bam and the 2003 earthquake. Retrieved from http://stephaneonblogger.blogspot.it/2015/12/the-cultural-landscape-of-bam-and-2003.html

- The interpretation of criterion (III): *The Bam and its Cultural Landscape represent an exceptional testimony to the development of a trading settlement in the desert environment of the Central Asian region*

The character of the "Bam and its cultural landscape" thus reflects the values of the people who have shaped it, and who continue to live in it. Therein, the culture as a shaping force and landscape as a cultural expression have revealed the interaction of men and nature and its development in ancient civilization of Iran in desert environment. This site can also be reviewed as a place of cultural exchange, where based on practices and processes of cultural exchange become form of cultural landscape. The cultural landscape of Bam expresses the diversity of the peoples who have lived and worked together through time, herein, landscape involves various interest and cultural objects and constitutes the stage of arena for human life and its social and economic development. The culture of Bam is further tempered by the severe weather condition of desert, severe that made people with patient and respect overcome it, and with their ability to survive in a hostile environment and to live in harmony with a very fragile and constraining environment. In Bam and its Cultural Landscape, Bam Citadel, cultivated terraces on urban fabric, gardens, sacred places, underground irrigation system, etc., testify to the creative genius, social development and the imaginative and spiritual vitality of its people.

As defined by Balkema (1998), Historic integrity is "The authenticity of a property's historic identity, evinced by the survival of physical characteristics of the property's prehistoric or historic period. Historic integrity is the composite of seven qualities: location, design, setting, materials, workmanship, feeling and association". In the case of Bam site, the relation between all of these seven qualities by some study about the history of this city is understandable and all related issue and their relations are discussed in Bam's nomination paper. The authenticity and integrity of Bam's Citadel and its related sites are proved on the bases of historical documents and archaeological studies.[226] Although owning to the destruction of all written documents related to the history of Bam Citadel, there is no precise information concerning the formation of Bam city and its first human settlement, based on available evidences (existence of traditional irrigation system (Qanat) and the position of Bam in the sub-branch of famous Silk Route), archeological research undertaken in the region, myths and stories remained from ancient time, records of early Muslim geographers after 7th century and Persian and European travellers in the 19th century well show that the history of this settlement can date back to Achaemenian period (6th-4th century BC).The information extracted from these basic sources exactly represents an exceptional testimony to the development of a trading settlement in the desert environment of the Central Asian region.

[226] ICHHTO. (2015). State of Conservation report of Bam and its Cultural Landscape World Heritage Site. Published by UNESCO World Heritage Convention. Retrieved from whc.unesco.org/document/135278.

The Cultural Landscape of Bam, in spite of the severe damage incurred during the December 2003 earthquake, was recognized to still retain a high degree of authenticity and integrity (Dudley, 2008). With regard to the historic fabric, although there was large destruction, and partial and total restorations and reconstructions were carried out between 2003 and 2017, they used traditional techniques of construction by employing a combination of innovative and traditional materials.

- The interpretation of criterion (IV): *The city of Bam represents an outstanding example of a fortified settlement and Citadel in the Central Asian region, based on the use mud layer technique (Chineh) combined with mud bricks (Khesht)*

The first and foremost part of Bam and its cultural landscape which is a symbol of cultural identity for the population of Bam is the Citadel of Bam. The Arg-e Bam, though the largest, is one of a series of Citadels and forts built to guarantee security along the trade routes of Bam (Noroozi et al., 2015). It is the most representative example of a fortified medieval town built in vernacular technique using mud layers (UNESCO, 2004). The Citadel of Bam as the most outstanding landmark in the cultural landscape of Bam used to be inhabited until the early 30s of the 20th century. Although in the middle of the 20th century the Citadel of Bam had gradually haunted but its most important symbolic monuments have kept being used not only up to the day they sustained a sever destruction by the earthquake, but even now. Before the earthquake, as most symbolic monuments of Bam Citadel which by their powerful religious, national symbolic elements and extraordinary architecture kept the Citadel alive, we can mention the Jame Mosque, the Chah-e Saheb-e Zaman, Tekiyeh, Payambar Mosque, some single monuments such as Mirza Na'eim School, Sistani House, West Sabat House, Gymnasium, Caravanserai, Stable, Barrack, First and Second Entrance Gates, Governor's House, etc. In the meantime, the religious places of Bam Citadel have special honor and grate level of importance among local people. There we can see three different districts related to people with different social class (governor's district, public district and konari mahale), which in its turn show the existence of a hierarchy in the governance of this fortified city. In term of architecture, the monuments of Bam Citadel exactly demonstrate the Persian vernacular architectural styles and elements, which were widely used in desert environment of Iran, these traditional form, designs, techniques and methods used for adaption of the inhabitants to the hot and arid climate are so noticeable. However, the vernacular architecture of Bam and its Cultural Landscape, as an organically evolved landscape is undoubtedly one of the most notable examples of its type.

- The interpretation of criterion (V): *The cultural landscape of Bam is an outstanding representation of the interaction of man and nature in a desert environment, using the Qanats. The system is based on a strict social system with precise tasks and responsibilities, which have been maintained in use until the present, but has now become vulnerable to irreversible change*

The power of adaptability of Iranian with nature can be seen in their habituation to the harsh weather condition of hot and arid areas of the country. Qanats in these areas, as a factor shaping the landscape, illustrate an adaptive and sustainable strategy of local communities to the seismic landscape. From ancient time, the underground water channels and samples of Persian engineering wonders have sustained the human being habitat and their well-being, as much as they have vital roles for their survival and resilience. The cultural landscape of the Bam city is highly influenced and controlled by fault lines and is undoubtedly vulnerable by the earthquakes. Although the Bam's fault lines gave life to the people through the water of Qanats, they also took away the life with the occasion of earthquake. According to ICOMOS evaluation from Bam site, "The beginnings of Bam are fundamentally linked with the invention and development of the Qanat system. The region of Iran was central to this technique, as a large part of the country would be not inhabitable and cultivable if water were not brought there even from long distances. The technique of using *Qanats* was sufficiently well established in the Achaemenid period from 6th to 4^{th} cent. B.C. They justified its systematic promotion in different parts of the empire. The archaeological discoveries of ancient *Qanats* in the south-eastern suburbs of Bam, on the fault, are datable at least to the beginning of the 2^{nd} cent. B.C. (UNESCO, 2004). After some centuries Bam's Qanats affected the foundation of life for local community in positive, sustainable and resilient way. Qanats had positive effects on the sustainability of groundwater resources and conferred to the communities' great socio-economic and cultural bonds (Mostafaeipour, 2010). However, to continue their function properly, Qanats required a system of strict social coordination with precise tasks and responsibilities by subsequent maintenance and repair, which in turn reveals the entity of strong social solidity and processes between the people of the community. Bam as one of the oldest Iranian city has been designed and shaped by people as an organic garden city, which its plan was derived from its access to underground water. Water in this city has a very crucial role in agricultural and economical concepts. Consideration of this fact results in social and economical sustainability of the region, which still respond to functional and psychological needs in the best way. The agricultural fields and gardens of Bam city, as an artifact created by inhabitants inside the urban fabric, shows a relationship between the cultural world of its creators and the natural environment of its context. The main economic source of the people of the region is based on agriculture and more especially on palm groves, so it assured constantly the livelihood of Bam settlement. Bam is famous for its high quality of dates in the world. Since this production has a very important value in the economy of Bam's families, in this regard, the palm in the local culture is not a mere tree, but also a member of the family and the sign of life (Sabri et al., 2006). In this case, measuring units in Farsi are different for a person as compared to a thing, and as for the palm tree, it is counted as a person (Ibid).

The cultural landscape of the city of Bam and its Qanats are intertwined. Generally, Qanats in Bam's landscape is the most imaginable and mellifluous expression of the non-variable culture-nature relationship over time. For Bam and its Cultural Landscape, water system from the

Qanats defines both the social regions in the city and the layout of the city both in ancient time and the present day (Wong, 2015). Qanats have been an integral part of Bam cultural landscape and their harmonious relationships with nature and culture thrived during centuries until the present day. Qanats are sustainable system built upon the local resources, in term of water, land, natural environment, through the capacities of local people and the local knowledge (Ibrion et al., 2014); the knowledge of this technique was transmitted from fathers to sons. However, Bam's Qanats empowered local people regarding the management of underground water resources. Exploitation of water from underground and its division between land ownerships, and contributed to the livelihood patterns and cultural landscape. The technique of Qanat that in turn is inherent from Bam ancestors well shows the integrity and continuity of a valuable pattern, which caused the development and agricultural prosperity of the region. However, Qanats have crucial significance for the later social and cultural geography of Bam area. As Noroozi et al. (2015) pointed, "The cultural landscape of Bam is an organically evolved continuing cultural landscape. The economy of the region has been traditionally based on agriculture, which is in turn based on the strict social-cultural system of water management using Qanats in this arid environment. The Qanats continue to be the fundamental basis for the sustainable land use, which allows the continuance of cultural system that have been consolidated over the centuries."

Since, the cultural landscape of Bam has reflected the intimate relationship between the development of a desert city and the access to underground water resources, it should be noted that the diminishing of water table in the region would be the biggest threat, without which the settled life would not have been possible. Over the few decades, it has dramatically been demonstrated that various technical solutions such as pumps, dam and modern water management are unsustainable and with severe effects for the sustainability and life of Qanats (Jomehpour, 2009). The failure or lack of attention to the Qanats could have lead to the death of the city of Bam at any time during the past 2500 years (Sabri et al., 2006). As an example, by the 2003 earthquake, when the Qanats were destroyed, villagers became poor, and they moved to live inside the city, so many native people have left Bam and are not willing to come back (Fallahi, 2008).

CHAPTER 4

Iranian Cultural Heritage Policies, and Conservation History of Bam Citadel

4.1 Development of Cultural Heritage Policies in Iran

4.1.1 Colonization and Iran Cultural Heritage Policy during Qajar Dynasty (1785-1925 AD)

In this sub-chapter, to describe the fate of Iranian cultural heritage policy from the beginning of Qajar Monarchy until its downfall and the onset of Reza Shah in decision-making of the country, we will have a brief glance upon the conditions prevailing and an overview of the principal factors affecting the adoption of social and cultural policies in this course.

Throughout the 19th and the early of 20th centuries, the rulers of Qajar dynasty (1785-1925 AD), one of the most incompetent Iranian dynasties in the history, faced enormous obstacles, poverty, military weakness, political factionalism and corruption. During this time, due to the lack of literacy and a comprehensive understanding about the history of the country and being apathetic with the value of Iranian cultural heritage properties, a large portion of country’s treasures and monuments were ruined or plundered by powerful European countries, particularly Russia, Great Britain and France.[227] Although during this period, the “miseries and difficulties” had also various dimensions: political, economic, military, etc. but among them, the cultural dimension had the most long-lasting negative effects (Daroogheh-Nokhodcheri, 2014).

As it is argued by the Daroogheh-Nokhodcheri (2014), “the Qajars’ disregard for pre-historic sites was twofold; firstly, the absence of political motivations for the Qajar to employ ‘pre-history’ as an appropriate tool to legitimize their authority and secondly, lack of a concept of ‘pre-history’, which led to substantial looting of these sites by Iranian and foreigners alike. More specifically, the Qajar model of kingship did not entail the necessity of historical verifications to legitimize its authority.”[228] In the meantime, one of the main reasons that had role in ignorance of Qajar rulers towards the country’s cultural heritage properties could be due to their Islamic religious sentiment, and lacked of the concept of pre-history during this period. However, this trend was chiefly shunted to ‘Islamic’ and ‘post-Islamic’ properties while ‘pre-Islamic’ and ‘pre-historic’ properties remained an alien concept, so the pre-historic period had

[227] If we go back to an era long before Iranian history, following the victory of Alexander the Great over the Persian army in 331 B.C., Alexander plundered Persepolis and carried away many of its treasures. Since the Sassanid capital was not far away, it was promptly captured and its vast treasures were plundered by the Muslim’s conquerors. However, it can be decisively said that the onset of the dilapidation of Iranian cultural heritage by foreigners had widely spread its roots in Iran by the neglect and ignorance of Qajars' rulers.

[228] Daroogheh-Nokhodcheri R. (2014). Nationalism, Politics, and the Practice of Archaeology: The Case Study of Iran (Doctoral thesis, Durham University, England). Retrieved from Durham E-Theses Online: http://etheses.dur.ac.uk/10658/

no place in the legitimization of Qajar rulers. In Qajar period, "*Ulama*"[229] as scholars or authorities in the "religious hierarchy" of the Islamic religious sciences obtained the major political power. As far as, Moussavi (2008) argued, "Qajar rulers regarded Ulama as one of their major sources of authority and political legitimacy. The founder of Qajar dynasty, Aqa Muhammad Khan Qajar (1794-1797AD), and his successor, Fath Ali Shah Qajar (1797-1834 AD),[230] actively engaged the Ulama in a process of reciprocal legitimacy. It was, however, Fath Ali shah Qajar who allowed Ulamas' widespread involvement in political and governmental affairs."[231] To the Ulama, any remains that constituted the period prior to the birth of Islam were considered to be from the age of *Jaheliat* (ignorance) and therefore unworthy of consideration (Daroogheh-Nokhodcheri, 2014). This great interest towards Islamic and post-Islamic values can be seen in extensive commands of Qajar rulers for renovation and restoration of country's religious places. In this case, Bloom & Blair (2009) noted that, "Major shrines, notably those of Imam Reza at Mashhad and Fatima at Qum, were restored and extended by the Qajar monarchs […]"[232]

As is obvious, in Qajar era various factors have contributed in the appearance of Iranian cultural heritage policies. However, during the 19th century subsequence to the social development that took place in Europe, the need for new markets created the economic motivation for European countries towards the ancient civilizations of the orient. Therefore, many European politicians, ambassadors, merchants, military men, orientalists, religious missionaries, antique dealers, tourists, scientists and archeologists were enchanted to this part of the world, particularly Islamic countries.[233] As Trigger (1980, p. 23) cited in his book entitled, "*Gordon Childe, Revolutions in Archaeology*", "this unilinear evolutionary pattern attested to the colonial attitude of imperial powers towards the less advanced countries according to which less technologically advanced people were viewed as being at lower stages of cultural

[229] The plural of 'alim', a learned individual, more commonly associated with religious scholars, and generally utilized with reference to the clerical class (Ansari, 2014).
[230] Iranian rulers during Qajar Dynasty:

- Aqa Mohammad Khan r. 1794-1797 AD
- Fath-ali Shah r. 1797-1835 AD
- Mohammad Shah r. 1835-1848 AD
- Naser al-Din Shah r. 1848-1896 AD
- Muzaffar al- Din Shah r. 1896-1906 AD
- Mohammad Ali Shah r. 1907-1909 AD
- Ahmad Shah r. 1909-1924 AD

[231] Moussavi A.K. (2008). "*The Basis and Nature of Ulama's Authority in Qajar Iran*", Foundation for Iranian Studies. Retervied from http://fis iran.org/en/irannameh/volxv/ulama-authority.
[232] Bloom, J., & Blair, SH. (2009). *The Grove Encyclopedia of Islamic Art & Architecture*: Three-Volume Set. Volume 1 (Abarquh TO Dawlat Qatar). OXFORD: University Press. p.176.
[233] The beginning of serious archaeological researches in Iran can be dated from the second half of the 19th century (Daryaee, 2009).

development."[234] Since the Qajar dynasty by beginning of relations between Iran and Europe, the ancient Iranian arts and works had gradually attracted the attention of Europeans. In this period, particularly after the accession of Qajars' second ruler "Fath-Ali Shah Qajar" (1797-1834 AD), the fate of Iran was determined directly by Russian and British interests, so that they brought to their ownership a large part of the Iranian territory and imposed the country with various unjust monopolies.[235]

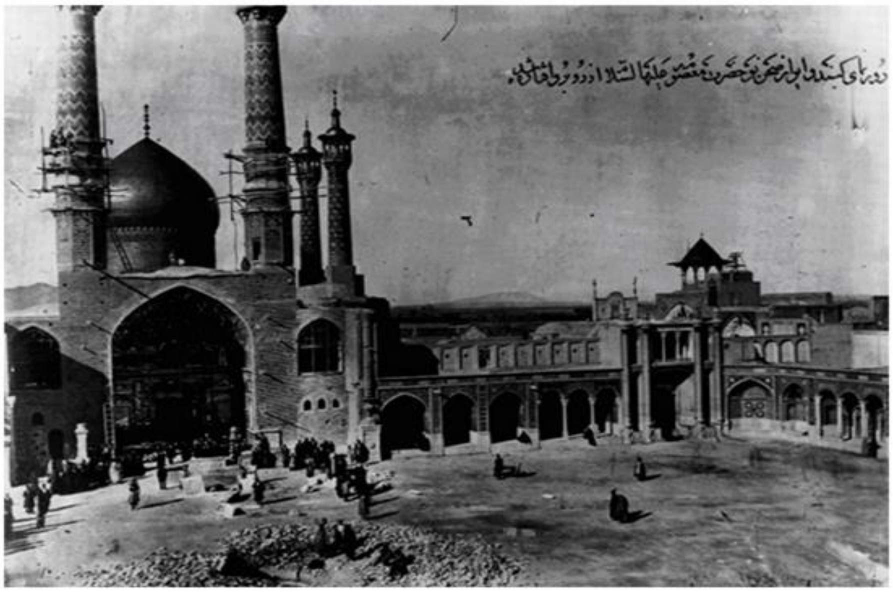

Figure 4.1- The Fatima Shrine of Qum during restoration (Photo by Abdullah Qajar, 1886. Source: archive of ICHHTO).

For the first time in Iranian history, British systemized the plundering of Iranian cultural heritage under the pretext of archeological works near Kazerun city.[236] As an article wrote by Ayati in CAIS with title of "*Bitter Story of Plundering Cultural Heritage of Iran*", "The first mission that came to Iran was a British one led by Sir William Ousely (1811). He came to Iran after the trip of Mirza Abolhasan Khan Ilchi, Fath-Ali Shah's ambassador to British Court (James Morier was a member of that mission). Roaming around Iran and acting as the eyes and ears of the British government, Ousely carried out excavations and discovered 'Shahpur Cave', and had Shahpur statue prepared by stone cutters and took it back to England."[237] During the

[234] Already there were some other enthusiasts that came to East and visit Persia; Benjamin ben Janah (1164), Marco Polo (1271), Odorish von Pordenone (1318) Ruy Gonzales de Clavijo (1403), etc.
[235] Following wars happened between Iran and Russiain (1804-1813 AD) and (1826-1828 AD), and as a result of shameful Treaties of Gulistan and Turkmenchay signed between Fath-Ali Shah Qajar and Russia, a large area of northern Iran was transferred to the Russian side.
[236] Kazerun city is an Iranian historical city in the capital of Kazerun County, Fars Province, Iran.
[237] Ayati, A. (2015). "*Bitter Story of Plundering Cultural Heritage of Iran*", The Circle of Ancient Iranian Studies (CAIS). Retrieved from http://www.cais-soas.com/CAIS/Culture/plundering_culture.htm.

reign of Fath-Ali Shah Qajar (1796-1834 AD), the motivation for archaeological work also arose between Iranian. Tabatabai (1906-1990 AD), one of the eminent Iranian scholars, in his remarks in the article "*A brief note on the development of archaeology in Iran*" mentioned some preliminary archaeological works by Iranian during Fath-Ali Shah Qajar that had been executed in the "*Oregon Cave*" in Zanjan and in the "*Tomb of Cyrus*" in Fars.[238] Then after some other British orientalists like Robert Ker Porter (1817) and Sir Henry Rawlinson (1831) had activities in Iranian archeological sites.[239] Afterwards, all along this period, Iranian political affairs were affected by France, particularly by the Napoleon Bonaparte (1769-1821 AD) and his expansionist tendency towards the Middle East. After Napoleon, France political influence in Iran can be seen through the increase in the number of travels to France by Qajars' rulers, and the relatively higher number of Iranian citizens graduating from France. In the meantime, Nasser-ed-Din Shah as the first ruler of Iran who traveled to Europe had three travels to France in the years 1873, 1878 and 1889, and the France, by their stupendous hospitality taken from the ruler of Iran, could get permission for their colonial approach towards Iranian historical sites. Thus, with the same motivations, many expeditions were made by France government in Iran one after the other.

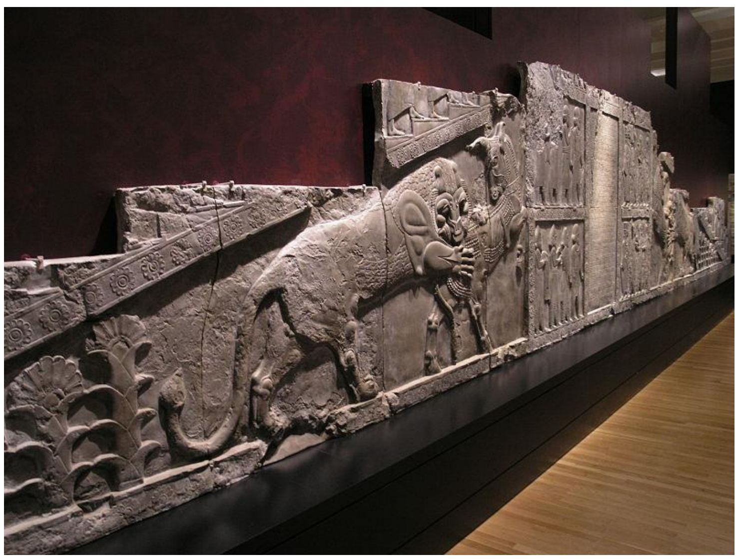

Figure 4.2- Cast of Persepolis bas-relief on display at the British Museum (Photo by Chohan, 2007. Source: British Museum Visit).

[238] Hodjat, M. (1995). CULTURAL HERITAGE IN IRAN: policies for an Islamic country (Dissertation for A DPhil Degree, Institute of Advanced Architectural Studies, The King's Manor University of York, England). Retrieved from etheses.whiterose.ac.uk/2460/1/DX193597.pdf
[239] Unlike Sir William Ousely (1811) who has archeological activates in Iran, Robert Ker Porter (1817) compiles precise information about the monuments that he visits in Kangavar, Bistun, Taq-e Boston, Azarbaijan, Rey and Persepolis. Porter was also the first person that tentatively identify Cyrus I's Tomb. Then Sir Henry Rawlinson (1831) also has valuable activities in Iran, so he copies the 1000- line inscription of Darius I in Bisotun and discovers several other inscriptions.

In 1840, two pair groups from France came to Iran and besides their useful studies on historical sites of Iran, they removed some Iranian relics out of the country. The first group was commissioned by the Academy of Fine Arts in Paris and was attached to the France diplomatic mission in Persia (Ghani, 2009).[240] In this group, Eugene Flandin (orientalist, painter, archaeologist and politician) set out for Persia accompanied by his architect assistant, Xavier Pascal Coste (painter). These two Frenchmen went with instructions to make a record of the archeological remains at Esfahan, Persepolis and Babylon (1840-1841 AD) (Ibid). During their two-years stay in the west and south of Iran, Flandin and Coste published the results of their efforts in their travel diary together with relevant pictures, see Figure 4.3 and 4.4.[241] Moreover, the second group by the names of T.A, de Bado and E.H, Lagard from the "*Secret Agent of France*" prepared reports on the Bakhtiaris' pre-historic, historic and Islamic towns and Shush archeological site.

During this period, Iran was never an official colony but rather what was termed by Lenin recognized as a "semi-colony". In semi-colonies, although the external imperial powers did not officially control the administrative infrastructure, they extensively manipulated domestic affairs towards their own political ends (Daroogheh-Nokhodcheri, 2014). As the reign of Nasser-ed-Din Shah Qajar (1848-1896 AD) was approaching to its last days, the interferences of the France in all affairs of the country was more felt. A salient example in case is Doctor Toulousain, who travelled to Iran as Nasser-ed-Din Shah's private physician, yet intervened in all affairs of the country, including that of securing the monopoly of excavations in Iran for France citizens (Hodjat, 1995). Jane Dieulafoy (1985) recorded about the role of Dr. Toulousain in arousing Nasser-ed-Din Shah's interest for giving him permission for his archeological excavation in Susa in 1883. As Dieulafoy (1985) wrote, "When our ambassador again entered into talks with the Iranian government, Dr. Toulousain, the Shah's private physician, appealed directly to the Shah, arousing his interest for archaeological excavations, which would reveal the resplendent history of his ancient predecessors [!]."[242]

To follow the most important events in this period, we can refer to memories of General Sir Albert Houtum-Schindler (1846-1916 AD), a scholar of Persia and an employee of the Persian government. During his work to set up the telegraph line between Tehran and Mashhad cities, Schindler encountered a group of locals who were working by non-methodical excavation methods at "*Teppe Hissar*" near Damghan to find relics. As Schindler (1968) writes in his memoirs: "At a distance of one meidan, southward of Damghän, stands a hill famous as Tappeh-Hessär. A few months ago, some ancient utensils were found on it, and the work is continuing

[240] Ghani, C. (2009). *Iran and the West: A Critical Bibliography*. New York (N.Y): Routledge. (Page No. Unknown).
[241] They had introduced Iran as an ancient country with their book "*Voyage en Perse*, Itinéraire".
[242] Hodjat, M. (1995). CULTURAL HERITAGE IN IRAN: policies for an Islamic country (Dissertation for A DPhil Degree, Institute of Advanced Architectural Studies, The King's Manor University of York, England). Retrieved from etheses.whiterose.ac.uk/2460/1/DX193597.pdf

ever since, with strange things being found. On the first time I was in Damghan, I went to see that hill, and saw that the work was not being done methodically. I told the men on the job to work in this way and that, and to carry water to the hill-top, so that the task can be better and sooner achieved. On the second time I was there, I saw that they were working better, and H5j-Ali-Akbar, the administrator of the mine, was also present. They had made a water channel across the hill, which washed out the antiquities without them being broken."[243]

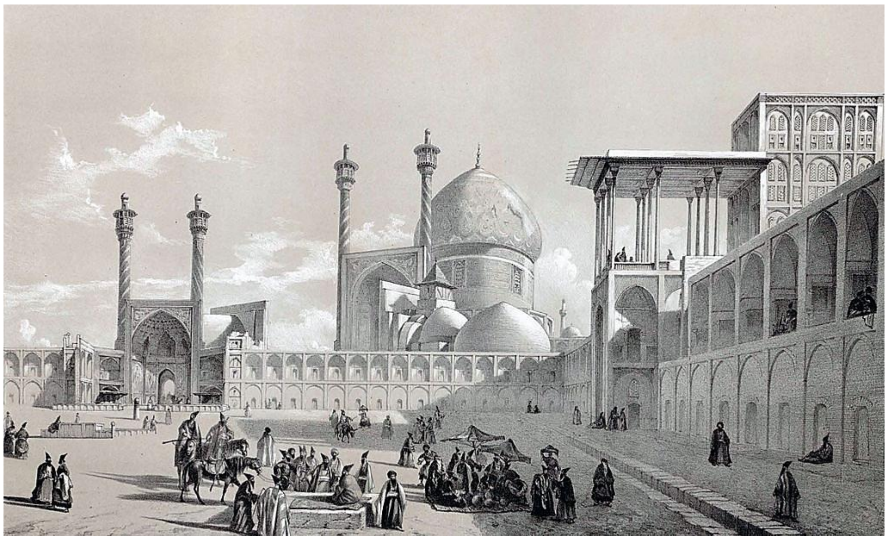

Figure 4.3- Maidan i Naqshe Jahan, Isfahan (Painting of Eugène Flandin, 1851. Source: Wikimedia commons).

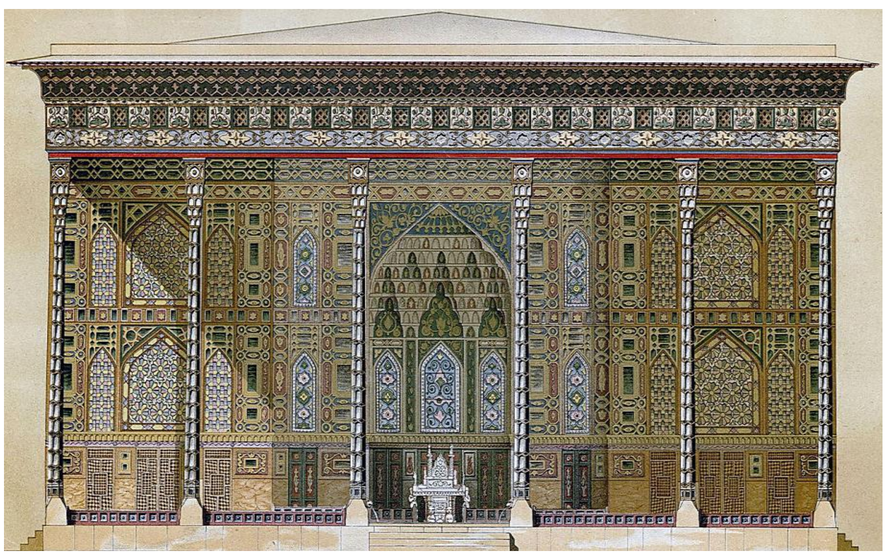

Figure 4.4- Garden and pavilion Chehel Sotoun (40 columns), Isfahan (Painting of Pascal Coste, 1867. Source: Wikimedia commons).

[243] Ibid, p.139.

In another case, Schindler also added on the export of Iranian ancient relics by foreigners: "[AD 1875] The Shahanshah has granted permission upon several farangis [Europeans] to excavate that hill [the brick hill near Reyshahr, the bricks of which bear cuneiform inscriptions] and other ones. It is a pity that all these ancient relics are taken away from this land. It would be best if everything, including seals and beads and the like, were putin the Shahanshah's museum-house […]."[244] Herrmann (1989) also about the fate of the relics excavated in Iran during the Qajar period notes: "At first the newly discovered artifacts were removed to the great museum of London, Paris and Berlin. The Pergamo Museum in Berlin was, in fact, originally built specifically for such a purpose."[245]

- Plundering and Destructing of Iranian Cultural Heritage Properties by the France

In 1881, a France couple, Marcel and Jane Dieulafoy, founded the most tragic looting from Iranian treasures. In this year, Marcel Dieulafoy was given a mission by the France Ministry of Education to study about Sassanian arts and ancient monuments. On this travel he was accompanied by his wife, Jane Dieulafoy. In the meantime, among all sites, which were visited by this France couple, the Susa archeological site in Khuzestan drew their attention to themselves. Before Dieulafoy, William Kennett Loftus (1820-1858 AD), a British archeologist, had some excavation in this site, although the works were done hastily and superficially, the results were remarkably successful, so Loftus and his colleges confirmed that Susa is indeed biblical Shushan.[246] He also identified the "*Apadana*" (the columned audience hall of the Achaemenid kings) and prepared an accurate map of the mounds (Harper et al., 1992).[247]

Actually, in Susa, the France amateur archaeologist Marcel Dieulafoy continued the way of Loftus by more extensive research, and published the results of his works in "*L'Art antique de la Perse*".[248] Eventually, in 1883 Marcel-Jane Dieulafoy could get a grant from the "*Department of Antiquities at the Louvre*" and the "*Ministère de l'Instruction publique*" as well as logistical support from the "*France army and navy*" in order to fund further study in Susa. In Iran, with the help of Dr. Toulousain, Dieulafoies obtained the necessary permission from the Nasser-ed-Din Shah Qajar, and started their works by two other France engineers, Charles Babin and Frederic Houssay. Based on the agreement made, it was decided that whatever was discovered during excavation, except for precious metals that totally belonged to the Iranian

[244] Ibid, 143.
[245] Ibid, 139.
[246] Susa or Susan of the Babylonians (also called Shushan, Greek Susiane) was an ancient city of the Proto-Elamite, Elamite, First Persian Empire, Seleucid, and Parthian empires of Iran, located in Khuzestan province of Iran. The ancient city of Susa is mentioned in the ancient books as the place where the prophet Daniel lived.
[247] Harper, P.O., Aruz, J., & Tallon, F. (eds.). (1992). *Royal City of Susa: Ancient Near Eastern Treasures in the Louvre*. New York (N.Y): The Metropolitan Museum of Art. p. 41.
[248] Marcel Dieulafoy published more than eight books about arts and ancient monuments of Iran. Meanwhile, in 1881, Marsel and Jane Dieulafoy made the first photographic documentations of the monuments of the terrace of Persepolis (Zargaran, 2014).

government would be equally divided between the Iranian government and the France group. As peters (1915) stated, "The excavations of Dieulafoy during his first travel enriched the museum of Louvre with precious beautiful bricks, the frieze of the lions and the frieze of the archers."[249] The results of Marcel Dieulafoy excavation in Susa was published in Paris in 1890 as "*L'Acropole de Suse d'après les fouilles exécutées in 1884, 1885, 1886 sous les auspices du Musée du Louvre*".

By the end of Marcel and Jane Dieulafoy mission in Susa, the government of France decided to begin a vast program of archaeological exploration/excavation in all ancient sites of Iran. However, Jacques de Morgan (1857-1924 AD), a France mining engineer, geologist and archaeologist, continued the France plundering by signing two monopolies under the title of "*Délégation Archéologique Française en Iran*"; once by Nasser-ed-Din Shah in 1895 in eight chapters,[250] and again by Mozaffar-ed- Din Shah in 1900 in eleventh chapters, one worse than the other.

In 1895, the France obtained a monopoly to explore archaeological sites in Iran in exchange for a sum of 500000 *Francs* (Chevalier, 1997), and later in 1900 a concession was granted which offered them the exclusive right to excavate all over Iran (Tissot, 1994).[251] About the history of the France archaeological delegation in Iran, De Morgan had published a book in 1905 entitled "*Histoire et Travaux de la Délégation en Perse du Ministère de l'Instruction Publique, 1897-1905*".

As de Morgan wrote about 1895 monopoly:

"In 1894, the France Plenipotentiary and Ambassador Extraordinary, the sire Rend de Balloy, who also entertained a close friendship with the Persian Court, was able to obtain the consent of His Majesty Nasser-ed-Din Shah to the conclusion of an agreement attributing exclusive rights of archaeological research throughout the Empire of Iran to the France Government. The two governments' negotiations were put into application pending the signature of the agreement. These took around three years to complete, because drafting the term of this agreement was truly complicated. The Iranian Government wished the agreement to be drafted in very courteous term accompanied with full political ostentation, while our representative was attentive to have the persons to whom the implementation of the agreement would be entrusted

[249] Peters P.J. Excavations in Persia, The Harvard Theological Review, Harvard University; 8(1): 82-93, 1915.
[250] One year later Nasser-ed-Din Shah Qajar was assassinated.
[251] Daroogheh-Nokhodcheri R. (2014). Nationalism, Politics, and the Practice of Archaeology: The Case Study of Iran (Doctoral thesis, Durham University, England). Retrieved from Durham E-Theses Online: http://etheses.dur.ac.uk/10658/

to be aloof from complications which will undoubtedly arise from our racial differences with the Iranian peoples."[252]

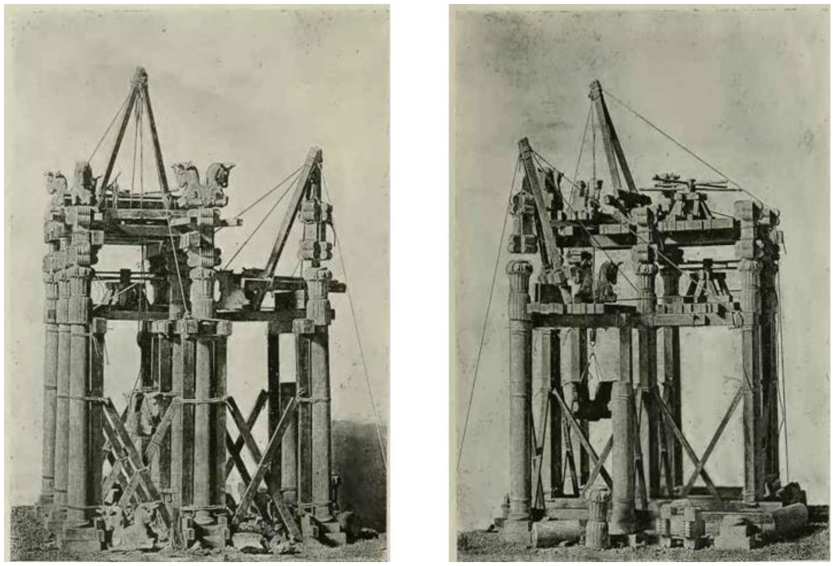

Figure 4.5- The technique used by the Dieulafoy for displacement of capital columns of the audience hall of the palace of Darius I (Photo by Dieulafoy. Source: http://fresh-seed.de/category/louvre-paris/).

Figure 4.6- Capital of a column from the audience hall of the palace of Darius I on display at the Louvre Museum (Photo by Frank Raux, 1999. Source: louver Museum website).

[252] Hodjat, M. (1995). CULTURAL HERITAGE IN IRAN: policies for an Islamic country (Dissertation for A DPhil Degree, Institute of Advanced Architectural Studies, The King's Manor University of York, England). Retrieved from etheses.whiterose.ac.uk/2460/1/DX193597.pdf

During his presence in Susa, for having a secure base for archeological exploration and excavation, similar to medieval monuments in France, De Morgan constructed a castle atop of a hill. As fatuity of de Morgan, this castle was built inside of an archeological site where it might have contained other relics from ancient times. Moreover, for building this structure, de Morgan used materials that existed in the Susa's site, some of which had high historical values, like Achaemenid inscriptions, see Figure 4.7.

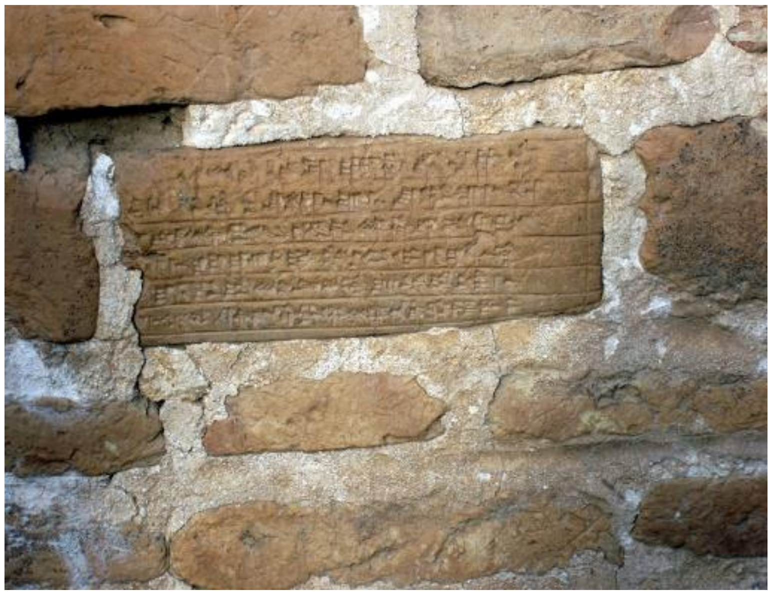

Figure 4.7- Achaemenian inscription used in the wall of France's castle in Susa (Source: http://forum.tarikhfa.com).

By a comparison between 1895 and 1900 agreements, Hodjat (1995) exactly showed the differences of those shameful agreements signed with France as follow:

- In the text of the first agreement, it is the Shah of Iran who, with extensive and pompous titles, is granting an authorization of excavation to the France, whereas in the second, we come across the sentence "The respected France envoys are authorized to prospect throughout Iran ...", which speaks of the sad political situation of Iran.

- The first agreement's independent statement concerning the respect of religious localities and popular beliefs has, in the second agreement, been incorporated into the second article, and the sentence "... shall respect and abide by all the custom, traditions and mores of the country." has become "refraining from actions contravening ethics and the law."

- The second and third articles of the second agreement deal with gold and silver artifacts. Their very inclusion indicates the aim of the agreement. It is most interesting that, while other objects are to be equally divided among the two parties, in the case of gold or silver artifacts, the France are only to pay their raw metal equivalent, and allowed to appropriate the whole loot. In the third article, following the dispositions for weighing these item, one reads "and once their weight is determined, its price must be remitted by the France embassy to the Iranian government.", which means that no way exists for Iran to appropriate these item; and this was the aim which dealers of cultural properties pursued under the disguise of scientific exploration. Comparing these two articles with the first six of the older agreement, which state that "Precious artifacts such as gold- and silver-ware, if found, shall be the strict property of the Sublime Government of Iran, ...", well illustrate the difference between the two agreements. And in corollary, France property over everything to be unearthed from the immense complex of Shush is officially recognized in the second agreement, while such a clause does not exist in the first."

- In the first agreement, no mention is made of provisions for housing, etc., whereas the fifth article of the second stipulates that the Iranian government is responsible for "securing their housing, providing for the transportation of their equipment, and facilitating their works and travels between its cities."

- In the fourth article of the first agreement, the France are committed, in order to fulfill their responsibilities, to dispatch a member of their embassy on site, while this condition has been dropped from the second agreement.

- In the fifth article of the first agreement, the rights of printing and publishing the results of excavations (scientific excavation reports) are made conditional upon the assent and permission of both parties, whereas, in the second, the matter has been dropped altogether, so that, even to the present day, all scientific information and reports of excavations have been published in France, inflicting an irreparable scientific loss to the progress of Iranians' knowledge about the relics of their own home land which were appropriated by foreigners.

- The seventh article of the second agreement authorizes the France to "build whatever kind of warehouse or building they may need for their work, whether as their own and their guards lodgings, or as storage locales for their own antiquities." It should be noted that, according to international laws of diplomacy, a country can only have an embassy and a residence for its ambassador, which enjoys political and judicial immunity on another country's soil. Yet, by virtue of this article, the France were allowed to build such immune edifices wherever they wished in Iran. In the following chapters, we shall see that this occupation of some places in Iran lasted well over a hundred years, until after the victory of the Islamic Revolution, and culminating in an interesting anecdote.

- The eighth article is totally new. Those familiar with the details of excavation operations know that only the excavators are aware of what is discovered, and that, if they are allowed

> to pack and send item to the border, the only hindrance to their exit, even if the border post does have a custom office, is a functionary whose silence can be readily secured, at a time when the king sells the rights of excavating throughout the country for 10,000 tomans.

Here it should be pointed that, the purpose of all excavation in Iran were not primarily to perform a scientific archaeological work, but the main objectives were to unearth valuable artifacts. Considering the above discourse, the artifacts appear to be ranged undervalued but with high historical value were destroyed and thus based on chronological sequence, numerous Iranian pre-historic sites were ruined. Dr. Feuvrier (1947) on his memoirs, "*Three Years at the Persian Court from 1889 to 1892*", writes about the year 1891: "The slightest digging in these ruins [in Rey, near Toghrol Tower] results in the discovery of a usable ancient relic. I possess several enameled ceramic vessels and a number of intact octagonal glazed tiles which were obtained from such excavations. But, as anyone can freely set upon exploring those ruins, this is done arbitrarily, without any regard for scientific methods."[253]

Certainly, at such period, the factor that incites the Qajar's rulers to sponsor the monopoly of excavations in the country was mostly their ignorance of the value of country's cultural heritage properties. Then by the victory of the "Constitutional Revolution" (1906), gradually the act of granting these monopolies elicited a negative reaction among the intellectuals who became aware of those abuses, so as Daroogheh-Nokhodcheri (2014) remarks, "[…] the nationalists who drove the wheels of the Iranian Constitutional Revolution were the single group who demonstrated sporadic concerns over the exploitation of antiquities by the France." Thence, motivations for preservation of the country's cultural heritage were increased.

In order to clarify the matter, it must be remembered that, as ratified by the first 'National Consultative Assembly' in 1907, which determined the structure of ministries, two offices were created under the names of "*Office of Museological Excavations*" and "*Office of Ancient Monuments*", and that, according to the 'Municipal Law' passed in the same year, the creation of museum and the preservation and restoration of mosques, schools and ancient monuments are cited among the latter's duties (Hodjat, 1995). Then in 1916, the first 'Antiquities Museum of Iran' in Tehran under the authority of Iraj Mirza Jalal-al Din in the old building of the office of science, in the northern side of Dar-al Fonun School opened,[254] along with 270 relics for exhibition.[255]

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[253] Hodjat, M. (1995). CULTURAL HERITAGE IN IRAN: policies for an Islamic country (Dissertation for A DPhil Degree, Institute of Advanced Architectural Studies, The King's Manor University of York, England). Retrieved from etheses.whiterose.ac.uk/2460/1/DX193597.pdf

[254] History of Iranian Cultural Heritage Organization, ICHHTO's Website (Posted in Persian). Retervied from http://www.ichto.ir.

[255] As evidence testify, the date of first Museum in Iran Back to Naser al-Din Shah in which he had a space within the Golestan Palace for the preservation of historic artifacts.

4.1.2 Nationalism and Iran Cultural Heritage Policy during Pahlavi Dynasty (1925-1979 AD)

In the previous section, it was discernible that by the end of the Qajar dynasty, in the first quarter of the 20th century, owing to the idiocy and ignorance of the Qajars rulers, and the plundering pursued by foreigners, the Iranian cultural heritage, either tangible and intangible or moveable and immovable, was threatened with destruction and dilapidation. During this period, gradually with sweeping changes that happened in the world and Iran, a new course of political adaption was imposed to Iran, and subsequently upon its cultural currents. The events which came to pass in Iran during this period were so bitter and astounding that their effects are felt even to the present day (Welayati, 1994).[256] In this period, to follow the major events affecting the policy governing of Iranian cultural heritage, we can point to the victory of the "Iranian Constitutional Revolution" (1906),[257] "the outbreak of World War I" (1914-1918 AD),[258] "the downfall of the Ottoman Empire" (1920),[259] "the onset of Reza shah in decision–making of the country and his assignment as the prime minister" (1921), "the onset of Pahlavi dynasty" (1925), "the outbreak of World War II" (1939-1945 AD), "the disposal of Reza Shah Pahlavi and succession of Mohammad-Reza Shah Pahlavi" (1941), "the alteration of the power scheme of alien forces influential in Iran from British and Russia to new American power" (1941-1979 AD), "nationalization of the Iranian oil industry" (1951),[260] and "the downfall of the Reza Shah Pahlavi" (1979), all of which had paved the ground for major changes in Iranian social and cultural life.

In this part, besides having an overview of the prevailing conditions, and studying the political and social developments of Iran during Pahlavi period (1925-1979 AD), it is tried to examine the effect of different factors influencing affairs related to Iranian cultural heritage policy. Meanwhile, there is a focus on turning points of the evolution of policy-making about the Iranian cultural heritage, and so inclinations and qualities of their setting up. Indeed, we are seeking to evaluate the factors that have considerable effects on Iranian attitude towards cultural

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[256] Hodjat, M. (1995). CULTURAL HERITAGE IN IRAN: policies for an Islamic country (Dissertation for A DPhil Degree, Institute of Advanced Architectural Studies, The King's Manor University of York, England). Retrieved from etheses.whiterose.ac.uk/2460/1/DX193597.pdf

[257] Since by gradual awareness of country's intellectuals about incompetency of Qajar rulers for governing the country, and their weakness for making important socio-political decisions, in 7 October 1906a constitutional movement aimed at creating a parliament and giving control of the country to the people's representatives was created. This event in its turn can be considered as one of the most important events in Iranian history.

[258] At the end of World War I in 1918, Iran had become a disoriented country without the sovereignty of a central government (Daroogheh-Nokhodcheri, 2014).

[259] This historical event had a significant impact on regional policies.

[260] The Persian Oil Company was established in 1909, before that the Iranian oil industry was under British control.

heritage properties and the policies adopted for their identification, registration, conservation and restoration.

On February 12, 1921, Reza Khan, backed by the ‘Cossack Brigade’, staged a coup d’etat. He occupied Tehran, declared martial law, and installed a pro-British politician [...] and in 1923, Ahmad Shah named Reza Khan as prime minister and then promptly left for a European vacation, never to return (Daniel & Mahdi, 2006).[261] In 1925, the Majles (Iranian Parliament) deposed Ahmad Shah and amended the constitution to transfer the monarchy to Raze Khan and his descendants. He crowned himself in a ceremony in 1926 (ibid) as Raze Shah[262] of the Pahlavi Dynasty.[263] With Reza Shah’s ascension to power in 1924, the political climate of Iran changed and became increasingly anti-colonial and nationalistic (Daroogheh-Nokhodcheri, 2014). In general, the political approach of Reza Shah can be considered as a non-Islamic Republic inspired by the example of Mustafa Kemal (1881-1938 AD) in Turkey.

- Development of Nationalism Sentiment by Reza Shah Pahlavi (1925- 1941 AD)

> “*For too long my countrymen have relied on others. I want to teach them their own values, so that they may be independent in mind and action.*” (Reza Shah cited in Menashri 1992).[264]

As Reza Bigdeloo points out in “*Bashangara’I dar tarikh-e mo’aser-e ira*n” (2001) (Archaism in the contemporary history of Iran), “the tendency to downplay the role of Islam in Iranian history and to emphasize ancient kingship and empire was particularly apparent during the Pahlavi era (1925-1979 AD).”[265] At the core of the nationalism endorsed by Reza Shah’s government was the promotion of a secular and ancient society (Daroogheh-Nokhodcheri, 2014). Reza Shah by his personal genius and perspicacity, in order to revive and exacerbate the nationalism ideology among Iranian people and saving the country from underdevelopment, by setting aside the Islamic and post-Islamic values, benefitted from the pre-Islamic and pre-historic Iranian values. However, the assertion that such attention was essentially an attribute of his rule and the upshot of his genius severely harmed popular interest and willingness to

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[261] Daniel, E.L., & Mahdi, A.A. (2006). *Culture and Customs of Iran*. Westport, Connecticut, London: Greenwood Press. p. 29.

[262] Persian term for ‘King’; *Shahanshah*: literally ‘King of King’, sometimes, though not accurately, translated as ‘Emperor’ (Ansari, 2007).

[263] Reza khan during history had been called by many different nicknames such as Reza Savadkouhi (the name of a city in Māzandarān province), Reza Maksim, Reza Khan and then by its military degree was named as Reza Mirpanj. However, the choosing of the family’s name of Pahlavi as a word rooted in the ancient language of Iran symbolized the Iranian nationalism that was the hallmark of Reza Shah’s policies.

[264] Menashri, D. (1992). Education and the Making of Modern Iran. New York: Cornell University Press, p. 99,

[265] Axworthy M. (2008). *A History of Iran: Empire of the Mind.* New York (N.Y): Basic Books, p. 352.

participate in affairs relevant to the cultural heritage (Hodjat, 1995). During Reza Shah monarchy, the purpose for creation of a potent nation-state caused extensive socio-political reforms, and the promotion of nationalism sentiment among Iranian, so he could pave the way for the introduction of a new disciplined approach to more respect to Iranian national heritage. However, as Kohl (1998) argued, "the emphasis on the political character of nation-formation is essential since it can be applied to the treatment of archaeology and its relations to nationalism. In this case, archeology in its new definition was employed as a political instrument to boost the government's account of national pride and to confirm the cultural 'continuity' and 'superiority' of the Iranians."[266] Archaeological activities and following that conservation and restoration works, which was implemented in Iranian historical sites had a major role in providing Iranians with a common historical and cultural past, so they not only united the multi-ethnic Iranian society, but they also contributed to the bolstering of Iranian identity. In fact, by recognition of the instrumental role of archeology in providing a sense of unity and superiority among Iranian, Reza shah tried to stimulate Iranian people to progress towards a better future as far as it would correspond with the Iranian "*Golden Age*"[267] in Achaemenid (550-330 BC) and Sassanid periods (224-651 AD). In this way, it was tried to monumentalize some selected architecture as symbols of a new modern emerging society. Consequently, by the 1920, a complete history of Iran that extended back to the time of Achaemenid, as opposed to the Sassanid as recorded by 'Ferdowsi', was re-discovered and re-introduced to the Iranian society (Pirnia, 1928).[268] However, the 'continuity' of Iran as a nation-state was thus emphasized through the prevalence of a long line of royalty extending from the Achaemenids to the Pahlavi dynasty (Wilber, 1975).[269] As Daroogheh-Nokhodcheri (2014) expressed, "To attest the spirit of homogeneity, Reza Shah's Administration promoted the ideals of an 'imagined community' that glorified the pre-Islamic Iranian history. Particular emphasis was laid on the common ancestry of all Iranians and their lineage with the 'Aryan race'." Yarshater (1989) also in his book "*Persia or Iran, Persian or Farsi*" in investigation about what was the significance of changing the name of "Persia" to "Iran" wrote: "In 1935 the Persian government requested countries with which it had diplomatic relations to call Persia Iran, which is the name of the country in Persian. This was a grievous error based on a misdirected sense of nationalism. The suggestion for the change is said to have come from the Persian ambassador to Germany, who came under the influence of the Nazis. At the time Germany was in the grip of racial fever and cultivated good relations with nations of "Aryan"

[266] However, this type of nationalism rendered by Reza Shah by relying on the concept of archeology and nation-states was initially experienced in Europe before spreading to other regions (Diaz-Andreu & Champion, 1996).
[267] During this period, Iranian pre-Islamic history was referred as a 'golden age' of Iranian history. As Smith (1999) mentioned, the future of the ethnic community especially relies on the "golden age" when men were "heroes". (p. 65).
[268] Pirnia, M.K. (1928). *Iran i Bastan*. Teheran: Parliament Press, p. 144. (Published in Persian).
[269] Wilber, D.N. (1975). *Reza Shah Pahlavi: The Resurrection and Reconstruction of Iran*. New York: Exposition Press. p. 175.

blood. It is said that some German friends of the ambassador persuaded him that, as with the advent of Reza Shah Persia had turned a new leaf in its history and had freed itself from the pernicious influences of Britain and Russia, whose interventions in Persian affairs had practically crippled the country under the Qajars, it was only fitting that the country be called by its own name, "Iran". This would not only signal a new beginning and bring home to the world the new era in Persian history, but would also signify the Aryan race of its population, as "Iran" is a cognate of "Aryan" and derived from it."[270] To further illuminate this continuity, the new dynasty, which comprised of only two shahs, Reza and his son Mohammad Reza, recalibrated the Iranian calendar so that it went back to 2,500 hundred years (Axworthy, 2008). This self-afflicted superiority and chauvinism had three intentions; firstly, to enhance national unity in the multi-ethnic Iranian society; secondly, to reiterate Iran's sovereignty over previous protectorates and extend the country's political power beyond its current borders; and thirdly, to place Iranian's "racial" composition, as superior in comparison with the rest of Middle Eastern nations (Abrahamian, 2008).[271] Therefore, at first in all nationalistic rhetoric, the emphasis was directed towards pre-historic sites. However, this political mindset provoked an impetus for a positive step towards creating a professional and scientific ethos in discipline related to pre-historic archaeological works. During the government of Pahlavi, nationalism became the incentive for widespread archeological researches, in so far as, Reza Shah advanced particular state-sponsored for archeological excavations in pre-historic sites. So that, the emphasis on nationalism and pre-historic values and traditions continued to be the dominant aspect of Pahlavi's father and son until the Islamic revolution of Iran in 1979. Therefore, all attitudes during this period were to seek an authentic national origin in ancient history of Iran, through which in the shadow of political matters one could create a sense of pride, unity and national identity between people. In the meantime, many measures have been taken by Reza Shah to reconstruct a national identity, ranging from creating interesting interplay between academic and scholarly works and the governmental agenda aiming to address a new image of the nation-state in the country. Overall, it can be said that the regime of Reza Shah by using the context of pre-historic values as specific political and propaganda motivated tried to form nationalism sentiment in the country. Based on Iranian intelligentsia, pure Iranian cultural and authentic national origins could be found in its pre-Islamic time, specifically during Achaemenid period (559-331 BC), through technically sophisticated documentations and categorizations to establishing its connections with past, recognizing its values, introducing them to the world and adapting them to the necessities of the modern society for political purposes (Zargaran, 2014). During Mohammadreza Shah Pahlavi, the Iranian nationalistic sentiments was more orientated towards modernization and so it reached its maturation phase. This modernized nationalism turned to be an important instrument for realization of political strategies of Mohammadreza Pahlavi's regime for almost 30 years. On the other hand, the

[270] Yarshater, E. (1989). *Persia or Iran, Persian or Farsi*, Iranian Studies, vol. XXII, No. 1. Retervied from http://www.iranchamber.com/geography/articles/persia_became_iran.php

[271] Abrahamian, E. (2008). *A History of Modern Iran*. New York: Cambridge University Press. p. 87.

archeological data obtained from the archeological excavations in Iranian ancient sites were also recognized as an instrument to re-establish the social and cultural values of the modern urban space through continual process of portraying the influence of past in the society and reawakening the collective memory through material imitating of past relics. Apart from all discussions issued about political performance of Reza Shah Pahlavi, there are some sporadic reports that show disrespects to Iranian post-Islamic cultural heritage. As one of the main examples of this neglect, we can refer to what was reported by Makki (1945), Rajabi (1976) and Taj-Al Moluk (2001) about demolition of Tehran historic gate and wall, and disruption of the integrity of historic centers by giving way to new wide roads for the recently imported cars. In this case, the second wife of Reza Shah in book entitled "*Memories of Pahlavi's Queen*" or "*Memories of Taj-Al Moluk*" mentioned her fuss with Reza Shah about destruction of palaces and exquisite buildings inherited from Qajar Periods, and Reza Shah said in response, everything that reminisced memories of Qajar dynasty have to be destroyed so that they would not be in front of the eyes of the people of the society (Taj-Al Moluk, 2001).[272]

Figure 4.8- National Bank of Iran by architectural symbol of ancient Persia (Source: archive of ICHHTO).

The major pillars of change that characterized the Pahlavi period were based on centralization, modernization, and the establishment of institutes (Banani, 1961).[273] During Reza Shah Regime, nationalism had undeniable effects upon ratifying legislation, so that this approach led to a number of progressive outcomes in the field of country's cultural heritage. As brilliant

[272] Taj-Al Moluk. (2001). *Memories of Pahlavi's Queen (Memories of Taj-Al Moluk)*. Khsorodad, M., Ansari, T., Batmanghelich, T (Interviewers). Tehran: Behafarin Publication Institute. pp. 161-185. (Published in Persian).
[273] Banani, A. (1961). *The Modernization of Iran, 1921-1941*. Stanford: Stanford University Press. p. 147.

examples of this process can be seen in the foundation of “SCINM” (1922)[274]; the “Annulment of the France Monopoly” (1927); the ratification of the “Law of Antiquity” and the re-organization of the “Office of Ancient Monument” (1930); evoking Iranian pre-historic memories by the foundation of new structures, whose designs had roots in ancient history of the country such as Ferdowsi’s Tomb, National Library, National museum, National Bank and the establishment of cultural and scientific centers like Tehran university (1935), etc.

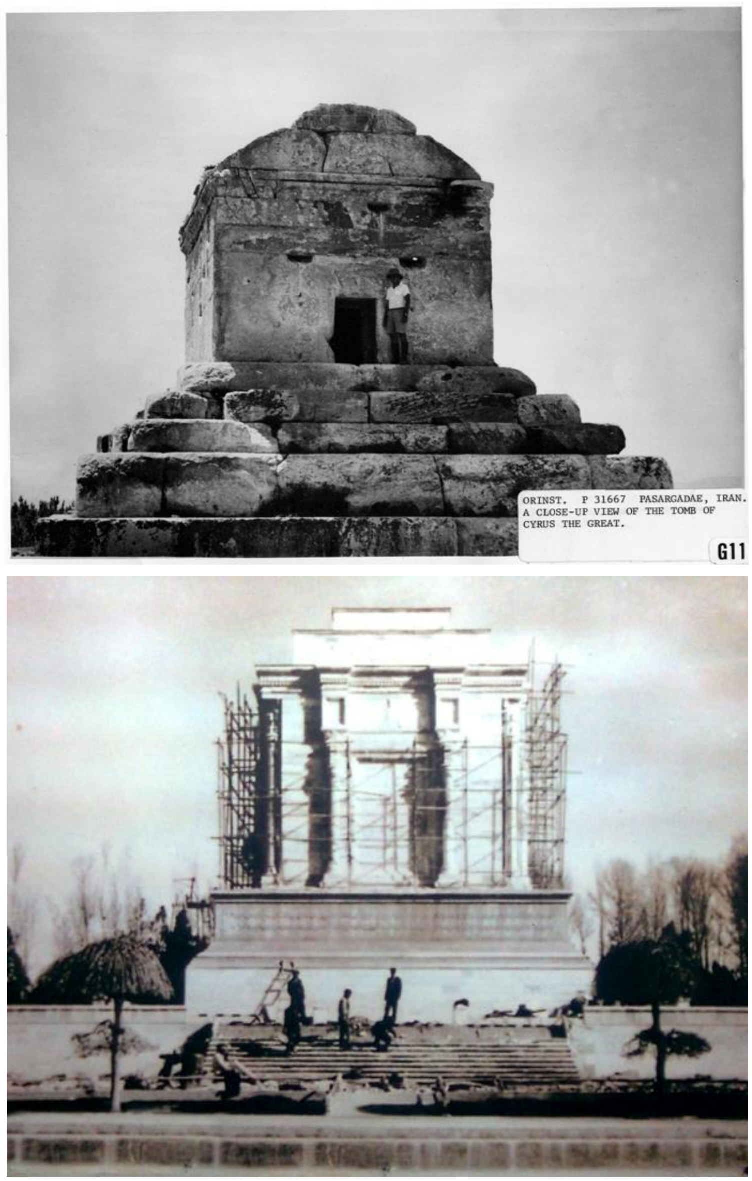

Figure 4.9- National Bank of Iran by architectural symbol of ancient Persia (Source: archive of ICHHTO).

[274] SCINM: Society for Conservation of Iranian National Monuments.

- The Society for the Conservation of Iranian National Monuments (SCINM) (1922)

The establishment of the "*Office of Museological Excavations and Office of Ancient Monuments*" in Iran in 1907 should be considered as the first governmental approach towards more attention to the country's cultural heritage properties. The importance of this event lies in the fact that it considerably antedates the emergence of an interest toward the cultural heritage and its preservation, which was believed to have occurred with the onset of the Pahlavi dynasty, to an earlier date (Hodjat, 1995). Thereafter, one of the most important action which took place during Reza Shah Pahlavi, after its accession in decision-making of the country, was the establishment of the "*Society for the Conservation of Iranian National Monuments*" (SCINM) in 1922. This society in its turn can be considered as the first active semi-governmental institution in the field of cultural heritage, which through its protracted activities, played an exceptional role in shaping the Iranians interest towards their cultural heritage. However, the SCINM as the first specialized national organization in Iranian cultural heritage affairs characterizes its aim as promoting public interest towards ancient Iranian relics and striving to direct attitudes towards preserving fine relics and handicrafts, maintaining their original styles and manners. In fact, by proposing SCINM, Reza Shah had a dual purpose: 1) to form a homogeneous national identity among Iranian, 2) to legitimate itself into Iranian historic context.

One of the main actions that was implemented by the SCINM was documentation and classification of Iranian national monuments, and registration of them in possession of government to be preserved as National Cultural Heritage. In 1925, the SCINM as its very first activity issued the first list of historical monuments in Iran. In this case, Ernest Herzfeld, the only foreign official councilor of the SCINM, was asked by the society to compile a list of Iranian historical monuments and also help to develop a plan for the department of antiquities. In 1928 the Herzfeld's efforts matured into the SCINM's first publication entitled "*A Brief Inventory of Historical Heritage and Edifices of Iran*" containing a list of 88 monuments considered to have historical value,[275] and then, the list was completed and finalized by André Godard in 1929 with 385 monuments. At the same time, the SCINM also became responsible for the protection and restoration of heritage sites, so a number of historic monuments more in view were repaired. In this case, Mostafavi (1955), who published the first report on the contemporary history of cultural heritage activities in Iran wrote about this period, "[...] Under the Constitution, until the advent of the Pahlavi era, no knowledge or trace exists of historic relics being repaired, and it is from 1330 AS [1921] onward that interest and action gradually appear toward the preservation and restoration of vestiges of the past [...]".[276]

[275] Herzfeld to prepare this list used of periodization and comparison as effective techniques in order to classify the historic monuments of Iran into neat periodic compartments of Achaemenians, Sassanians, Seljuks, and Safavids (Zargaran, 2014).

[276] Hodjat, M. (1995). CULTURAL HERITAGE IN IRAN: policies for an Islamic country (Dissertation for A DPhil Degree, Institute of Advanced Architectural Studies, The King's Manor University of York, England). Retrieved from etheses.whiterose.ac.uk/2460/1/DX193597.pdf

In addition, in 18 May 1928, for the first time in Iran a legislation for preservation of Iranian cultural heritage was ratified in Article 26 of Iran civil law, which is proposed as follows:

"The State properties which have been intended for public interest such as fortifications, fortresses, moats, military earth works, armory, weapon, reserve, war-ships, as well as equipments and furniture, buildings and monuments belonging to government, State telegram cables, museum, public libraries, historical products and relics, and the like-totally any property, whether movable or immovable, which, under the title of public benefit and national interest, is in the state possession or have been allocated by government to any province, city, district or village, may not be owned privately." (Cited in UNESCO/CLT/NATLAWS).[277]

After this historical event, due to the presence of foreign archaeologists, architects and historians SCINM benefited from the experiences of great professionals in the world. These experts were mostly sponsored by institutes such as the University Museum of the University of Pennsylvania, the Pennsylvania Museum of art, Musée du Louvre, Royal Swedish Academy, the Museum of Fine Arts Boston, the University Museum in Philadelphia and the Oriental Institute of the University of Chicago.[278] Among all specialists who worked in Iran, Herzfeld and Godard as the most well-known experts of Persian history had a very important role in finalizing and flourishing of Iranian cultural heritage policy. In the following section, a review of the activities of Herzfeld and Godard on the development of the cultural discipline in Iran is presented.

- Ernest Emil Herzfeld

Ernst Emil Herzfeld (1879-1948 AD) is recognized as a German archaeologist and Iranologist. He finished his preliminary studies in architecture at the University of Technische Hochschule (Berlin), and in Assyriology, art history and philosophy at the University of Friedrich-Wilhelm (Berlin). In 1907, Herzfeld presented his doctoral dissertation on Iranian archeological site of Pasargadae and then after 'World War I' (1920), he was assigned as full professor of "Landes- und Altertumkunde des Orients" (Berlin). As a newly-minted professor at the University of Berlin, Herzfeld was recognized as a leading European authority on the culture and history of ancient Iran (Jenkins, 2012). From 1923 to 1925, Herzfeld started valuable excavations in western, central and southern parts of Iran.

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[277] UNESCO Cultural Heritage Laws Database (UNESCO/CLT/NATLAWS). Retrieved fromhttp://www.unesco.org/culture/natlaws/index.php

[278] Among all foreign institutions active on the archeological matter of Iran, the American institute of the Oriental Institute of the University of Chicago (OIUC) (1931-1939 A.D) had more active role rather than other institutes. The OIUC except for organizing a comprehensive works in different fields related to exploration, excavation and sometimes restoration of Iranian monuments, managed one of the valuable visual documentation of many of historic/archaeological settlements of the country. For more information, see the Photographic Archives of "*Persepolis and Ancient Iran"* (https://oi.uchicago.edu/persepolis-ancient-iran).

Figure 4. 10- Sasanian Gur, Looking Approximately NE, From an Altitude of 854 M on March 30, 1936; Note the Circular Wall of Defense, AE 204 (Source: archive of Oriental Institute of Chicago).

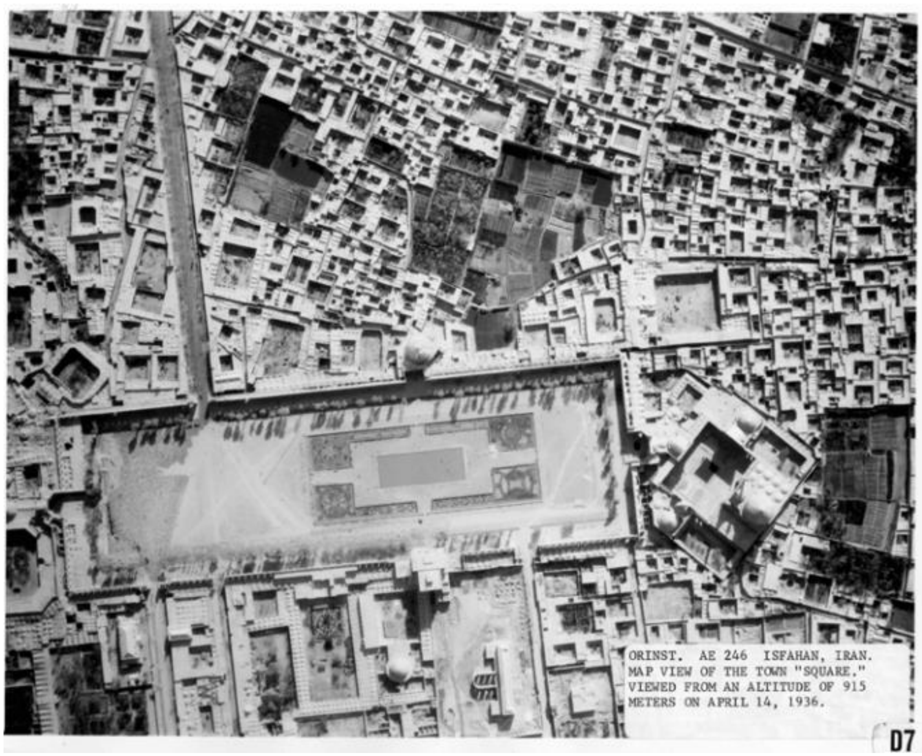

Figure 4.11- Isfahan, View of the Town “Square”, From an Altitude of 915 M on April 14, 1936, AE 246 (Source: archive of Oriental Institute of Chicago).

Figure 4.12- Excavation in archeological sites of Iran under field directory of the Oriental Institute's expeditions to Iran by Professor Ernst Herzfeld (1931-1934 AD) and Professor Erich F. Schmidt (1934-1939 AD) (Source: archive of Oriental Institute of Chicago).

The information gathered by Herzfeld during these years are considered as one of the main references about Iranian archaeological sites. In 1923, Herzfeld was appointed as the first foreign official councilor of the SCINM, and then he have had key role in codification of the Law of Antiquities (1930). Herzfeld also by his excavation in the Achaemenid capitals, Pasargadae and Persepolis had great contribution in the formation of the historical profile of Iranian pre-Islamic archeology.[279] The involvement of Herzfeld in the development of nationalism ideology intended by Reza Shah can be seen in architectural form of "*Ferdowsi's Tomb*", where he and Andre Godard, by an inspiration of "*Cyrus Tomb*", proposed the design of the structure for a Persian Muslim poet. Meanwhile, during his last activities in Iran (1931-1934 AD), Herzfeld was assigned as the field director of Oriental Institute of Chicago.[280]

Figure 4.13- Archaeologist Ernst Herzfeld at Persepolis (Source: archive of ICHHTO).

Zargaran (2014) well noted about services rendered by Herzfeld to Iranian cultural heritage: "Ernst Herzfeld is the foremost specialist, of any nationality, in the field of Iranian archaeology. While the France delegation contributed little to the history of the Iran, Herzfeld contributed immensely in shaping the future of archaeology, institutionalizing special organizations, formulating specific norm and regulations for archaeological explorations in Iran and more importantly helping the new emerging Iranian archaeology to be liberated from France-influences domination."

[279] The detail of Herzfeld's description about ruins of Persepolis is published in "*Rapport sur l'état actuel des ruines de Persépolis et propositions pour leur conservation*".
[280] By ending the management of Herzfeld in the Oriental Institute of Chicago, Erich f. Schmidt continued the pre-established scopes of the Herzfeld's program until 1939.

Through the method of what he called "Archaeological History," Herzfeld wrote an interdisciplinary history of Iran and its Aryan foundations that contested the assumptions of decades of European orientalist scholarship (Jenkins, 2012). Herzfeld published the results of his travel and archeological activities in Iran in three compiled books; "*Rapport sur l'état actuel des ruines de Persépolis et propositions pour leur conservation*" (1924), "*Archaeological History of Iran"* (1934) and "*Iran in the Ancient East*" (1940).

- André Godard

André Godard (1881-1965AD) was a France art historian, archaeologist and architect that was mostly graduated from the "*École des Beaux-Arts in Paris*". The study area of Godard was limited to Middle East and more specially that of Iran. After annulment of France Monopoly (1927), according to the agreement signed between France and Iran, André Godard came to Iran to assist Iranian authorities in administrative matters related to Iranian cultural heritage.[281] In 1928, the Iranian government invited Godard to Iran, and he officially began his work as the directorship of "Office of Antiquities" (APPENDIX.IV). At first, in 1929, to follow the work that was started by Herzfeld in 1925, Godard organized necessary documentations for the registered Iranian national monuments and for the monuments, which needed to be registered in the index of Iranian national monuments.

In 1936, Reza Shah appointed André Godard as director of the Iran-e Bastan Museum. In fact, the '*Iran-e Bastan Museum*' (National Museum of Iran) is another distinguished example of the process of the Iranian new attitude towards pre-Islamic values,[282] which was designed by André Godard, see Figure 4.14.[283] André Godard during his tenure in different sectors of Iranian cultural heritage affairs and more especially as the first dean of the Faculty of Fine Arts professionally trained the first generation of Iranian architects and had main contribution in familiarizing of Iranian young archeologists with systematic researches on historic monuments of their country. Moreover, Godard formulated policies for archeological excavations and historic preservation and restoration in Iran. Godard was also responsible for restoration work on some major architectural edifices, including the Masjed-e Jomʿa, Masjed-e Šāh, and Masjed-e Šayḵ Loṭf-Allāh in Isfahan, etc. (Encyclopedia Iranica).[284] In addition, Godard employed

[281] After the annulment of the French monopoly on the archaeological matters of the country, according to the agreement signed between the Iranian and French government, the French scholars got permission to remain and continue their activities in Susa, which was mostly plundered by Dieulafoy and de Morgan. On the other hand, to continue its effects on Iranian cultural heritage affairs, France government sent Andre Godard to assist Iranian authorities to establish the department of antiquities.

[282] The '*Iran-e Bastan Museum*' was modeled after the Sassanid Palace of Ctesiphon.

[283] He was also instrumental, in the design of the National Library of Iran, Hafez's Tomb, Ferdosi's Tomb, the main campus of the University of Tehran and the foundation of Fine Arts Faculty of Tehran University.

[284] Encyclopaedia Iranica. "Andre Godard". Retrieved from http://www.iranicaonline.org/articles/godard

expert traditional masons "*Usta*"[285] for managing necessary restorations on these monuments on the request of local branches of archaeological department throughout Iran when needed. The method of interventions was still that of traditional and far from European methods in those years; in fact, like other France scholars, Godard was also more interested in archaeology and history of art than to conservation activities in architectural monuments, with the result that historic monuments remained still in threatening situation and in need of serious attention (Zargaran, 2014).

The mission of André Godard in the title of director lasted from 1928-1953 and then again from 1956-1960.[286] After that, André Godard returned to Paris and continued to write about Persian art. The results of Godard's archaeological and architectural investigations were published twice annually in France from 1936 to 1949 in journal of "*Athār-éĪrān: Annales du Service Archéologique de l'Īrān*" with high quality photographs and illustrations and architectural drawings and inscriptions.[287]

Figure 4.14- (Top) the Sassanid Palace of Ctesiphon (Photo by Dieulafoy, 1884. Source: http://www.iranicaonline.org); (Down) the 'Iran-e Bastan Museum' (National Museum of Iran) designed by And Godard (Source: http://www.makanbin.com).

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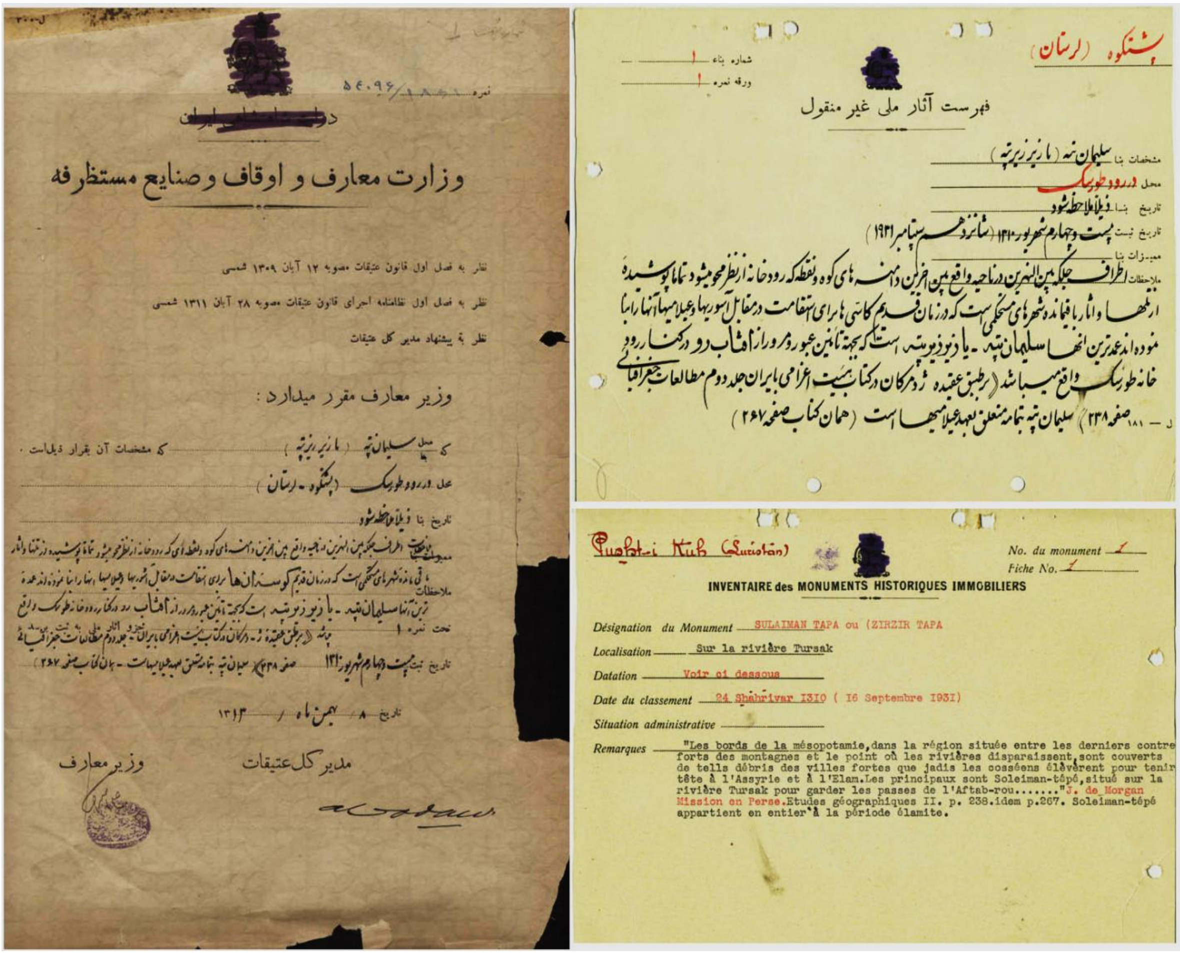
[285] In Iranian traditional context, chief masons or ustas were responsible for all interventions in traditionally constructed buildings; as construction techniques were all well-known from old times, they were called for all interventions the traditionally built edifices needed (Zargaran, 2014).
[286] Ibid.
[287] Ibid.



وزارت معارف و اوقاف و صنایع مستظرفه

نظر به فصل اول قانون عتیقات مصوبه ۱۲ آبان ۱۳۰۹ شمسی

نظر به فصل اول نظامنامه اجرای قانون عتیقات مصوبه ۲۸ آبان ۱۳۱۱ شمسی

نظر به پیشنهاد مدیر کل عتیقات

وزیر معارف مقرر میدارد :

مدیر کل عتیقات

وزیر معارف

پشتکوه (لرستان)

فهرست آثار ملی غیر منقول

Pusht-i Kuh (Luristan)

No. du monument 1

Fiche No. 1

INVENTAIRE des MONUMENTS HISTORIQUES IMMOBILIERS

Désignation du Monument SULAIMAN TAPA ou (ZIRZIR TAPA

Localisation Sur la rivière Tursak

Datation Voir ci dessous

Date du classement 24 Shahrivar I3I0 (I6 Septembre I93I)

Situation administrative

Remarques "Les bords de la mésopotamie,dans la région située entre les derniers contreforts des montagnes et le point où les rivières disparaissent,sont couverts de tells débris des villes fortes que jadis les cosséens élèvèrent pour tenir tête à l'Assyrie et à l'Elam.Les principaux sont Soleiman-têpé,situé sur la rivière Tursak pour garder les passes de l'Aftab-rou......."J. de Morgan Mission en Perse.Etudes géographiques II. p. 238.idem p.267. Soleiman-têpé appartient en entier à la période élamite.

Figure 4.15- The new dossier prepared by Andre Godard for registration of Iranian cultural heritage in the index of national monuments (Source: archive of ICHHTO). The current dossier of Iranian Cultural Heritage's regulation, with more detailed information based on ICOMOS's recommendations, is shown in APPENDIX.V.

- The Annulment of France Monopoly (1927)

Apart from the Government's mandate to 'liberate' Iranian archaeology as a precursor to Iran's national independence, the France archaeological policies in Iran were detested for their inadequate approach in promoting Persian culture and their obsolete methods of excavations (Gholi, 2003).[288] This decision by Iranian government was also supported by the Americans, who clearly expressed a great inclination to take part in Iranian Archaeology. As Goode (2007) expressed about this situation, "These claim were supported by American diplomats who maintained that the France through their "closed-door" policy had achieved little in the field of Iranian archaeology and Iran should adopt an "open-door" policy to allow other nations to make

[288] Gholi, M.M. (2003). *The Great American Plunder of Persia's Antiquities 1925-1941*. Oxford: University Press of America, p.67.

“marvelous discoveries”.[289] In addition, the Iranian Government regularly complained about the loss of antiquities to France, with no benefit for Iran (Goode, 2007).[290] A sample of this claim is exposed in APPENDIX. VI.[291] However, while Reza Shah was passing through Shush, came across the citadel the France had built for their dwelling and archaeological activities, and, finding it like a military fortress, enquired about it and, upon learning about the agreement, he immediately revoked it (Hodjat, 1995). The annulment of the France monopoly by Reza Shah (1927), whom Hodjat (1995) named as the “heroic saviour” of the Iranian cultural heritage from foreigners and the obliterator of the shame of Qajar times, not only can be considered as a political act, but also it can be considered as a continuation of Reza Shah’s nationalistic policy in the country. The annulment of the France monopoly and cutting off their hands from plundering Iranian national treasures highly contributed in the development of new scientific archeology and its all related disciplines.[292] This monopoly annulment, besides providing a catalyst for the colonial mandates of expansionist powers, it also created an opportunity for other foreign expeditions and foreign scholars who were interest in expanding the margins of their projects into Iranian archeological sites. However, after this historical stage, the presence of European scholars was very fruitful for development of Iranian cultural heritage policy and its evolution.

- The Law of Antiquity (3 November 1930)

Owning to the necessity of a unique approach in order to control and organize archaeological activities in Iran, the Iranian Parliament approved the “*Law of Antiquity*” in 3 November 1930, in 4 chapters and 52 articles (APPENDIX. VII).[293] In fact, the aim of this law, the first legislation in its kind in Iran, was to define and regularize the legal approaches regarding the necessity of the registration of cultural monuments, the execution of the archaeological activities and the supervision of the registered national monuments. While this law had a very great importance on the future of Iranian cultural heritage policy, and therein the primary approaches confronting the indigence of conservation of historical monuments had been adapted through the provisions of the legislation, according to its content, the concept of progress had been standing in contrast to the conservation and restoration of cultural and natural

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[289] Goode, F.J. (2007). *Negotiating for the Past: Archaeology, Nationalism, and Diplomacy in the Middle East, 1919- 1941.* Austin: University of Texas Press. p. 135.

[290] Ibid, p. 133.

[291] Although in APPENDIX. VII the nationality of addressed foreigner is not clear, while it well show that there was done something against of contract assigned between Iranian government and foreigner group. By this letter, it is also understandable that Iranian authorities during this period became more accurate about their cultural heritage.

[292] Although the monopoly of Frances was revoked in 1927, they continued their rule upon the country's cultural heritage and related disciplines for 30 more years.

[293] The chapters are categorized as: 1) Movable antiquities; 2) Immovable antiquities; 3) Archeological excavation; and 4) Antiquities trade.

heritage.[294] Regarding this weakness, Zargaran (2014) expressed that, "[...] in practical levels, due to the lack of the understanding, the concepts of "Perseveration" and "Antique" on the one hand, and following the modernizing projects of Pahlavi government, on the other hand, the necessity of preserving heritage was misunderstood and the discourse on Iranian architecture witnessed occasional quarrels over techniques of preservation, authenticity of heritage, and ownership of archaeological sites." Also about inattention of Herzfeld and Godard about this issue, who have important role in codification of this law, Zargaran (2014) added, "Although present famous foreign archaeologists and architects, who were completely aware of the current cultural movements regarding the conservation of historic monuments in international context, have worked in preparation of the Law of Antiquity. However, this law is limited, in major parts, to define legal approaches of archaeological activities and regularizing its commercial orientations and not to go beyond the extent that it values attention to conservative maintenance of archaeological and historical monuments. For example, this law never talks about post-excavation conservation in archaeological fields."[295]

- Mohammadreza Shah Pahlavi (1941-1979 AD)

"*Twenty-five centuries after Cyrus the Great history is repeating itself through another great King, Mohammad Reza Shah Pahlavi, whose nation has given him the title of* "*Aryamehr*" *(Light of the Aryans) for his gallantry and far-sighted efforts to revive the splendour of Persia, and to uphold a tradition of humanitarianism established by the founder of the Persian Empire.*" (The Times, 1971).[296]

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[294] During this period, recuperating the cultural heritage through the preservation, conservation and restoration of ancient monuments was in the shadow of archeological excavation.

[295] The year after 1931, by increasing global concerns about the issue of cultural heritage and the necessity of their conservation and restoration for the future generations, the International Museums Office organized the First International Congress of Architects and Technicians of Historic Monuments in Athens. As result of this congress, its participants produced the "*Athens Charter*" for the Restoration of Historic Monuments in a seven-point manifesto:

- to establish organizations for restoration advice
- to ensure projects are reviewed with knowledgeable criticism
- to establish national legislation to preserve historic sites
- to rebury excavations which were not to be restored.
- to allow the use of modern techniques and materials in restoration work.
- to place historical sites under custodial protection.
- to protect the area surrounding historic sites.

This global solidity in its turn has a very great positive impact in preservation, conservation and restoration of cultural heritage properties in international level.

[296] Darooghe-Nokhodcheri, R. (2014). Nationalism, Politics, and the Practice of Archaeology: The Case Study of Iran (Doctoral Thesis, Faculty of Social Sciences and Health, Department of Archaeology, Durham University, England). Retrieved from Durham E-Theses Online: http://etheses.dur.ac.uk/10658/

‘World War II’ (1939-1945 AD) like ‘World War I’ (1914-1918 AD) added to the problem in Iran. Even though Iran was not a party to the war, it was caught between the opposing forces.[297] Until the outbreak of World War II, during Reza Shah, the principles related to the Iranian cultural heritage were progressively and intensively applied in all cultural domains, including growing public awareness to celebrate and respect country’s cultural heritage and policies governing cultural heritage. After World War II and by succession of Mohammadreza Shah Pahlavi (1941), he tried to continue the way that his father was its standard-bearer. However, the reign of Mohammad Reza Shah can be considered as a continuation of Reza Shah’s policies as the official objectives for modernization and westernization of Iran continued, albeit with less emphasis on secularizing the society (Pahlavi, 1961).[298] At first, by the physical withdrawal of foreign’ archaeological expeditions from the country, there was an opportunity for the Iranian who were trained in Tehran University to begin to advance into positions previously reserved by the foreign experts.[299] Then with the growth of American influence over Iran, this exceptional opportunity was diverted to the United States of America, as far as the number of excavations executed by Iranians, until the victory of the Islamic Revolution, were limited to a small number.[300] However, the events that happened in the early 40s led up to new trends concerning Iranian cultural heritage. It should be noted that the purpose of the past excavations in Iran was mostly to discover objects, but in the new era of Iranian history, the political reform brought about basic changes in the infrastructure of the theoretical framework of archeology in Iran. Consequently, they promoted ‘new archeology attitude’ with new orientation towards more scientific, methodical and anthological approaches.

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[297] During Reza Shah Period, “the Iranian policy of seeking close relations with a third Western power to offset the influence of the Russians and the British. For a number of reasons, economic and cultural, that power turned out to be Nazi Germany.” [...] “After Hitler invaded the Soviet Union in 1941, the USSR joined Britain in claiming that the rise of German influence in Iran was intolerable; this was mostly a pretext for aggression since the Allies needed control of Iran to facilitate their defense against the German advance and to secure the unimpeded movement of lend-lease equipment from the Persian Gulf to the Soviet Union. In August 1941, the Soviets invaded Iran from the north, and the British attacked by sea in the Persian Gulf. Iranian resistance collapsed after three days; a few weeks later, Rezâ Shah abdicated in the hope of preserving the throne for his son Mohammad-Rezâ Pahlavi. Since the Allies could not find anyone else, they could agree on as a successor, they accepted this arrangement. Rezâ Shah died in exile in 1944.’’ (Daniel & Mahdi, 2006).

[298] In the previous section, it was argued that the policies of Reza Shah’s government were to modernize Iran through a mélange of ethnic nationalism, therefore, the reforms that were carried out, aimed to achieve these objectives. However, this modernization during Mohammad Reza Shah Period by increasing of the country's oil revenues, along with nationalization was inclined towards westernization and industrialization.

[299] During this period, the University of Tehran developed a comprehensive program in archaeology for training Iranian archaeologists to serve in the archaeological services of Iran.

[300] In general terms, during the First Pahlavi Regime (1925-1941 AD), the activities related to Iranian cultural heritage were mostly dominated by French, England, German and Americans, but after, by the onset of Second Pahlavi Regime (1941-1979 AD), these influences were mostly skewed towards just American.

From 1950 onwards, by the emergence of a political stability in Iran and in the world, Iranian archaeologists and foreign expeditions from countries such as American, France, German, Italian and Japanese, Austrian, Belgian, British, Canadian and Danish executed numerous excavations in different archaeological sites of Iran, both in the form of a joint team or individually.[301] Besides them, major archeological institutions in the world, with the establishment of offices in Iran have had a major contribution in the development of archaeological activities in Iran. Among important institutes, we can refer to German Archaeological Institute of Persian Studies, France Institute of Persian Studies, British Institute of Persian Studies, Asian Institute of Iranian Studies, American Institute of Iranian Studies and the Istituto Italiano per il Medio ed Estremo Oriente (IsMEO), whose partnership following the Islamic Revolution of Iran (1979) had been terminated. It is worth mentioning that during this period in the route of Iranian cultural heritage development, several museums were established throughout the country such as Abadan Museum (1948), Chehelsotun Museum in Isfahan (1958), Susa Museum (1963), Naderi Garden Museum in Mashhad (1963); Ghazvin Museum (1965); and Rasht Museum (1970).

Among the first actions taken during Mohammad Reza Shah, we can refer to some changes brought in the "*Law of Antiquity*" in 1944. According to the Art.1 of the *Law of Antiquities* approved in 1930, "All industrial works related to ethnics that lived in Iran until the end of the Zand period (1750-1794 AD) are called antiquities", but in 1944, the cultural heritage dating back to Qajar period (1785-1925 AD) was also considered as antiquities. Then in 1950, a special department entitled "Fine Arts" was set up within the "*Ministry of National Education*" (1936), so in its new name the ministry was called the "*Ministry of National Education and Fine Arts*". After that, the next important mobility happened in 1958, when the local branches of archaeological department were obligated to take all necessary measures for registration, conservation and restoration of cultural heritage in their jurisdiction. In 1964, the *Ministry of National Education and Fine Arts* encountered with another change, as Djamchid (1973) pointed out, "in view of the intensification of cultural activities and the development of educational affairs, this ministry was divided into the "*Ministry of Education*" and the "*Ministry of Culture and Arts*"."[302] Actually, the *Ministry of Culture and Arts* intended to encourage

[301] At that time, all excavations were subject to authorization by the Ministry of Culture and Arts. Official permission has been given for the following excavations: (a) those carried out by foreign missions or joint groups of Iranians and foreigners; (b) those carried out by teams of the General Administration of Archaeology and the University of Teheran; (c) those carried out by private groups with special authorization from the Ministry of Culture and Arts. All excavations are carried out under the supervision of the General Administration of Archaeology. Where foreign missions or private teams are concerned, finds are shared in accordance with specific regulations. Authorization is granted to private teams because Iran offers such immense possibilities. Moreover, such authorization prevents fraudulent activities and results to date have been excellent (Djamchid, 1973).

[302] Djamchid, B. (1973). Cultural policy in Iran. Paris: Published by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Retrieved from unesdoc.unesco.org/images/0000/000027/002769eo.pdf

international excavations in the future and to invite mixed groups of archaeologists from various countries to come and work in specific regions. For the execution of the above projects, the "*National Institute of Archaeology and History of Art*" was attached to the *Ministry of Culture and Arts* was set up (Djamchid, 1973). Apart from the administrative and financial services, the most important sections of this ministry were organized in the form of general administration sections as follow (Ibid):

▪ General administration for archaeology and popular traditions.
▪ General administration of museum and historic monuments.
▪ General administration of libraries.
▪ General administration of cinematographic affairs.
▪ General administration of artistic education.
▪ General administration for artistic creation.
▪ General administration of artistic activities.
▪ General administration for audio-visual activities.
▪ General administration for cultural relations.

Then in 1st July 1965, an important action was carried out about collaboration with the *Ministry of Culture and Art*, regarding the conservation of the city's ancient buildings and monuments, public buildings, mosques, etc. According to Article 102 of Municipal Law (Annexed Article):

"In case historical monuments are discovered during the planning stage and implementation of the program concerned with developing the streets and providing for other urban needs, mentioned in the Article 96 annexed herewith, the municipality is obliged to meet the approval of the Ministry of Culture and Art in advance. Furthermore, municipalities are obliged to observe plans and considerations of the Ministry of Culture and Art regarding the conservation of ancient monuments, extent of the protected areas, and the appearance of buildings and neighboring squares." (Cited in UNESCO/CLT/NATLAWS).

In 1967, under a special law the "*Higher Council for Arts and Culture*" was established. The members of this council included; 1) the Minister of Culture and Arts, 2) the Minister of National Education, 3) the Minister of Information, 4) the Minister of Science and Higher Education and sixteen sociologists, 5) economists, 6) psychologists, and 7) artists.[303] About the inter-sectoral functions of the HCAC, Djamchid (1973) expressed that, "The council's main function is to supervise the implementation of the cultural policy and to co-ordinate the activities of the different organizations responsible for carrying that policy into effect. It has a secretariat directed by one of its members who acts as secretary-general. The secretariat has research, co-ordination and publications services and a documentation centre. It also maintains permanent relations with public and private bodies throughout the country. By organizing

[303] All members were appointed for four years by royal decree.

meetings and seminars, the secretariat maintains permanent personal relations with a large number of artists and writers and keeps the council informed of their ideas and opinions.[304] The secretariat also conducts studies on problem relating to the cultural heritage of Iran and the dissemination of culture. The documentation centre keeps in touch with cultural activities in other countries.[305] The secretariat is in close contact with the planning organization which is responsible for preparing the five-year plan, and collaborates in drawing up the cultural part of that plan."

In 2 July 1968, the principle 127 of General Penal Code in article 14 for the acquisition of the grounds, buildings and structures for preservation of the historic and archaeologically important monuments and their surrounding boundaries was approved. Upon this principle, any damage, destruction, misuse, illegal excavation, selling and illicit export of Iranian national heritage would be included for prosecution. As mentioned in Article 1 of this law:

"Anyone with intent to insist or gain benefit, entirely or partially damage to buildings and facilities or decorative objects and accessories and other objects belongs to historical buildings registered in the Law of Antiquity (1930), according to their violation are sentenced to imprisonment from 2 to 10 years." (Cited in UNESCO/CLT/NATLAWS in Persian).[306]

Almost two years later in 31 January 1970, the law of buying lands, buildings, and facilities for preservation of the historic and archeologically important monuments was passed. According to Article 1 of this law (principle 27 of Iranian constitution):

"Whenever to preserve archeological and historical monuments, and their repair and restoration, as well as better visage of referred relics, and archeological excavation and research, there is need to buy lands, buildings, and facilities belonged to individuals and private institutions, The Minister of Culture and Art will act in accordance with the articles of this law." (Cited in UNESCO/CLT/NATLAWS in Persian).[307]

In October 23, 1973, the new law of 'National Heritage Registration Act' under a single Article was passed. Based on this law:

"The Ministry of Culture and Art is hereby authorized to register – in addition to the properties subject to National Heritage Protection Act dated Nov 3, 1930 – the immovable properties

[304] In 1970 and in 1974 two international Architecture Congresses were held respectively in Esfahan and Shiraz.
[305] In this period, all cultural activities came under the control of two main councils: the "*Imperial Cultural Council*" related to the Foreign Affairs; and the "*Higher Council for Arts and Culture*" related to affairs within the country.
[306] Translated by Author.
[307] Translated by Author.

which are important from the view point of history or national dignity, regardless of age and origin, among the national properties included in the mentioned Act. These properties shall be registered following the approval of the Supreme Council of Culture and Art. The properties mentioned herein are subject to the rules and regulations concerned with national heritage."(Cited in UNESCO/CLT/NATLAWS).

Then in 1975, the "*Custom Regulations For Exporting And Importing Original Treasures And Cultural And Artistic Relics*" were made conditional upon securing the authorization of the *Ministry of Culture and Higher Education*. In addition to all those national laws adjusted, during years between 1959 to 1975 in international level, there were also some other Conventions, Protocols and Agreements which had been ratified and no-ratified by the state party of Iran as a member of UNESCO world heritage protection (see APPENDIX. VIII and IX).[308]

During Pahlavi period, the excavations in Persepolis contributed on the future of Iranian archaeology and sufficiently enriched the knowledge of the Achaemenid Empire. Through special attention of the Pahlavi government, Persepolis has maintained its unique status in Iran as a national monument par excellence (Zargaran, 2014). By uncovering the historical and archeological values of this extraordinary complex and its relation with the glorious past of Iranian, Pahlavi rulers tried, by extensive propaganda in this subject, to affirm their existence in national and international levels, and the inherent dynastic nationalism with its emphasis on the institution of dynastic continuity. However, a high degree of attention was given to preserve the physical vestige of this forgotten Persian dynasty, as ultimate symbols of Iran's monarchy and civilization, which was crystallized in the monumental complex of Persepolis, which from its foundation has always been considered as the symbol of Iranian identity. Moreover, the excavations that started in Qajar dynasty by some foreign expeditions had evolved during Pahlavi by activities of some important institutes such as Oriental Institute of Chicago (1931-1939 AD) and the Scientific Bureau of Persepolis (1939-1961 AD) and the activities of ISMEO (1964-1978 AD). Although each of these institutes with their activities have had remarkably positive contribution on development of archeological studies and technical achievements in Iran, among them, ISMEO in the form of Italian-Iranian collaboration had more role in offering a precious opportunity for training in excavation techniques, modern culture of conservation and restoration, and interpretive researches.[309]

[308] At international level during the years between 1979 until 2016, as a result of activities that have been done by the state party of Iran it could be successful to nominate 21 cultural and national sites in WHL and 49 others on the Tentative List.

[309] In 1964, the Society for the conservation of Iranian National Monuments (SCINM) launched several extensive projects with the collaboration of Italian team from (ISMEO) for conservation of monuments and critical historical studies connected with the restorations themselves. Among 15 years activities of ISMEO in Iran, we can be refer to their works in Persepolis, Pasargad, Ali Qapu, Chehel Sutun, Hasht Behesh and so on.

In the late of Mohammad Reza Shah's monarchy, the attention towards cultural heritage was tainted with political, propagandistic and commercial abuses. To the extent that on the initiative of the *Ministry of Arts and Culture*, every year, the days between the Reza Shah's anniversary (October 26th) and that of his son (October 31st) were called as the "*Week of Arts and Culture*", and its Offices throughout the country held festivities (Hodjat, 1995). In 1971, to build a bridge between East and West, Mohammad Reza Shah Pahlavi decided to celebrate "The 2,500th Anniversary of the Original *Persian Empire Founded* by *Cyrus the Great* in the 6th Century BC" and named that year as the "Year of Cyrus the Great".[310] During the "*2,500-years of Iranian monarchy celebrations*" which was held yearly in Persepolis by high overspending, seniors and well-known musical groups from different countries were invited. However, by these extremist approaches, there was a rift between the government and the people, so it proved to be the beginning of an anti-Pahlavi revolution and resulted in the overthrow of the Pahlavi's regime.[311] Then by Islamic revolution of Iran (1979) and by aversion created towards Iranian imperial government, Iranian national monuments were to be targeted to much wrath by revolutionaries who wanted to annihilate and eliminate them as symbols of monarchial and aristocratic system.

Figure 4.16- The 2500-year celebration of the Persian Empire in Persepolis (Source: archive of ICHHTO, 1971).

[310] As Hodjat (1995) pointed, "On the international scene, Iran, while unable to produce even a needle, could however boast on two accounts: its oil wealth and its glorious past. The conjunction of these two factors is displayed during the festivities held in 1971 in commemoration of 2,500 years of Iranian monarchy."

[311] For more information, you can see the article wrote by Cyrus Kadivar (2002) about "What Led The Downfall of Mohammed Reza Shah's Kingdom of Iran. [Online] Available at: https://zoroastrians.net/2009/03/28/2500-years-of-iranian-monarchy-celebrations-in-persepolis-1971/.

4.1.3 Islamization and Iran Cultural Heritage Policy after Revolution (From 1979 until Now)

"*Neither East Nor West, just Islamic Republic*"
(Revolutionary's principal slogan of Iran).[312]

As previously reviewed in the last two sections of this chapter, in different periods of Iranian history, powerful European countries such as Russia, Britain, France, Germany and America have had interferences in affairs related to the country's cultural heritage, but by the occurrence of Islamic revolution, these interferences have been completely interrupted. In fact, this event as the main page of Iran's contemporary history can be considered as the outcrop of factors that had aroused public disapproval of the government policies in the Pahlavi era. Hodjat (1995) well expressed about desires of Iranian people about Islamic revolution, "If, in the course of years, all the country's aspects were shaped by foreigners and their local agents, naturally enough, we would expect the Revolution to end foreign interference in its affairs. If, through the intermediary of local rulers, the country's interests and resources were swindled into foreigners' pockets, the Revolution came after the abolition of this unbalanced "equation". If only a particular group benefitted from the country's wealth, leaving the destitute classes of the society to live in the worst conditions, the Revolution was intent upon reasserting the rights of the deprived." […] "If, through foreign interference and a parliament of yes-men, the people were denied their say as to their fate, the Revolution desired to have this right returned to them. If the people's Islamic beliefs had become a toy in the hands of individuals who perceived the eradication of Islam as the key to their survival and aspired to reaching the American "Great Civilization", the Revolution aimed at reviving the Islamic values existing within the society." […] "If all the country's cultural matters served the dissemination of Western culture, the Revolution wanted to open a new chapter in which the country reverted to values of its own."

In this sub-chapter, like previous sections, all events that have had major effects in the fate, continuation, annulment or reform of the policies that had been left behind from the past or the adoption of new cultural heritage policies in Iran are to be followed. Therefore, it tries to visualize a general picture from current affairs related to the Iranian cultural heritage policies and the reasons for their formation.

[312] By the Referendum of March 1979, Islamic Republic was appointed as the official Government in Iran. The means of this slogan is that, it rejects the congruity of western and eastern models of life and faith with the management of a Muslim society as far as it strongly insists to return to Islamic identity. In this way the best approach to create Islamic atmosphere in the country was to emphasize on the preservation of post-Islamic cultural heritage, whether tangible or intangible, and ignorance of pre-Islamic cultural heritage. As primary examples of this approach can be seen in the termination of "2500th anniversary of the Iranian Empire" and turning the Iranian calendar back to Hijrah origin.

The formation of Islamic country has deeply rooted in the Iranian post-Islamic history, which according to Islamic Shi'ite creeds, for setting up a governmental system it must belong to the Prophet Mohammad "peace be upon him" and his appointed Imam or their successors. In the absence of these individuals, in a particular condition, this mission will be transferred to one of the popular '*Maraje` Taqlid'* (Shi'ite leader), who will have the duty for governing the country with Islamic values and criteria. In this regard, the "*Iranian Revolutionary Council*" for running along revolutionary values decided to merge the "*Ministry of Culture and Art*" with the "*Ministry of Sciences and Higher Education*", the new formed ministry was to be called as the "*Ministry of Culture and Higher Education*". However, following the victory of the Islamic revolution, the attention towards pre-Islamic monuments cultural heritage was not remarkable because of three reasons. Firstly, the employment of their values could not be easily achieved. Secondly, the inappropriate images which existed in the society about the benefiting of pre-Islamic monuments from the attention of previous government. Thirdly, wrong attitude that existed among revolutionaries much about knowing pre-Islamic monuments as a symbol of monarchial and aristocratic system.[313]

During the year before the revolution, most foreigners who had been involving with excavation, conservation and restoration activities in Iranian historical monuments and sites had left the country, and by their departure, the activities concerning these sites were mostly halted. Thus, after revolution until the outbreak of Iran and Iraq War (22 September of 1980), the Iranian experts graduated from Tehran University took over the affairs and continued their control over Iranian cultural heritage properties. In this period, the conservation, restoration of monuments and emergency works were carried out likewise. It is interesting to note that, after the revolution, experts from cultural heritage departments attempted to show that they were capable of running all such affairs and prove that they had no need to the presence and supervision of foreigners (Hodjat, 1995). After beginning of war between Iran and Iraq,[314] Iranian cultural heritage was endangered because of the consequences of this protracted war,[315] and due to prominent social and financial problems, no special work had been executed in this filed. However, here within a few months after the victory of the revolution, three noteworthy measures concerning the country's cultural heritage were put on the agenda:[316]

[313] A blatant example of this reason can be found exactly two days after the victory of the revolution in efforts of a group of extremists for destroying of the Persepolis, as symbol of Iranian Monopoly.
[314] This war took place only 7 months after the victory of the Revolution and lasted almost 8 years.
[315] The war between Iran and Iraq had finished in 30 October 1988. Numerous sites were damaged as they were situated within the peripheries of hostilities during the course of the War. The direct pressure of this war was upon four provinces of Iran, which contain of valuable cultural heritage. As examples of historic sites damaged during Iran and Iraq war we can mentioned to Qasr Shirin, Susa, Haft Teppeh, Chuga Zanbil, Ivan Karkhe, and many other.
[316] The documents are taken from UNESCO/CLT/NATLAWS. Retrieved from http://www.unesco.org/culture/natlaws/index.php

i) The first was related to the approval of the "*Principle 83 of the Islamic Republic of Iran Constitution (1979*)", based on which:

"The ownership of the precious buildings, monuments and properties belonging to the State and being considered as national treasures, may not be transferred to any person, unless otherwise approved by National Consultative Assembly, provided they are not among unique national treasures."

ii) The second was issuing an act entitled, "*The bill concerning the palaces of Niavaran and Sa'd-abad, and evaluating and maintaining the pertinent properties thereof; dated Apr 12, 1980*", into two Articles:

Article 1- All palaces of Niavaran and Sa'd-abad together with their sites and installations shall be devoted to the Ministry of Culture and High Education in order to create museum and park.

Article 2- A commission composed of the representatives of the Prime Ministerial, Ministry of Culture and High education, Ministry of Economy and Finance Affairs, Bank Markazi Iran (Central bank of Iran), Bank Melli Iran, National Attorney-General, and Mustazafan Foundation shall examine and evaluate the properties of the mentioned palaces…

iii) The third belonged to the ratification of the "*Legal bill on preventing clandestine diggings and illegal excavations intended to obtain antiquities and historical relics which are, according to international regulations, 100 years in age or more*"; dated May 17, 1980, into a single Article:

Considering the importance of conserving Islamic and cultural heritage from the view-point of sociology, and scientific, cultural, and historical research, and considering the necessity of preventing plunder and export of these valuable reserves, which according to national and international rules and regulations are prohibited, the following Single Article is hereby approved:[317]

1- *Any digging or excavation intended to obtain antiquities and historical relics is absolutely forbidden. The violator shall be sentenced to correctional confinement of 6 months to 3 years. The discovered objects and the digging equipments shall be confiscated in the interest of Public Treasury.*
2- *In case the objects - mentioned in this Article – are found by chance, the finder shall be obliged to deliver them to the nearest department of Culture and High Education as soon as possible.*

[317] Here just introductory section of this law within four parts is presented.

3- *According to International laws, antiquities are objects made or produced at an earlier period at least 100 years ago. For objects with less than 100 years in age, the discoverer may own them after paying the one-fifth of their evaluated price (as ordained by Islamic law- Khom) to the National Treasury.*
4- *Any person who, in violation of provisions of this law, trade in such discovered objects shall be liable to the penalty provided for in subparagraph A above.*

In 21 March 1982, the "*Ministerial Cabinet of Iran*" decided to do some organizational changes in the scope of the duties of the *Ministry of Culture and Art*, so far by which, the *Ministry of Culture and Art* was disbanded, and two new the "*Ministries of Culture and Higher Education*" and the "*Ministry of Islamic Guidance*" were established. In this case, such institutions as universities, scientific and cultural research centers, academies and the like were to be transferred to the *Ministry of Culture and Higher Education*, and such organizations as the cinema, the theatre, the press, etc. to the *Ministry of Islamic Guidance*. Some other units like the Archaeological Centre, the Ethnological Centre, the General Office for the Historic Monuments, the Council for the Preservation of Historic Artifacts, etc., whose scientific and research-oriented types of activities were proven also constituted as a part of the *Ministry of Culture and Higher Education*. However, the outcomes of the integration of the *Ministry of Culture and Art* and the *Ministry of Sciences and Higher Education* as the *Ministries of Culture and Higher Education*, the multitude of monuments scattered throughout the country and financial restrictions, restricted foreign policies and the abandonment of sites where foreigners had been active, popular dislike of the department of cultural heritage organization, the ever increasing demands of the revolution, the loss of civilians and the destruction of heritage sites that resulted from the impacts of the Iran-Iraq's War, and finally the prevailing legal vacuum and the inconsistency of instructions are to be considered as the main reasons for mismanagement in the scope of Iranian cultural heritage policy. Despite weaknesses that existed, eventually in 30 January 1986, by legislation from the Iranian Parliament, the *Ministry of Culture and High Education* was thereby authorized to establish the "*Iranian Cultural Heritage Organization*" (ICHO), as its affiliate, by integrating the 11 governmental units.[318]

[318] The governmental units which ICHO would be established by their integration are as follow:
- The Iranian Archaeological Centre
- The General Office for Traditional Arts
- The Centre for Ethnology (social and cultural anthropology)
- The Office for Historical Monuments
- Iran Bastan Museum
- The Office for Conservation of Cultural Heritage
- The General Office for Museums
- The General Office for Historical Buildings
- The General Office for Palaces
- Iranian National Organization for Conservation of Historical Relics
- The General Office for Court Palaces (Golestan Palace)

The aim of the establishment of ICHO were to be (Cited in UNESCO/CLT/NATLAWS):[319]

A. *Study and research on relics remained from the past for the purpose of presentation the concealed values thereof,*
B. *Research on the subjects regarding archeology, anthropology and traditional arts,*
C. *Survey, explore, register, and conserve national heritage which are of cultural and historical value, both movable and immovable properties,*
D. *Design and carry out plans for repairing and revitalizing the monuments, buildings and complexes of cultural and historical importance.*

Then after, in 19 July 1988, the Law on the "*Statute of Iranian Cultural Heritage Organization*", as the main cultural heritage orientation today, which includes the headlines of the legislation made in this domain, was also ratified, fulfilling its legal establishment (APPENDIX. X). According to Article 1 of this statute, cultural heritage was defined as follow:

Article 1) Definition: Cultural heritage consists of the resources remaining from the past that evidence the passage of man through history; recognizing these resources, makes it possible to learn about the identity and the line of man's cultural evolution, and in this way to create a context for receiving lessons.

In fact, the year of the establishment of ICHO can be named as the year of maturity in affair related to Iranian cultural heritage policy when according to Abdi (2001), "The ICHO began to launch its activities following the ratification of the institute's constitution in 1988". Up to this point, creating an independent organization for cultural heritage affairs simplified the implantation of the organization and made the creation and implementation of relevant laws easier. By respecting the needs of Iranian cultural heritage after the establishment of ICHO, some other important laws such as "*Statute of the Cultural Heritage Center for High Education*" (1990),[320] and the "*law on punishment of saboteurs on the country's economic system*" (1991) were passed. In addition to foregoing laws, in 27 February 1992 a Single Article entitled "*Law on Exemption of Monuments and Places, Registered among the National Heritage of Iran, from Municipal Charges*" has been passed by the "*Iranian Islamic Consultative Assembly*", and then the "*Iranian Council of the Guardians*" confirmed it, the Article is proposed in following:

"All the historical monuments, places and sites which are in possession or ownership of Iranian Cultural Heritage Organization, as well as monuments and places in natural or legal persons' possession or ownership, registered or to be registered in the List for National Heritage of Iran

[319] The ICHO was firstly affiliated to the Ministry of Culture and Higher Education and later in 1993 it was placed under the supervision of the Ministry of Culture and Islamic Guidance.
[320] The aim of this law with the coordination of relevant organizations was designing and implementing educational programs to train personnel efficient for the activities concerning cultural heritage.

according to the pertinent Laws, and also the museum affiliated to the above-mentioned Organization – shall be exempted from all the municipal charges." (Cited in UNESCO/CLT/NATLAWS).

In 1994, during the deputy of Mr. Serageldin Kazeruni (1993-1997 AD) and owning to the consolidation of the basis of ICHO in the Central Government, further developments were exerted to enhance the efficiency of this organization. This included the establishment of ICHO offices in all Provinces and parts of their subfolders. According to the law of "*The Statute of Iranian Cultural Heritage Associations*", throughout the country the measures for establishment of ICHO's association were put into agenda, as follow (Cited in UNESCO/CLT/NATLAWS):[321]

▪ *The association in provinces capital cities,*
▪ *The association in cities and towns,*
▪ *The associations in districts,*
▪ *The associations in rural districts,*
▪ *The associations in villages,*
▪ *The associations for museum or historical monuments.*

In fact, the aim for the establishment of associations in various levels of the country was to attract tangible and intangible support and all-out collaboration of the community concerning research, conservation, revitalization, presentation and education in the fields related to the national cultural heritage (ICHO law, 1994). According to Article 3 of this Law, the duties and authorities of these associations were summarized into ten sections:

1. *1-Acquaintance with the rules and regulations provided for research, conservation and revitalization, presentation and training of the national cultural heritage, and paving the ground for the community to be acquainted with them as well;*
2. *2-Discussing and examining cultural and social issues, and providing consultative opinion for ideal implementation of program on research, conservation and revitalization, presentation and education concerning the cultural heritage of the pertinent area of authority, with respect to the local requirements and facilities and submitting the prepared proposals in this regard to the Organization.*
3. *3-Endeavoring to identify and introduce the unknown aspects of the local cultural heritage;*
4. *4-Encouraging and promoting the community to respect and protect the cultural heritage;*
5. *5-Deliberating on, and finding practical ways to prevent any illegal actions such as clandestine excavations, destruction of historical monuments, trade in the cultural properties, and submitting the prepared proposals in this regard to the Organization;*

[321] In Article. 5 of ICHO law (1994), the members of each cultural heritage association in province center, city, town, district, rural districts and village are exactly defined.

6. *6-Examining the ways for summoning tangible and intangible support of the community, and submitting the prepared proposals in this regard to the Organization;*
7. *7-Cooperating with expert commissions and inspectors delegated by the Organization;*
8. *8-Cooperating with local institutions and organs, and summoning their full-scale support for realizing the aim of the association;*
9. *9-Submitting proposal for expenditure item out of financial revenues of the association to the Organization and expending them according to the regulations, which shall be enforceable after being approved by each association and confirmed by the Iranian Cultural Heritage Organization;*
10. *10- Carrying out the other duties, referred by the Organization within the scope of the pertinent regulations.*

Since the establishment of the ICHO (1968) until 1996, the *Iranian Cultural Heritage Organization* (ICHO) has always been called as an organization, but in 1996 based on new "*Statute of the Iranian Cultural Heritage Organization*", some changes happened in the structure of this organization. Thus, according to Article 1 of the present law; "For improving the enforcement quality of the Law on the Statute of the Iranian Cultural Heritage Organization, approved by the Islamic Consultative Assembly, studying and researching on remains from the past for the purpose of introducing the underlying values, and also developing the researches on national cultural heritage, supporting the relevant scientific and research achievements by enjoying potential and actual facilities, efficient man-power, equipments and laboratories, libraries and other available research means in the best possible way, the Iranian Cultural Heritage Organization (hereafter called Research Center), affiliated with the Ministry of Culture and Islamic Guidance, shall be altered on the basis of the substantive Agreement No. 34/6323/28843-Mar 12, 1991 by Higher Education Development Council and shall be administered according to the present Statute". Thus, the ICHO was transformed into a research institute. In general term, the aim of this change was conducting research with the purpose of conservation and revitalization of the national cultural heritage, and dissolving the relevant questions, problem and straits and other aim included in the Law on Establishing the Iranian Cultural Heritage Organization, and the Law on the Statute of Iranian Cultural Heritage Organization, approved by the Islamic Consultative Assembly (ICHO law, 1996). However, as ICHO matured, new conservation labs were established; museum were renovated and opened to public; and the most significant archaeological sites in the country received independent research institutes (Lawler, 2003). Meanwhile, in the same year (23 May 1996) in the 5th book of "*Islamic Punishment Law*" [precautionary and preventive punishments], some strict laws for violation of cultural heritage properties have been considered, Articles (558) to (569).

In 13 January 2004, based on a law in 12 Articles, the organizations of the *Iranian Cultural Heritage Organization* (ICHO), and the *Tourism Organization* were separated from the *Ministry of Islamic Guidance*. However, by the integration of these two mentioned organizations, the "*Iranian Cultural Heritage and Tourism Organization*" (ICHTO) as a unique organization with its previous authorities, duties, and all of its facilities, possessions and man-powers, under the supervision of Iranian President was established.[322] In 1 September 2004, attention for conservation and restoration of cultural heritage reached its highest level, so in Articles of (114) and (115) of the "*Fourth Economic, Social and Cultural Development Plan of the Islamic Republic of Iran*", policies for regulating management, supervision, protection, conservation and restoration of country's monuments and sites were approved. Eventually, in 130th meeting of the "*Supreme Administrative Council*" on 5 April 2006, in order to strengthen and promote the country's handicraft and also harmonizing the policies related to the development of tourism industry in Iran, the *Handicraft Organization* of Iran with its previous authorities and duties, as well as all of its facilities, possessions and man-powers was separated from the Ministry of Industries and Mines and was integrated with the Iranian Cultural Heritage and Tourism Organization. Because of the integration of these two organizations, the new organization of "*Iranian Cultural Heritage, Handicraft and Tourism Organization*" (ICHHTO) was formed, which today by this name is working out.

In the early years of the evolution of ICHO, the head of this organization was recognized as the main authority responsible for revitalization and sectoral intervention in some important historic sites and monuments in Iran. In this period, the organization was usually more interested in the conservation and restoration of single historical monuments and sites rather than major large-scale physical regeneration. In this case, the limited legislative authority and funding imposed on the organization exerted more restrictions on new buildings or any urban development around specific historical sites, so this made the old fabric of the cities even more deserted. The recent merging of ICHO, respectively with Tourism, and Handicraft organizations, in the form of one of the presidency deputies, and its renaming to the *Iranian Cultural Heritage, Handicraft, and Tourism Organization* (ICHHTO) opened a new window in the responsibility of the ICHO. In fact, this newly established organization by using the potentials of these three aforementioned organizations has aimed to use their potentials for development of whole affairs related to Iranian cultural heritage policy. Nowadays due to the significant role of cultural heritage properties in tourist attraction and economical development of the countries, Iranian authorities have paid a special attention for better efficiency of ICHHTO organization. Therefore, by the immensity of the architectural and cultural significance in Iran, the ICHHTO as one of the main pillars of the country's art and culture has a major role in promoting the cultural, historical, natural and architectural potentials of the country throughout the world, as well as introducing Iranian rich civilization, and utilizing its advantages and potentials to endorse its position as one of the major poles of global tourism. However, this issue has being significantly important in this era when cultural values have become as one of the most important sources of national income. Nevertheless, the conservation, restoration and preservation of country's national heritage, which included as a

[322] The deputy of the ICHTO was appointed by presidential decree.

part of the ICHHTO responsibility, have major positive roles in creating jobs, increasing foreign currency income and improving the level of payment in the country.

From a general view, although this organizational integration weakened the ICHO's focus from the only revitalization and conservation of historical monuments and sites to tourism and handicraft, it gives the organization more power in term of governmental budgets, the scope of activities and bureaucracy. In term of administrative hierarchy after the revolution, by changes that happened in this area, unlike the Pahlavi era, the power centers from vertical power structure converted to plural and parallel power centers so that before revolution all cultural heritage activities were under the decision of the headquarter in the Iranian capital, but after revolution by the establishment of local associations, these duties have been entrusted to local and provincial associations, and headquarters in the Iranian capital have supervision on their activities.

- The Current Problems of Cultural Heritage Management in Iran

In recent years, ICHHTO for being more sufficient, and for allocating the responsibilities at different levels, at both national and local levels, has made fundamental changes in its infrastructure, so it established many dependent sub-organizations (APPENDIX. XI). Although this has had many positive aspects, but due to the existence of some dominant legal vacuum, eventually it has led to some discord and strife in different echelons of this organization, so sometimes this act reduced the effectiveness of the ICHHTO, and resulted in lack of proper utilization of resources and the interference of the scope of duties of ICHHTO's sub-organization. Consequently, their delay for making decision about the future of a historic monument and site usually opens space for expansionist demands of municipals and private owners to do whatever they want upon valuable assets of the country. In this case, how often the destruction of Iranian cultural heritage properties are to be heard, as an example of this ignorance could be seen in the destruction of Tadaion House in Najaf Abad of Isfahan city, where although ICHHTO being aware that the original owner of the house is selling his house but didn't do anything to purchase it. As a result, the new owner destroyed the house for execution of a new construction project.

Figure 4.17- The Tadaion House before and after its destruction (Photo by Hosseini 2012 and 2016. Source: Mehr News).

The necessity of recognition, protection and maintenance of historical monuments and sites as a researchable documents entered different groups of studies to this realm. This entry is specifically for identifying (study of understanding about different dimensions of historical monuments and sites), planning (urban development program), designing (protective design in accordance with historical features of monuments) and maintaining (protecting antiquities for future generation and preserving them from damages). The field of conservation and restoration of historical monuments and sites in Iran is divided into two parts: theoretical activities (theory, training, promoting and designing), and executive activities (acquisitions, restoration and usage). In the administrative field, the cultural heritage activities are affiliated among three groups.

1. Public sector executives (ministries, etc.): in the field of historic monuments, sites, texture, etc. Golestan Palace is an example of these buildings.
2. Governmental sector executives (municipalities, institutions, etc.): in the field of historic monuments, sites, etc.
3. Private sector executives (property owners and private investment groups, etc.): especially in the field of single historic building.

Of course, there are some public, governmental and specially private sectors, which by abuse of legal vacuum, consciously destroy historical monuments and sites or sell them to dealers and urban construction groups. In public sectors that are usable by the public, we can refer to such buildings as National Bank of Iran, the house of Dr. Chamran and Shariati, Mosques, Bazaars and so on. In governmental sectors, for conservation and restoration of historical monuments and sites, they are often bought with state organizations, and issues related to the maintenance of their buildings and premises are under the responsibility of the resident organizations. Examples of this governmental approach can be seen in the restoration of building of the Ministry of Foreign Affairs, Post Office in Imam Khomeini Avenue, Oil Company, Dar-al-Fonun School, Darband Palace and many other buildings in historical cities of Iran such as Isfahan, Shiraz, Tabriz, Yazd, etc. In private sector, the property owners or new purchasers to maintain the status quo of historical buildings or to change their usage as Restaurant, Guest House, Shop, etc., they have usually executed some interventions in those valuable types of structures.

Since in Iran the issue of conservation and restoration of historical monuments by the governmental and private sectors do not follow any specific pattern, and even sometimes they damage these monuments with their abnormal approaches, in the following part the aim is to have a review of activities which are implemented by public sector so systematically. Here the conservation and restoration of monuments by the public sector has the following features:

a. Usually these buildings in term of their architectural and historical values, quality of their interior and exterior decorations, circulation, national registration, maintenance and usage are special. It means that this category of Iranian national heritages due to their symbolic representations have a high degree of value in comparison to other categories. Typically, mentioned factors include the factors that usually result in considerable costs in conservation and restoration of these historic buildings. In many of these projects, only structural retrofitting against earthquake or restoration of their particular decorative objects are costly, but the necessaries for their preservation will justify their high cost.

b. The non-technical problem that existed in these projects can cause particular sensitivity that cannot be handled by any manager and technical department of the government. However, there is the necessity of a “Steering Committee” that can make the main decisions for projects which sometimes have political, administrative, financial, technical, artistic aspects, and is able to defend the consequences of approaches it adopts.

c. The special characteristic of this type of buildings have made inevitable the necessities for careful selection of a fully professional group for study, design and execution.

d. The wide extent of such buildings and their usages have made inevitable the necessities for having a regular maintenance program.

e. Here usually the most of new technical preservation methods are firstly analyzed in large public projects and then they are extended to the entire projects. The above practices are practically and legally possible in circumstances that their reversibility are approved. Even ordering new materials and technical tests by the relevant institutions are practically possible only by large governmental sectors, and private sectors have neither the willingness nor the ability to afford the above-mentioned costs.

In Iran, the management of the projects related to cultural heritage preservation is composed of three components: employers, consultants, contractors, and in some cases these components based on requirements of the project correspond themselves to employer, alliance manager, the contractor, and a forth component and E.P.C. group. Issues related to employers, consultants and contractors as a member of this three-component set could be summarized as the following topics:

A. Employers

i. Technical competence is not required for employers, so by using ‘Steering Committee’ or ‘Think Tank’ or any other similar system, they can manage technical affairs related to a project. In the meantime, the problem appears when the employer, without technical competence and without using appropriate consultants, typically based solely on the quarterback that funds the project imposes its personal preferences, which all can cause irreversible losses of funds and interventions.

ii. Unnecessary and over-capacity speed of projects, all of which are mostly due to continuous changes of management, which causes multiple inauguration of projects and substantial duplication of administrative tasks.

iii. In some cases, the instability of managements and changing of the project managers can cause change in project objectives, usage, and inappropriate enforcement actions in the middle of executive operations, which can cause changes in design, execution and damage to some parts of the project. As an example, a project in Tehran was designed firstly by the "administrator of foreign meetings" of a governmental organization, but after changing the head of this organization, the new head disagreeing with the halfway implemented work issued a new order.

iv. Legal restrictions: there are no legal remedies for such projects and current legal structures do not meet all legal requirements. That is why usually contracts including the compilation of provisions and the assignment of tasks are more a matter of personal insights.[323]

v. Employers in some cases because of some legal vacuum, instead of devolving the work to consultants and contractors, have constituted executive offices and groups, a practice which experience has shown will cause lengthening of projects and imposition of additional costs.

vi. One of the problem of the projects is that the employers, even those with good will, begin some interventions without fund and legal permission and make the administrative system to take an action that causes many problem in the execution process of the project.

B. Consulate Engineers

i. Numerous economic problem in current condition of the country have caused much pressure in the burden of the office and personnel costs, which make consulting engineers to participate in tenders even with minimum price. Simultaneous invitation of strong and weak consultants, and winning of those with very low experience, and their negotiation with other consultants to accept the lowest tender price as the base price is the current tendering practice.

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[323] In many big conservation projects, powerful managers are trying to put aside supervising system as a moderator and hinder administrative works, and weak managers are prolonging the projects for eligibility and respecting the rules.

ii. These conditions have encouraged some supervisors at the consultant level to become the executor and editor of employers' demands in compliance with budget and the expedient deemed by the employers.

iii. High speed of projects due instability in management and other factors listed in section A, along with reduced fees have resulted in lack of serious research and unprincipled design, and thus, all these negative factors together reduced the quality of consultants' services.

iv. In many cases, executive plans have been prepared without considering the possibilities and requirements of the time; that is why they were unenforceable or their continuation were dependent on the decision of the contractors. In some cases, some consultants leave the preparation of the phases of executive plans under the responsibility of contractors practically because of the weakness of the employer monitoring groups and for cost efficiency, which result in self-determination of contractors and the reduction of the quality of projects.

v. Low wages for "Consulting Engineers" have made a number of them not have the possibility for using their expertise with sufficient experience, and virtually the projects are studied, planed and designed by lower experienced forces and inexperienced students.

vi. No payment and/or delayed payment of the claim of consultants and contractors, legal vacuum, inconsistency in management, technical and financial matters and regulatory bureaucracy, low efficiency of offices, administrative corruption, etc., are all the attributes of governmental administrators. Therefore, consultants and contractors waste a significant portion of their valuable time to follow up on demands of their jobs done in the previous years.

C. Contractors

i. Bad economic conditions, governmental sanctions, rising of costs and non-technical competition have made a number of contractors to resort to unreasonable low prices in order to win in tenders. In this case, 20% off the project costs is another weird measure taken by "Plan and Budget Organization" (PBO).

ii. Low prices, delays in payments by the employer and inflation all result in the reduction of the quality of interventions, materials applied, and performance of contractors and craftsmen.

iii. Unreasonable speed and economic savings in some cases reduced the quality of interventions. Managers who have recently presided to their management position are not aware how essential it is to plan long-term projects.

iv. The structure of new companies by inexpert forces, poor facilities, low prices, unhealthy job conditions and the culture of maximizing profit are not responsible for the problem in the conservation and restoration of large projects. Only in a continuity of work, training specialized forces, practical experience, etc., there is a possibility of offering bigger projects to the contractors.

v. Lack of continuity of craftsmen: there is a shortage in supplying of trained young people in different fields related to Iranian traditional architecture such stone, brick, plaster, wood working and so on.

4.2 Conservation History, Its Basis and Problems in Bam Citadel before Earthquake

- Restoration in Iranian Culture

The word "Restoration" in Persian language is expressed as "Marammat" [to repair, to mend], an Arabic word, which in singular form is defined as the verb of "preparation and modification of anything still it remains unchanged". From the past in Iran although many intervention works have been implemented in historical buildings, but most of them have not benefited from the basic characteristic of the modern restoration intervention. Therefore, it is difficult to categorize any of those interventions as the ideal one. As has already been said, until the end of Qajar dynasty, there had been scarce citations of the word of restoration, and there were no sufficient documentations for classification and exact identification of the traditionally executed interventions in Iranian past. However, as evidences and documents have had confirmed, it is clear that the principles of those restoration interventions, which can be named as personalized techniques of intervention, just have superficial and provisional aspects, so in this way the deteriorated parts had been replaced to take the buildings away from their unpleasant façade. Therefore, in which any constant, definite and lifetime solution had not been applied during those restoration works.[324]

In Iranian traditional context, there has always been a social awareness versus protecting and preserving the historical edifices not just for improving their physical aspects, but also for guarantying the continuity of the society itself. In fact, although there was a lack of legal supports and officially responsible organizations in Iran, all citizens as a part of their civil duty know themselves responsible for maintaining their living place and memorial urban structures in reasonable conditions. In this way, when needed the interventions of maintenance and/or repair have been implemented. During Pahlavi government, when the nationalist sentiment as a political approach was noticed, the efforts for conservation and restoration of country's cultural heritage got a systematic meaning by establishment of certain specialized institutions and organizations. In this period along the country's modernization and urban development, refereeing to the law of antiquity, old structures related to past periods of Iranian history were considered valuable so their conservation were to be essential.

Characteristically, there is a distinct definition between traditional Iranian context of restoration with its today's derivations in literal and practical levels. The origin of traditional restoration practice in Iran has definitely a root in traditional social awareness of Iranian versus the

[324] In Iran due to climate condition of the country and abundance of clay everywhere, the traditional restoration techniques is commonly related to the techniques applied in adobe structures for resolving their problems. About the weakness of traditional Iranian restoration, the Bam Citadel can be named as a big failed example of this kind of restoration intervention in Iran.

necessity for preserving the historic edifices. In this restoration approach, all interventions, regardless of artistic, historic and intrinsic differentiations have been based on prevailing temporary functionalities to resolve the problem of those monumental buildings. It should also be noted that financial budget has always been a determining factor for necessary repairs of Iranian cultural heritage properties. When the budget is not enough, the principal resolving of problem does not fall into the priority; as a result, the profound study of the nature of the problem will become a secondary subject.

- General Overview on Conservation History of Bam Citadel before Earthquake

The way that we are looking now at ongoing conservation and restoration measures in such historical landmark like Bam Citadel is obviously diverse from the practical repairs, changes and modifications that their residents carried out based on the environmental needs of the region and practical necessities of the time. In this part, to have a precise view of conservation activities that have been done in Bam Citadel. The course of works implemented are divided on two periods of time; before being hunted, and after being hunted in the second decade of the 20^{th} century.

- **Conservation History of Bam Citadel before being Hunted**

In the course of history, the citadel of Bam was occupied whether by traders, merchants and industrialists or it was used as a fort and military base, so all practical conservation efforts were carried out according to the needs and necessities of the time to improve the living conditions, security of the settlement and trade. In this period, usually the causes of the complete and collective practical repairs, in their turn were due to three causes: seasonal conservation, conservation after wars, and new architectural principles introduced in every historical periods. As the first reason, to eliminate deficiencies arising from previous seasons, the adobe-mud buildings in their lifetime need regular care and repair, and any failure in this regard will develop the structural damages. In this case, all measures have been based on simple modification and replacement of disturbed coating surfaces and adobe bricks with new ones. The second reason is related to the reconstructions which were performed after the devastation caused by war. Beyond the usual evolution and development of every human settlement, Bam Citadel faced with many wars. Constantly, these wars always led to the remodeling of the citadel and its settlement, repairing the damaged parts and rebuilding what were ruined. It seem that this remodeling has often happened on unsound existing structures as the former ones were damaged and not necessarily well repaired structurally (Auroville Earth Institute, BAM AND ARG-E-BAM). However, as stated by shad (2015), in analyzing the extracted dates presented by Karimi (2005) about the reconstructions and repairs that happened in Bam Citadel after wars, "According to the historical references the longest period of time for repair was 205 years and the shortest was 6 years. Some written historical texts exist about the history of wars in the Citadel, an average of 67.1 years for repair and restoration out of 672 years of the lifetime of the Citadel, since 1212 up to 1281." Moreover, the third one is due to the existence of remarkable differences between the architectural patterns, conservation and reconstruction principles in different periods of Iranian histories. Based on what is estimated about the history of Bam Citadel and its settlement, Bam Citadel has faced 22 main Iranian dynasty from Achaemenid dynasty (550-330 BC) to Pahlavi dynasty (1925-1979 AD), so each ones had their models of operation.

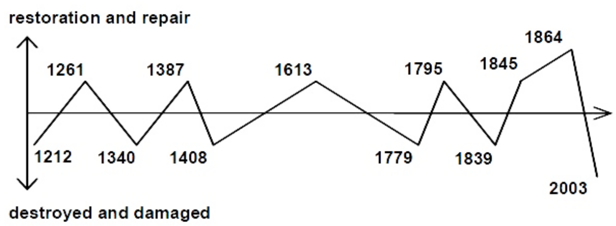

Figure 4.18- Cycling of destruction and repair in Bam Citadel (Source: Shad, 2015).

- **Conservation History of Bam Citadel after being Hunted**

Conservation of Bam Citadel in this period had basically been carried out with distinct outlooks from the previous approaches, according to which the citadel is to be considered as a national monument that must be preserved. So far, many activities have been performed more scientifically to retain its past glory. Since the 19th century, the Citadel of Bam had been gradually uninhabited. In the meantime, the walls and roofs of monuments within the Citadel turned into ruins through a slow process of deterioration. Following the transition of power form Qajar dynasty to Pahlavi dynasty in 1925, the Citadel was used a garrison until 1932 but it seems that no one was living in the old city at the foot of the citadel anymore. Arg-e-Bam and the old city have therefore been totally abandoned since 1932 (Auroville Earth Institute, BAM AND ARG-E-BAM),[325] when the military base moved into the new town of Bam. Therefore, without any repair and even with the little annual rainfall, weathering had already severely deteriorated the earthen buildings before the earthquake. Before the start of the restoration works, Arg-e-Bam was in ruins and the vaulted roofs were extremely damaged (Auroville Earth Institute, BAM AND ARG-E-BAM). The nationally inscribed property of Bam Citadel has been protected since 1945, under Iranian national legislation (Law of Conservation of National Monuments, 3 November 1930), and other instruments of legal control and norm of protection related to architecture and land use control (UNESCO, 2004). In the late 1955 and early of 1956 (winter of 1344 Hejri Shami), the nomination of Bam Citadel was examined by ICHHTO, and in 21/03/1956 under the registration No.519, it was declared as a national heritage by the Iranian authorities, and fell into supervision of the Society of National Preservation of Archaeological Sites. Although in this period, Bam Citadel was inscribed in the National Heritage List, but it did not automatically benefit from a minimum protective measure. At the time of registration

[325] In this period, the damage to the citadel was kept at minimum, and humanly no drastic damage was induced to it, here the barrack, stable and governor's house were the best conserved.

by ICHHTO, the minimum and feasible protective zone is considered on a case by case basis, and decided upon by ICHHTO (State of Conservation of Bam and its Cultural Landscape, 2013). However, the milestone of inscription of Bam Citadel in the national heritage list was fundamental to start the first repairs in 1958 and in 1973, the beginning of a comprehensive restoration of the citadel 'with a different emphasis on conservation measures ranging from preservation to reconstruction' (Mokhtari et al., 2008a). The records concerning Bam Citadel suggest that the first restoration work at the Citadel of Bam was taken in 1948. As Tohidi (2014) pointed, "Hasan Roshan, the owner of a photography shop in Bam after taking a photo from Bam Citadel in 1948 sent it along with a letter to the head of "General Office of Archaeology on behalf of the Ministry of Culture of Kerman". Based on what was mentioned in this letter, it was asked for the possibility of assigning a budget for the restoration of the "Chahar Fasl" of Bam Citadel. By accepting this request, the Head assigned a sum of 5000 Rials budget for this project, and Roshan in collaboration with the Master Builder Reza Tai started to work."[326] After that, the next step of repairs in Bam Citadel was started in 1972, after the visitation of Shahrbanu Farah (the wife of Reza Shah) from the Citadel. During this period, an annual budget was allocated to the citadel, but due to the extent of damage and limitation of the budget only the most urgent conservations and protective repairs were done during a half year. After the Islamic Revolution (1979), Bam Citadel was owned by the state, through the Iranian Cultural Heritage Organization (ICHO). In 1993 following the visit of President Hashemi Rafsanjani from Bam Citadel, a special program under the management of Prof. Tayari was devoted for one of the most significant project of the Iranian Cultural Heritage Organization. Since then, a comprehensive and multilateral program in three sections has been considered for the future conservation of Bam Citadel: [327]

1- Research: Maintaining comprehensive information about Arg's construction and repair during different periods of the history and documenting this information.
2- Protection and Repair: Repair and complete organization of Arg and preparation of it for visits by researchers and other interested people.
3- Organization and introduction: Preparing the complex for scientific and cultural activities and also the necessary facilities for visitors and researchers.

As the Author's personal interview with Prof. Tayari (August 2015), the Head of Bam Citadel's Recovery Project before the 2003 Bam earthquake, about the comprehensive management plan of Bam Citadel and activities implemented, "during this period the purpose of Bam Citadel's comprehensive plan has not been the complete restoration of the complex. But at least enough repairs must be done to show the Arg in different stages of history and construction, this is why

[326] Translated by Author.
[327] This information and other documents related to the conservation history of Bam Citadel, since 1993 to 2003 are given from personal archive of Prof. Tayari, and Author's personal interview with Prof. Tayari in August 2015.

the restoration of main elements of Arg like walls, passageways, squares, some noble houses and urban establishments have been fit into this program. In the meantime, an exceptional work was conducted on several monuments, as far as the results were quite praised." Prof. Tayari also added, "Through all of these efforts the Citadel of Bam had became one of the most popular tourist destinations in the southeast of Iran, attracting more than 100,000 visitors each year." In following section, a summary of the proposed plan related to each of the three-section of Bam Citadel's comprehensive management plan before the 2003 Bam earthquake is explained (Personal archive of Prof. Tayari, 2015):

A- Research

1- Performing a complete documentation and topography of Arg and its surrounding.
2- Performing archeological, architectural, historical and city planning inspection of Arg completed with scientific investigations of important elements of both inside and outside the Arg.
3- Establishing a research centre for mud brick and mud brick architecture.

B- Protection, repair and restoration

1- Organization, strengthening and protection of eroded structures and their surroundings.
2- Preparing executional plans for complex's structural installations (Water electricity, sewage network, accessibility, etc.)
3- Preparing executional plans for repair and if needed restoration of valuable constructional examples like rampart, passages, Bazaar, Squares, The main governmental buildings, public buildings like mosques, Takyieh, Schools, Caravanserai, Baths and some special private houses.
4- Preparing executional plans for organization, repair and protection of the complex's boundaries in connection with city of Bam council plans and the mutual needs of both the city and Bam.
5- Preparing executional plans for organization, repair and protection of different constructions in Arg with high percentage of fatigue, at least to the extent of protecting the existing situation and clarifying the architectural tissue in a recognizable manner.
6- Stone paving of all different passages, based on the existing patterns.[328]

C- Introduction and training

1- Establishing a centre for documents connected to Arg.
2- Prepare audio and visual documents like slides, brochures, post cards, video tapes, posters, etc. for introduction of Arg.
3- Editing and publishing a book about Arg.
4- Establishing a museum in the governmental stable.

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[328] During this period, reconstruction of the main stone pavements was one of the valuable efforts, which has an important role in the finding of the allays and streets after earthquake.

5- Preparation and execution of a plan for the use of sound and light.
6- Establishing temporary and permanent exhibitions, seminars, conferences and festivals suitable for Arg.[329]
7- Preparing and performing publicity program for introduction of different aspects of complex and attracting interested people.
8- Documenting different stages of research, repair and restoration of the complex.
9- Training the necessary manpower for guiding visitation and tourists.
10- Training the skillful man power for repairing molded brick buildings.
11- Collection and publishing of executive tasks preformed in the complex.
12- Preparing suitable spaces of Arg for cultural and instructional activities such as (course for repair of historical buildings, traditional architecture or traditional and crafts, also preparing a suitable place for visitors convenience (teahouse, restaurants) in a suitable scale.

Following the above three main principles of operation, all activities were taken with the available old plans, traditional techniques and materials, sometime some new materials were introduced in the restoration plans. Meanwhile, restoration work in this period also led to the gradual identification and revival of the urban fabric of the old parts of the Citadel. As example of buildings which were restored, revived and reoriented, we can refer to: ‘Tea House’ in the Second Gate, ‘Bam Cultural Heritage Office’ in the Sistani House, ‘Exhibition Hall’ in the Stable, Takyieh, Payambar Mosque and Masjed-e Jāme for ‘Religious Purposes’, ‘Amphitheater and Conference Hall’ in the Ice House, ‘Archaeological and Architectural museum’ in the Mirza Na’eim School, ‘Craft Booths’ in the Bazaar and so on.

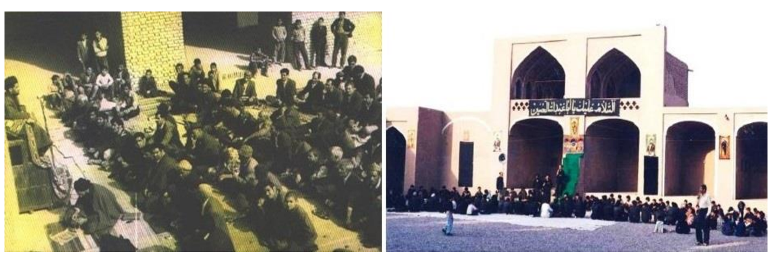

Figure 4.19- Religious ceremony in the Friday Mosque and Tekiyeh of Bam Citadel before the 2003 Bam earthquake (Source: archive of ICHHTO).

[329] It was scheduled that, every three-year two thematic international workshops related to urban design and architecture would be held in Bam Citadel. Before earthquake two conferences were organized. The first congress of architecture and city planning was held in the year 1996, with the participation of more than 800 specialists and 53 lectures. Relating to this congress, 30 round table sessions and eleven expert exhibitions also created a dynamic atmosphere at the complex. The second congress of architecture and city planning in the year 1999 was held with more splendor than the first one because of the participation of more than 1200 specialist researchers (UNESCO 2004).

Figure 4.20- Tea House in the Second Gate of Bam Citadel (Photo by Mark Daffey, before earthquake. Source: archive of Gettyimages).

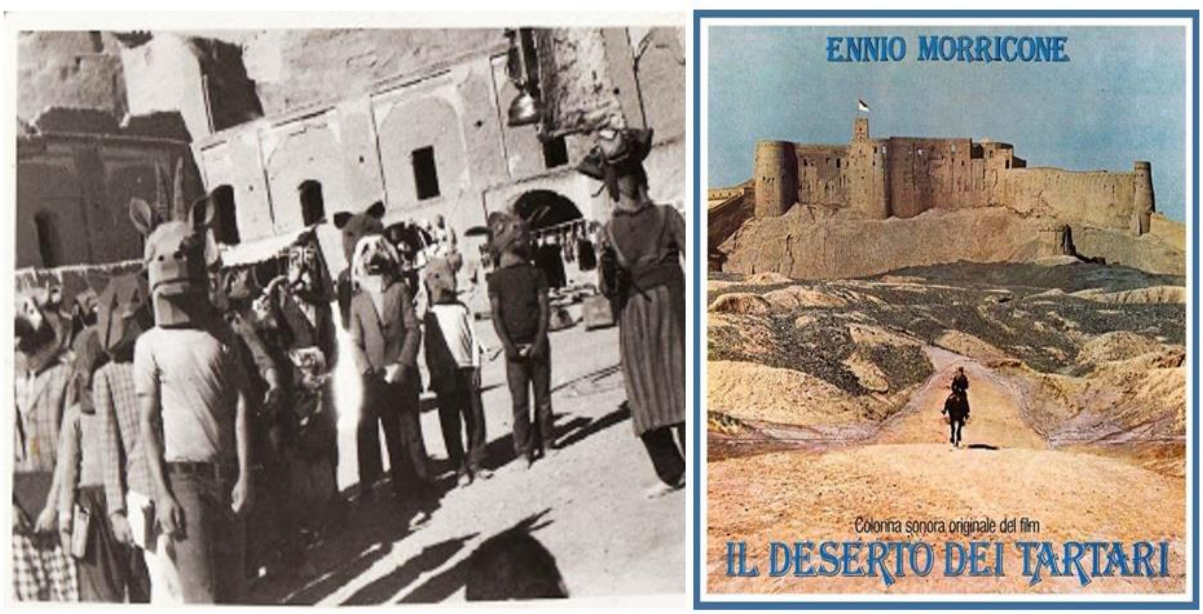

Figure 4.21- (Left) the production of the film of “Shahre Qese” in the Barrack of Bam Citadel (Directed by Manuchehr Anvar, 1969); and (Right) the production the film of “Il Deserto Dei Tratari” in Bam Citadel (Directed by Valerio Zurlini, 1976).

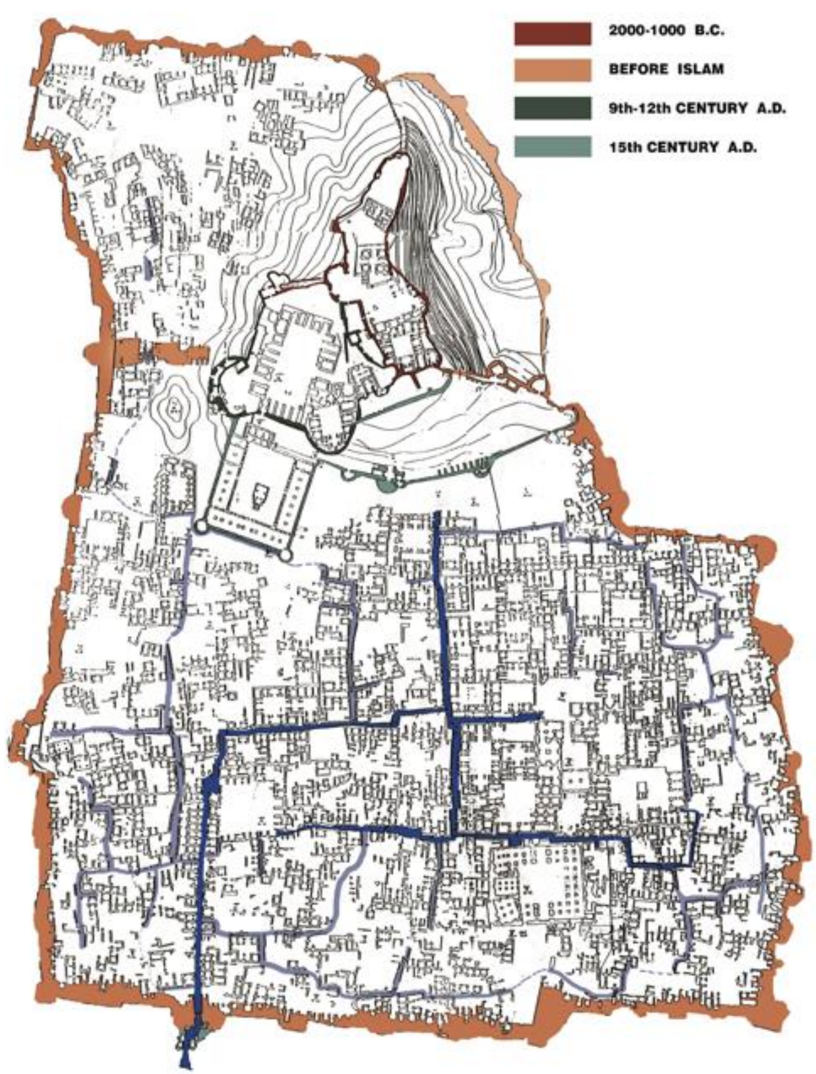

Figure 4. 22- Map of the construction history of different part of Bam Citadel (Source: Personal archive of Prof. Tayari).

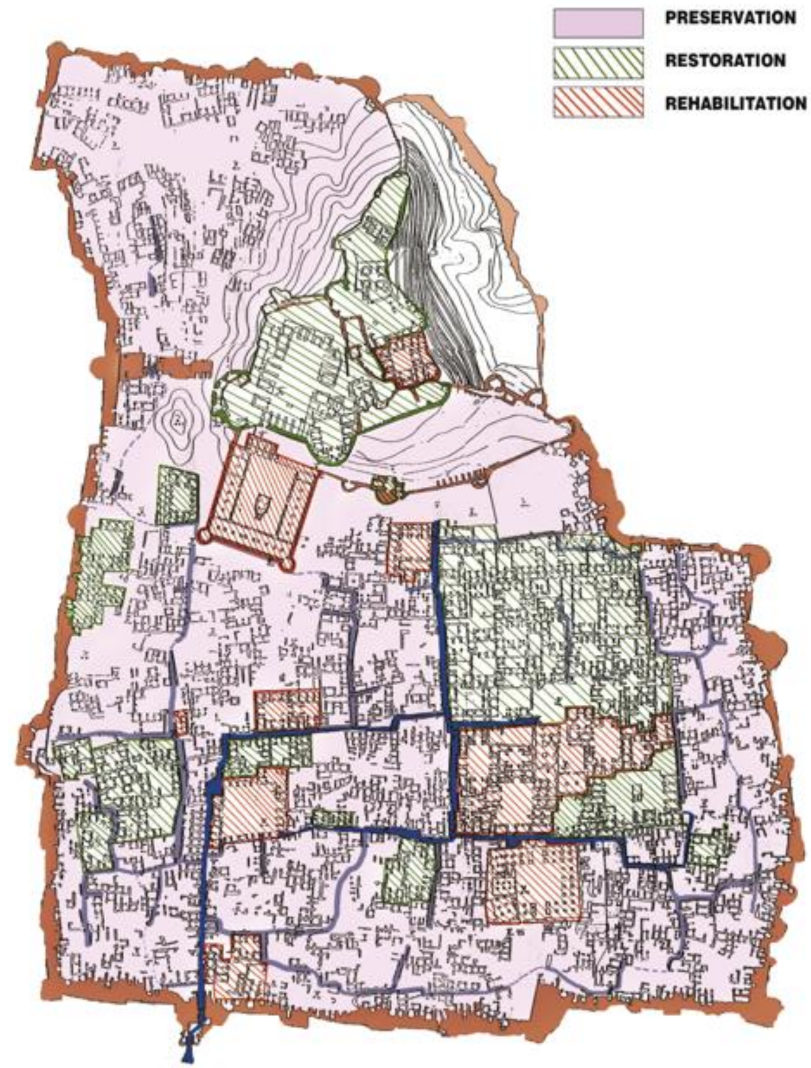

Figure 4. 23- Map of activities carried out in different part of Bam Citadel before earthquake (Source: Personal archive of Prof. Tayari).

Figure 4.24- Map of Archeological priority before the earthquake (Source: Personal archive of Prof. Tayari).

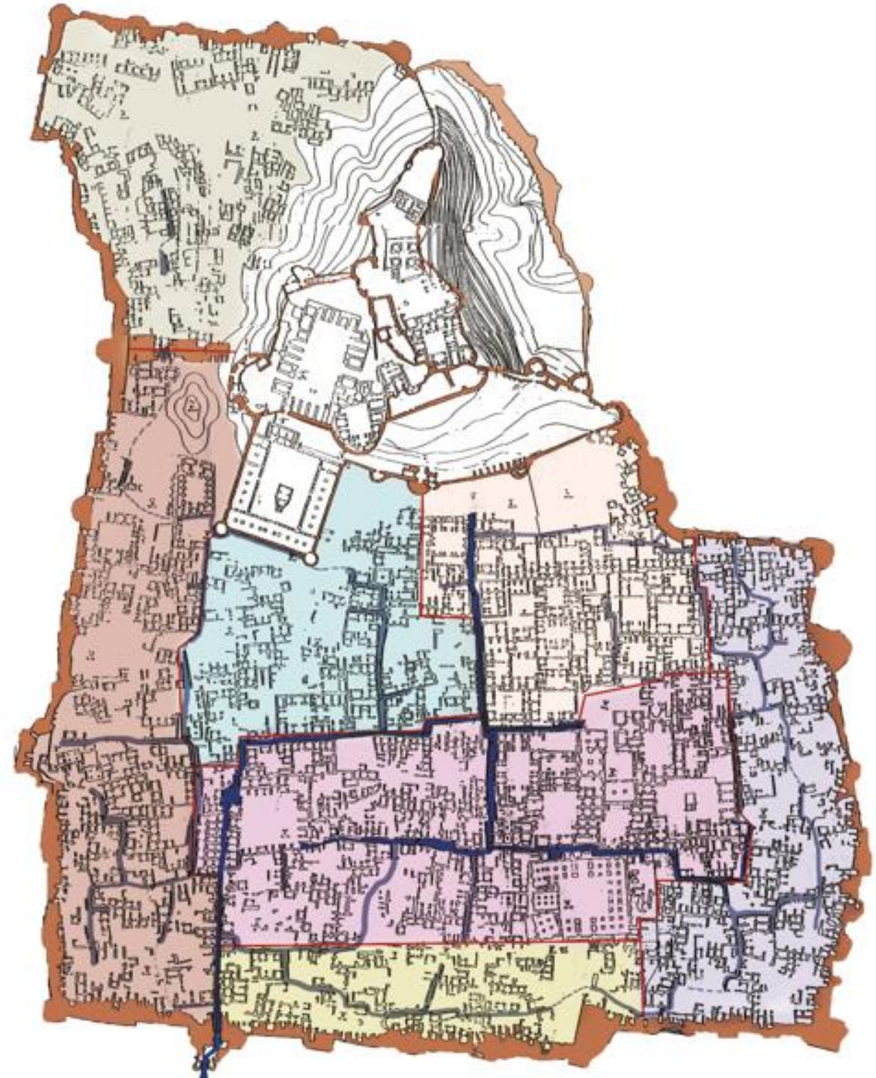

Figure 4. 25- Map of neighborhood's division in Bam Citadel (Source: Personal archive of Prof. Tayari).

- The Problems of Previous Conservation Measures Carried out in Bam Citadel before the 2003 Bam Earthquake

Despite the results of Prof. Tayari's annual report from 1994 to 1999, in order to restore and renovate the Bam Citadel, the 2003 Bam earthquake severely damaged it. In the case of Bam's ancient monuments, one important aspect needs to be pointed out: most of the recently maintained or restored monuments before earthquake had faced with a lot of more damage than non-maintained and restored ones, so the restoration works in Bam Citadel have aggravated the situation. As examples of this case, we can refer to Konari Mahale, the Zoroastrian Temple, Qale Dokhtar, etc. Before the earthquake, all these monuments were severely ruined and the earthquake did not damage them as much as the restored Citadel of Bam. Since the walls in Bam Citadel had been composed of materials of different density and cohesion resulting from their phases of construction, repair and reconstruction, each phase had represent different seismic response, the parts with more changes during their lifetime had suffered more destruction.

About the comprehensive management plan of Bam Citadel before the earthquake, the earlier restoration work, although meticulously done, had largely been concerned with architectural surfaces: the appearance of the buildings and matching the repairs with the original in order to retain integrity and authenticity of the site (Vatandoust et al., 2008). The original fabric was respected and conservation intervention comprised of the use of adobe and earthen mortars and plasters (Correia, 2009) so that the final step in this process was to plaster the construction with a layer of mud reinforced with straw.

Here remains a question: what were the basis and the problem of interventions in Bam Citadel that it could not resist against the earthquake? In this case, John Curtis, keeper of the ancient near east at the British Museum, said that the Iranian government had a good record in preserving cultural sites, but that there were not many precautions they could have taken to prevent damage to a site such as the citadel.[330] The weaknesses of previous interventions in Bam Citadel before the earthquake can be summarized as four main reasons that are listed below:

▪ The main problem of the previous conservation work was that the strengthening of the buildings was not predicted. In restored parts, due to lack of appropriate bond and structural discontinuity between the original parts and the repairs, the structural remains mostly appear to be damaged much worse than the other parts.

[330] THE IRISH TIMES. (2003). "Ancient citadel destroyed in minutes". Retrieved from http://www.irishtimes.com/news/ancient-citadel-destroyed-in-minutes-1.402282

▪ Although basically isometric forms and shapes in some of the earthen structures in Iran produce sufficient resistance to incoming shocks, a number of previous interventions within the Citadel resulted in changes to the original plans, increasing the side effects of the earthquake loads (Vatandoust et al., 2008) , such as what was previously mentioned in the Caravanserai.

▪ The deteriorated parts of wall basements and the roofs which had been exposed to moisture and rainfall slashing, were not accurately strengthened. In this case, replacing of the deteriorated parts with new ones not only did not give their former stability and strength back, but also caused more overloaded on the origin of the buildings.

▪ The basis of previous interventions was more cosmetic approach: the added thatch coatings on the façades have had detrimental effects to the original walls, so they overloaded the walls and increased the stress on them during the earthquake. The diversity of the seismic behavior caused by this factor could be seen in various parts of the Citadel. For instance, Konari Mahale, which was completely ruined before the earthquake and did not face any special repairs, suffered much less damages.

4.3 Past and Present State of the Conservation of Bam Citadel's Monuments by Co-operation among Governmental and Non-Governmental Institutions and Associations at the National and International Levels

Given the high destruction rate of Bam Citadel during the earthquake, its restoration process is known as one of the largest reconstruction project in the world. Yet after 13 years of Bam earthquake and despite various interventions and rescue operations, ruin scars continue to exist on the Citadel. Here the reconstruction was undertaken in selected areas of the Citadel and all reconstruction was based on archeological evidence and not on conjecture (Jokilehto, 2013). Fortunately, since the foundations of several walls in some properties were still standing after the earthquake, this made the restoration work move convenient. At present as regards activities, which have been implemented by co-operation among governmental and non-governmental institutions and associations at the national and international levels, the citadel is slowly returning to its past structural and architectural form as before the 2003 Bam earthquake.

In August 2015 as a part of Author's research activity and to provide pictorial report from the present state of Bam Citadel's monuments, after all restoration works carried out, a site visit from Bam Citadel was organized. Along this site visitation, there was also a pre-planned interview with three main figures of the recovery project of Bam Citadel both before and after the earthquake: 1) Prof. Hosein Tayari, Head of Bam Recovery Project until almost five days before the earthquake, 2) Prof. Eskandar Mokhtari Taleghani, Head of Bam Recovery Project from the beginning of the earthquake until 2009; and 3) Dr. Afshin Ebrahimi, Current Head of Bam Recovery Project.[331] Based on the Author's interviews, which are listed in the tables of 25 and 26, by bringing up of some questions, it was tried to figure out the priorities and principles that were considered at the time of their own administrations.

Table 4.1- A summary of the Author personal interview with Prof. Mokhtari.

Person Interviewed: Eskandar Mokhtari Taleghani	**Date: 24/08/2015**	**City: Tehran**	**Address: Milad Tower**
At the beginning of implementing restoration plan, what was your notion of damages and what range of monuments within citadel needed to be restored?			
In my view, the percentage of damage in Bam Citadel was not more than 60-65 percent, with respect to the Governor's district which retained its overall shape after earthquake. It should be noted that the Public District which suffered high damage, before the earthquake was almost turned into ruin. In the case of restoration activities, depending on how much evidence we could find by looking through the available documents (map, photographs, aerial photo and…) and archeological value of structures, our approach was different from one to another. It was important to try to maintain the integrity and authenticity of the structures.			
According to what priorities have you selected the buildings for the retrofitting measures?			

[331] In the part of 'Conservation History of Bam Citadel before the Earthquake', I have referred to my interview with Prof. Mr. Tayari.

In this step, the vulnerability of structures were assessed and was brought on a map; besides, the value of each monument also have been considered and based on a careful analysis, priorities have been identified. Meanwhile, it should be mentioned that the means of vulnerability assessment is not just the percent of damages, but it consists of physical vulnerability, functional vulnerability, access vulnerability, management vulnerability, environmental vulnerability, socio-economic vulnerability, and Infrastructure vulnerability. In addition, in the case of value, various factors such as historical value, socio-cultural value, archeological value have effects. In fact, each monuments that has more value and the rate of its damage was less than others, was placed in higher priority for retrofitting measures.
Some beliefs that, during reconstruction, Bam Citadel was converted into a laboratory for testing of methods proposed by different groups, what is your idea about it? Meanwhile, if you analyzed different methods, why have you not chosen a special procedure? Actually, this judgment is not correct. In the case of Bam Citadel, we are confronted with traditional adobe buildings. This type of construction material is so vulnerable against earthquake; on the other hand, except for general recommendations and guidelines presented by UNESCO, ICOMOS and other active institutes in this field, there is no routine method for those protection and rehabilitation. Meanwhile, in the case of proposed interventions, all of them have shown their seismic capability under seismic test and were accepted by UNESCO criteria. Moreover, these methods were not applied before in real samples, hence the case of Bam Citadel could be a best place to see their seismic function to achieve an ideal conclusion in the future.
Can you explain something about the measures implemented for improvement of the quality of adobe brick (Khesht) in Bam Citadel? The first measure for production of khesht was finding clay with high quality from local mines. For this purpose after some laboratory test, the clay from Nezam Abad was identified as the best in the region. In addition, it should be pointed that the produced Khesht after passing the laboratory tests could be used in the construction process. Meanwhile, we have not used any addictive materials in our works, but in two cases based on the order of *Dresden University* of German active in Sistani House, and *Italian Ministry of Culture* active in restoration of Tower one, Khesht reinforced by palm fiber and cement were produced.

Table 4.2- A summary of the Author personal interview with Dr. Ebrahimi.

Person Interviewed: Afshin Ebrahimi	**Date: 26/08/2015**	**City: Tehran**	**Address: Research Institute of Cultural Heritage & Tourism**
What percentage of Bam Citadel has been restored? On average, some 80 percent of the reconstruction of Bam Citadel has been completed.			
Don't you think the pace of recovery project in Bam Citadel is slow? With respect to the large volume of work and the rate of damage, our pace is not slow. Meanwhile, the conservation and management action in the site need to guarantee the preservation and presentation of all the key characteristics of the Citadel. We cannot forget them and move forward quickly. Furthermore, there are some funding problem.			
How long will it take to finish the reconstruction project of Bam Citadel? When we are dealing with a project as large as Bam Citadel, determining a definite time by which the project will be completed is just impossible. In fact, the work will never finish when we face a set of deterioration factors, we must preserve the site and rebuild it all over again. Meanwhile, UNESCO does not permit the state party of Iran to eliminate the impacts of earthquake since the earthquake is a part of the history of Bam Citadel that should be displayed. By the way, the project to save Bam Citadel is still in progress and will end by 2017.			
What activities have been done to conserve Qanats in the city of Bam?			

Except for the earthquake, some other causes such as recent drought, indiscriminate and illegal perceptions have significant roles in the drying out of these traditional water irrigation system in the city of Bam, as an important water source in the region. Hence, based on historic, socio-economic values of Qanat, we are doing some activities to register them in the World Heritage List.
Are the activities of foreign groups in the citadel finished or will they continue? At present, all activities are being done only with Iranian experts but the *University of Milan* declared its readiness for possible intervention in Governor's Tower, yet it should be examined.

The Arg has long been a living symbol of Bam, and many among the population feel an intense sense of attachment to the site. Plans for recovery must consider the cultural, economic, and social value of this unique complex (EERI, 2004). One of the issues in discussion after the earthquake will obviously be related to the limits of restoration and reconstruction in view of the presentation of the site without losing its historical authenticity and archaeological interest (Jokilehto, 2006). In this regard, in the reconstruction plan of Bam Citadel, a wide range of national and international, governmental and nongovernmental organizations and institutes have had technical and financial assistance in various schemes of activity to preserve the citadel and handing it down to future generation. During these years that have passed since the 2003 Bam earthquake, some organizations and institutes have been involved in specific projects at Bam Citadel, which are explained in following:

Form the initial research CRAterre-ENSAG (France) experts contributed to the management plan of Bam Citadel and have practical studies focusing on how best to strengthen adobe-mud brick buildings, as well they have participated in restoring work carried out in the Second Gate. The Faculty of Architecture of Dresden University (Germany) has contributed in restoration of Sistani House. Experts from Kassel University (Germany) addressed tests for retrofitting adobe-mud brick buildings using natural fibers. Japan has granted some $500,000 (365,000 Euros) through UNESCO to Iran for the reconstruction, and supported the project by providing equipment to clear the rubble. Besides them, Japan's experts from the National Institute of Informatics (NII) with the help of Tehran University (UT) (Iran), Paris-Val de Seine National School of Architecture (EVCAU) (France), Waseda University (GITS) (Japan) created the 3D plan of some parts of Bam Citadel to increase the accuracy of the renovation,[332] and Mie University (Japan) contributed in the restoration of the Bazaar. The Ministry of Cultural Heritage and Activities and Tourism (Italy) has funded $ 300,000 for the Bam's heritage restoration project, and dispatched a team of experts to restore Tower No. 1. Furthermore, universities from Italy such as Milan, Padua, Parma and Florence have contributed in restoration of the Mirza Naim School. In the other cases, Iranian groups such as Isfahan

[332] In preparing of 3D Map of Bam Citadel, NII was the project and research executive and financial supporter, EVCAU have developed 3DCG models of case studies inside the Citadel of Bam consisting of: School of Mirzā Naim and small caravanserai. UT has developed 3DCG models of case studies inside the Citadel of Bam; GITS has developed 3DCG models of case studies inside the Citadel of Bam consisting of the main entrance gate, part of bazaar, Chāhār-Fasl edifice and prepared Virtual Reality demonstration.

University in Tower No. 32, The Soil Engineering Services Consulting Engineer (SES) in Stable and the Recovery Project of Bam Cultural Heritage (RPBCH) in Barrack, Payambar Mosque, Bazaar, Tekiyeh, Emam Zamān Shrine and so on have been implemented. Meanwhile, it should be noted that the Building &Housing Research Center (BHRC) and the Iran Cultural Heritage, Handicrafts and Tourism Organization (ICHHTO) have significant roles in relevant researches. After the earthquake, the Citadel of Bam has turned into a unique walled open-air museum, research center and laboratory for the earthen structure in the world. A glance at the history of construction of buildings in the Citadel shows that there has been an unceasing trend to utilize and adapt new technological developments in order to screen new disaster preparedness techniques (Mokhtari et al., 2008f). As older samples of this issue can be seen in using the palm tree trunk in the body of adobe structures in Bam Citadel, and their new ones can be seen in activities which have been implemented after the 2003 Bam earthquake.

The resulting Bam Declaration and Recommendations 2004 spoke about the qualities of the traditional environment in Bam, and stated: The conservation, wherever possible, should be preferred and their reconstruction should be seen as a chance to perpetuate the living identity of Bam. Thus, through its urban landscape, there is an opportunity for real improvement in building technologies, and a reduction in vulnerability to natural forces, such as future earthquakes (Jokilehto, 2013). The works in Bam Citadel made it clear that just using traditional construction methods cannot respond to all the requirements of the conservation process.[333] As regards to that point, and since the possible relation between respect to the values of monuments and their seismic upgrading are always on two opposing fronts, in Bam Citadel tremendous efforts have been made by participating groups to introduce new methods alongside the traditional local practice for overcoming the weakness of the adobe buildings against the future disaster. Although each proposed method for each monument differed from the materials used and the technical methods applied (typically a mix of traditional and modern techniques and materials), their suggested methods had to pass through filters to correspond to international conservation guidelines, following International Charters and ICOMOS Recommendations. In all structural interventions of Bam Citadel, relevant charters and recommendations such as the Venice Charter (1964) and ISCARSAH-ICOMOS recommendations (2003) and any other international conservation and restoration norms have been considered to maintain the integrity and authenticity of the monuments within Bam Citadel. From the viewpoint of the international charters and recommendations, the principles of interventions have been based on minimal intervention and maximum safety level so that this implies the maximum respect to the

[333] In springtime of the year 2007, the University of Technology Dresden conducted a detailed collapse-analysis of two rooms of the Sistani House. As the results, the weak point of the traditional adobe brick architecture in which the Citadel of Bam is almost exclusively constructed, is determined by a lack of coherence within the brickwork. Seismic stress has an immediate effect on the weak bonding of the brickwork and caused the almost total collapse of the building. The model furthermore unmistakably proved that if the building were reconstructed in the same way as before, it would certainly not survive a further earthquake. (Jäger and Fuchs, 2008).

originality of the materials, technologies, typology and environment. Meanwhile, extensive intervention was avoided. On the other hand, other criteria such as durability, compatibility, reversibility, and cost effectiveness of techniques and materials also have been considered. Meanwhile, all reconstruction procedures have been taken based on archaeological evidences and not on conjecture. At present, the Citadel of Bam and the surrounding old city is step by step recovering to its initial shapes.

Generally, the significance of the present section is to ascertain precisely the present condition of recovery process ongoing the Bam Citadel along with a comprehensive study about the condition of its main single monuments both before and after the earthquake. In fact, it has an accurate focus on the strategies and techniques that have been employed by different national and international groups, and evaluates the traditional and modern engineering techniques that have been used in reconstruction project of Bam Citadel. Here it is tried to understand why intervention mistakes are repeated and why successful conservation results are still scarce in such important cultural heritage. To achieve this purpose, the main monuments in the Citadel that had faced with major restoration works before the earthquake are chosen, and then after grading of their values and damages incurred, the measures taken in those monuments are categorized into three categories: 1) Initial Actions, 2) Normal Conservation Works, and 3) Seismic Retrofitting.[334] Here also after giving a comprehensive knowledge about Location-Geographic Co-ordinates, Period of Construction, Property Description, Property Values, Conservation History before Earthquake, Physical Condition after Earthquake, the proposed Intervention Plan of each property is analyzed in details. Finally, to valorize the effectiveness of two innovative techniques that one by local materials and another with modern materials have been executed, a ‘SWOT’ analysis is taken on each of these intervention plans.

[334] Each of these categories are defined in Page No. 398.

The selected properties inside of Bam Citadel for assessing the quality of their reconstruction process					
Property's Name and No.	**Page No.**	**Property's Name and No.**	**Page No.**	**Property's Name and No.**	**Page No.**
1. Main Entrance Gate	291	**7. Mirza Na'eim School**	332	**13. Stable**	370
2. Tower No. 2	297	**8. Sistani House**	343	**14. Barrack**	376
3. Tower No. 1	304	**9. Payambar Mosque**	350	**15. Commander's House**	381
4. Bazaar	311	**10. West Sabat House**	356	**16. Governor's Residence**	385
5. Tekiyeh	319	**11. Caravanserai**	358	**17. Yakhdan**	392
6. Friday Mosque	327	**12. Second Entrance Gate**	363		

Figure 4.26- The selected properties inside of Bam Citadel for assessing the quality of their reconstruction process (Designed by Author).

- **Property No. 1: Main Entrance Gate** or **First Gate**

▪ **Location-Geographic Co-ordinates:** According to the zonation map which was proposed by the archeological group, the Main Entrance Gate of Bam Citadel is located on zone (XV-F), and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'46.84"N – Longitude: 58°22'3.03"E).

▪ **Period of Construction:** There is no exact date regarding the history of the Main Entrance Gate, but by referring to the architectural styles of this property, it can be understood that its 'interior gateway' may date back to the older periods of the Citadel (Sassanid dynasty (224-651 AD)) (Mehriar, 2004). Then for more security in Safavid dynasty (1501-1736 AD), the "Octagonal-shaped" space and the "exterior gateway" were probably added to the Main Entrance Gate (Tayari, 2004).[335]

▪ **Property Description:** In the southern part of Bam Citadel, there was a huge gate as named Main Entrance Gate. This gate was exactly located in front of a steep mobile bridge over a moat. Before the earthquake, the Main Entrance Gate of Bam Citadel consisted of two gateways and four watchtowers. The first-two-watchtowers of this property with a height of almost 14 m were located on both sides of the first exterior gateway. Right after the first gateway, an "Octagonal- shaped" or "vestibule" space ("Hashti" in Persian) was designed with some room in three stories for the guards.

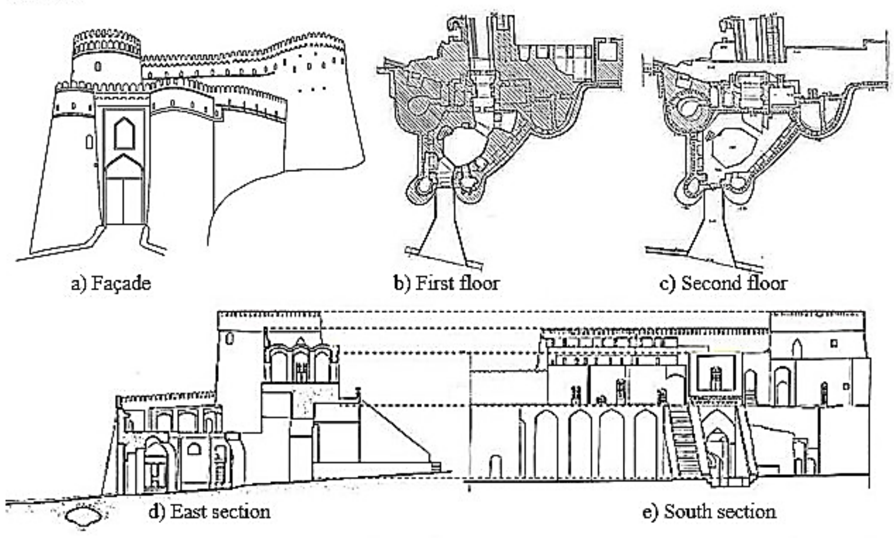

Figure 4.27- Plans and sections of Main Entrance Gate of Bam Citadel (Sources: (a) designed by Author; and (b, c, d and e) Kinji et al., 2008).

[335] Tayari, H. (2004). "Arg-e Bam", Field Survey. Personal archive of Prof. Tayari. (Unpublished in Persian).

In past times, "Octagonal-shaped" or "vestibule" space as a narrow defensive slot could be a dangerous place for enemies to approach the army in the Citadel. After passing from the "Octagonal-shaped" space, there was the second gateway of the Main Entrance Gate along with a narrow corridor. In fact, the second-two watchtowers of this gate with a height more than the first-two ones were an extension of Citadel's fortification from east and west. The height difference between the top of the first-two watchtowers with the second-two watchtowers was around 6-8 m.

Table 4.3- Architectural information of the Main Entrance Gate of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Octagon-shaped space, Huge gateway, Under walled arches or arched windows for the positioning of the archers of guards, Iwans, Decorative latticework by adobes and woods on openings, Adobe design in façade and Crenellations.
Types of Roofs	Different types of closed and opened barrel vaults.
Surface Coating Material	Gypsum Decoration, Chalk Trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** The Main Entrance Gate under its plaster has an interesting feature revealing the history and the quality of development of a property according to necessities of the times. This property with all its defensive assets clearly revealed the military function of Bam Citadel. The Main Entrance Gate as the main communication bridge between inside and outside of the ancient city of Bam had a significant strategic value; most of the commutes in Bam Citadel had been done in this gate. From the beginning until the first decades of the 20th century, this part of the Citadel was designed to protect the city's inhabitants from foreign invasions. Meanwhile, in the time of wars, the main goal of invaders were to overcome this sector. Despite the consecutive changes in the design of the Main Entrance Gate, it properly have not missed its architectural character during the time until before the earthquake. One of the main significant aesthetic aspect of this property could be seen in its "Octagonal-shaped" space where after entering from the first gateway, it visualized a spiritual space, which performed as an interruption space between inside and outside of the city. Sometimes during past conservation activities, the repair and renovation of several rooms at the entrance were carried out to be used as storage and booking office.

▪ **Conservation History before Earthquake:**[336] According to reports, the restoration activities in the Main Entrance Gate had started in 1976; then in 1977, this activity had been continued

[336] The results of previous reporting exercises have been complied based on Dr. Tayari's annual report from 1976 until 2003, which without any detail of technique used are written in the nomination paper of Bam and its Cultural Landscape in World Heritage List (2004). As before said all of restoration works

by installation of a guard post in ground floor. Until 1993, no special activities had been reported, as far as in this year, the work continued more seriously with restoration of the upper floor of this gate and some conservation activities were carried out in its different parts. Between the years 1995-1996 AD, the restoration procedures were followed by the restoration and renovation of the rooms in the ground floor and conservation work in its towers and crenellations. In later years until 1999, the total restoration of main entrance gate and conservation of its different part was completed.

Figure 4.28- View from the Main Entrance Gate before beginning of restoration works (Photo by Stephan, 1968-1972 AD. Source: http://www.betterphoto.com).

Figure 4.29- The Main Entrance Gate of Bam Citadel during restoration works (Photo by Eastbound, 1973-1975 AD. Source: https://www.flickr.com).

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on monuments of Bam Citadel had been performed in simple ways with traditional Iranian restoration methods.

Figure 4.30- As can be seen in this photo, the recovering of the façade with mud and sieved straw is started in the second-two watchtowers of Main Entrance Gate (Photo by Adam, 1998. Source: https://www.flickr.com).

Figure 4.31- The finished façade of Main Entrance Gate (Photo by Fernando Mobu, 1999. Source: http://www.panoramio.com).

Figure 4.32- View from northern part of the Main Entrance Gate (Photo by Asghar Riahi, 2001. Source: http://iranian.com/Bam/2006/May/Riahi/80.html).

▪ **Physical Condition after Earthquake:** As shown in Figure 4.33, this property after the earthquake was damaged to a considerable extent; all of the floors with their adjacent watchtowers had totally collapsed. The damages in the second-two watchtowers due to their conjunction with adjacent fortifications were less than the first-two watchtowers. According to the placement of this property in manmade steep area and also because of the weakness of its foundation, occurrence of this level of damage was predictable.

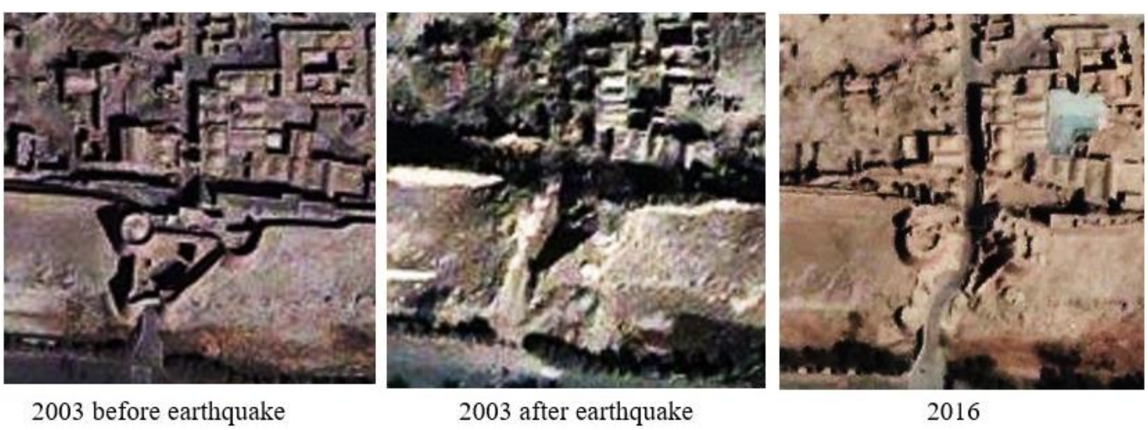

Figure 4.33- Aerial pictures from the Main Entrance Gate taken in subsequence years (Source: Digital Global and Google Earth).

▪ **Proposed Intervention Plan:** In this case, the intervention plan has not been addressed yet. As the top priority in this damaged property, the aim of RPBCH is to give it an acceptable shape like the one before the earthquake. However, the complexity of the original form in plan, its location as the only way for entering the Citadel, and the high volume of the damage made it difficult to restore or reconstruct the whole Main Entrance Gate as before. During the years after the earthquake, some parts of the watchtowers have been preserved and restored, some more restoration and reconstruction is on the way.

Figure 4.34- The Main Entrance Gate after the 2003 Bam earthquake (Photo by Ahmadi and Boroomandi, 2003. Source: archive of ICHHTO).

Figure 4.35- The Main Entrance Gate under restoration (Photo by Joao Leitao, 2012. Source: https://www.flickr.com).

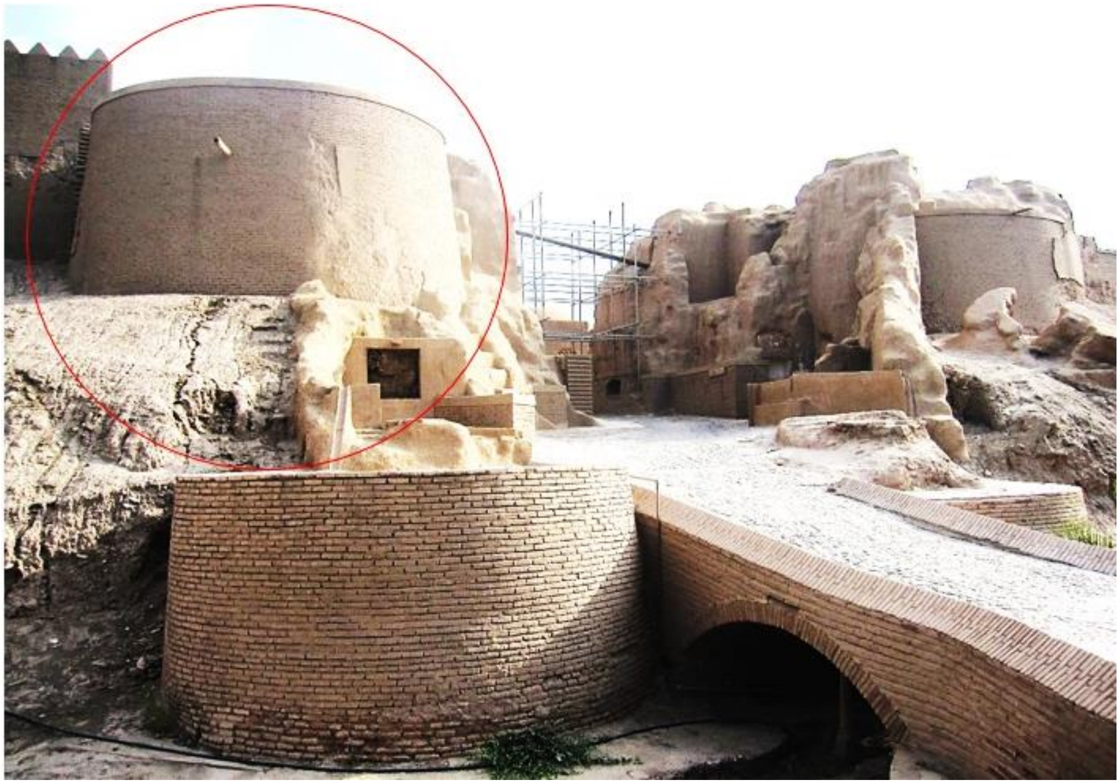

Figure 4.36- The present state of Main Entrance Gate, the highlighted section of this photo and previous photo exactly show the work progression between the years 2012 until 2015 (Photo by Rouhi, 2015).

- Property No. 2: Tower No. 2 and its Adjacent Fortifications

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, Tower No. 2 of Bam Citadel and its adjacent fortifications are located on zone (XIV and XV- D to F), and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'46.84"N – Longitude: 58°22'3.03"E).

▪ **Period of Construction:** Different parts of Bam Citadel's enclosure wall belong to different periods of the history. After 2003 Bam earthquake, the older layers of the fortification (probably Sassanid period (226-651 AD)) became evident (Mehriar, 2004). However, according to the available references, the fortification next to the southwestern part of the Citadel can date back to the pre-Islamic period.

▪ **Property Description:** The enclosure wall of Bam Citadel with a length of about 1800 m includes of 48 towers. The Tower No. 2 and its adjacent fortifications from west to east are located in the southern part of the Citadel. The height of this area is around 18 m, although the real depth of the fortification's foundation is not visible, according to the present configuration, it varies in width reaching a maximum of about of 8-10 m, and when it goes to the upper part it gets a width of about 4-6 m (Jafarizadeh & Behzadifar, 2011).

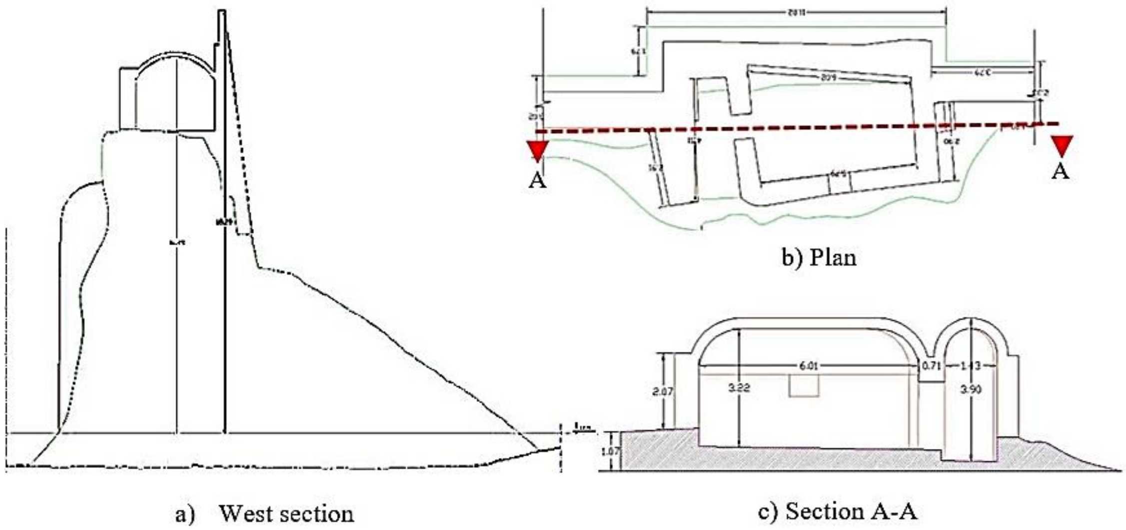

Figure 4.37- Plans and sections of the Tower No. 2 of Bam Citadel and its adjacent fortifications (Source: archive of RPBCH).

Table 4.4- Architectural Information of the Tower No. 2 and its adjacent fortifications of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches or arched windows for the positioning of the archers of guards, Decorative latticework by adobe on openings, Adobe design in façade and Crenellations.
Types of Roofs	Closed barrel vaults.
Surface Coating Material	Mud and Sieved Straw and Mud and Straw Plaster.

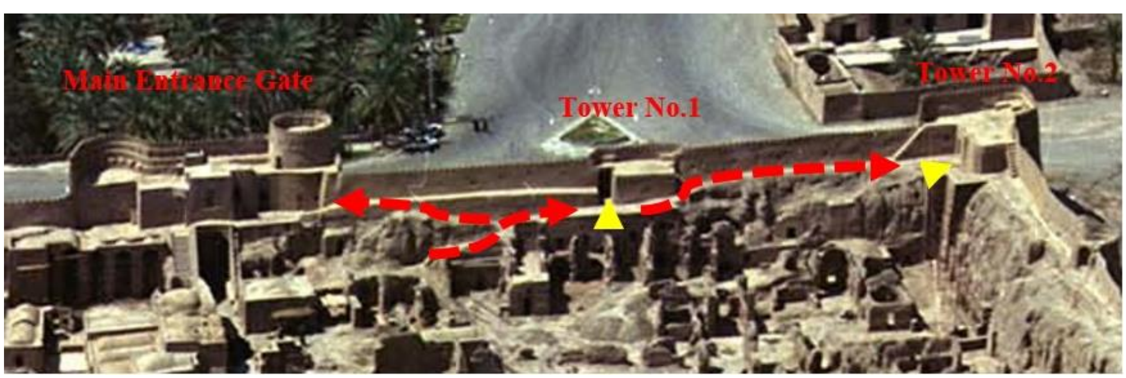

Figure 4.38- The access way to the Tower No.2 and Tower No.1.

▪ **Property Values:** The values of this property can be attributed to its close proximity to the Main Entrance Gate of Bam Citadel. From the past, fortifications as the main strategic part of any walled city included watchtowers and crenellations were erected to prevent invasions from the aliens. Watchtowers in fortifications usually had two main functions: firstly, they increased the stability of ramparts; and secondly, they provided a place for guards to protect from the Citadel. However, the diversity of historical layers in the enclosure wall of Bam Citadel marks pages of the vicissitudes of Bam's history and provides an opportunity for the researchers to find out information about the history of its construction and restoration. According to archeological studies done after the earthquake, some adobe-mud bricks were found dating back to the Buyid dynasty (934-1055 AD) and Timurid dynasty (1370-1507 AD) (Tayari, 2004). The main watchtowers and crenellations of Bam Citadel's fortification are probably the most visible architectural elements of the Citadel. In addition to the security aspect of these elements, they also can be considered as a decorative aspect; crenellations with their regular rhythm gave a certain beauty to the landscape of Bam Citadel. Although after the earthquake, visitors have been prohibited to visit some dangerous parts of Bam Citadel like enclosure wall, before the earthquake, they could have a close-up view from them, so they could put themselves in the position of the guards of Bam Citadel in the past.

▪ **Conservation History before Earthquake:** About the conservation history of Bam Citadel's enclosure wall, there are no exact written documents. Although more extensive conservation works which started in 1977 were mainly concerned with the repair and preservation of the fallen and olden parts of fortification, during this time most of activities were done randomly. From 1993 until 2003, the conservation activates on Bam Citadel's fortifications had been performed more precisely. As a review of the activities that have been carried out in this area, we can refer to conservation, restoration and renovation of the enclosure wall, including its crenellations, the middle corridors and towers. These activities have concentrated more on obstructing holes and cracks, sloping of corridors and new plastering of façades. In addition, some consolidation work has been carried out on the body of fortification such as replacing the deteriorated and troubled parts with new similar materials.

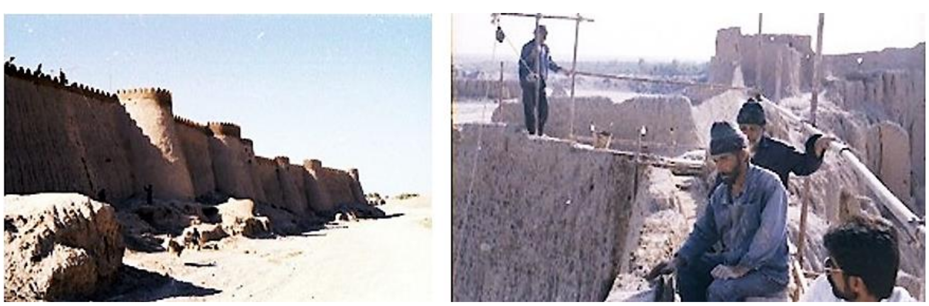

Figure 4.39- Some restoration works in enclosure wall of Bam Citadel before the earthquake (Source: personal archive of Prof. Tayari, 2001).

▪ **Physical Condition after Earthquake:** The earthquake has shattered most of the upper parts of the enclosure wall of Bam Citadel, whereas the stability of the remaining walls and sections appear to be unstable. Cracks and layer detachments were observed everywhere. The exterior part of the fortification around Tower No.2 has two parallel layers with almost a thickness of 1 m, which after the earthquake was destroyed from the base towards outside (Jafarizadeh& Behzadifar, 2011).

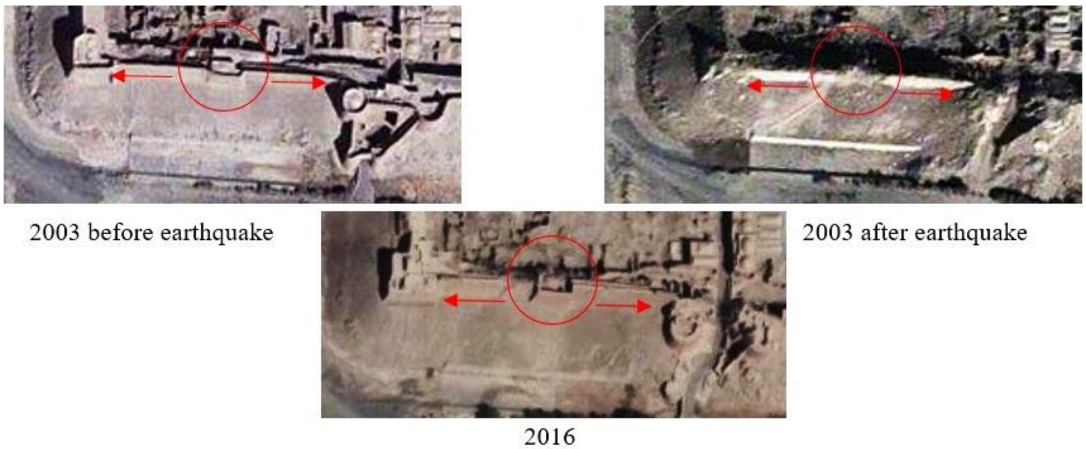

Figure 4.40- Aerial pictures from the Tower No. 2 and its Adjacent Fortifications taken in subsequence years (Source: Digital Global and Google Earth).

Figure 4.41- A comparison between the original state of Tower No.2 and its condition after the 2003 Bam earthquake, and after debris removal ((Top right) photo by Ahmadi and Boroomandi, 2003 (Source: archive of ICHHTO); and (Top left and Down) archive of RPBCH 2008-2009).

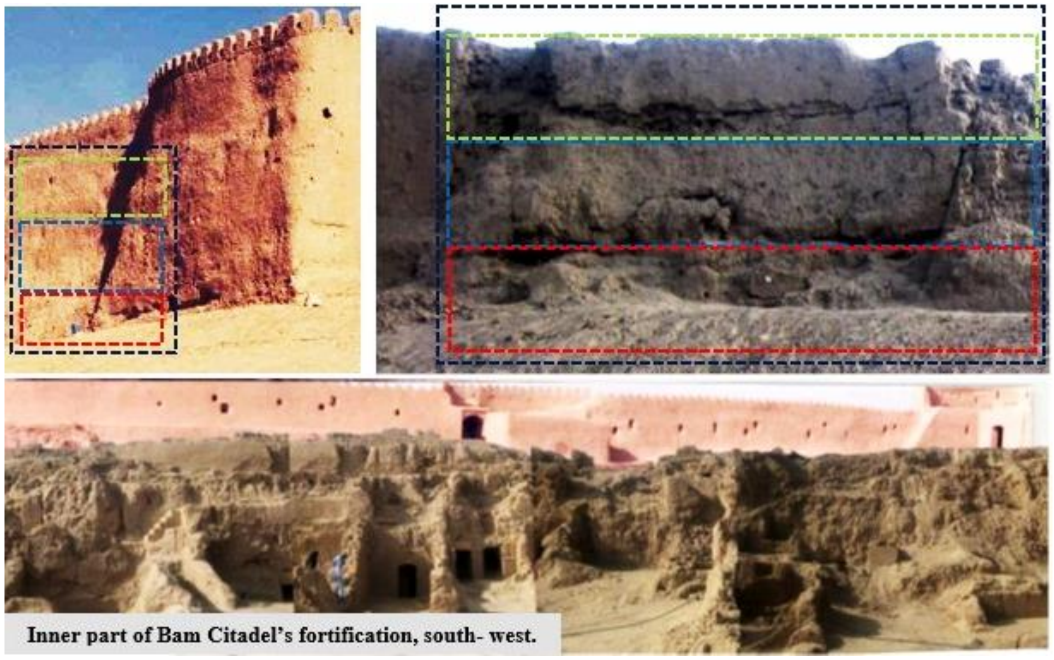

Figure 4.42- (Top) the state of destruction, cracks and detachments in west side of Tower No. 2 (Source: archive of RPBCH); and (Down) a comparison between the original state and destructed state of the inner part of Bam Citadel's fortification, south-west (Source: archive of RPBCH).

▪ **The Proposed Intervention Plan:** By the demolition of fortification around the Tower No.2, at first after removal of debris and dislocating adobe's portions at the top of the walls, experts started to examine the status quo of the property. In places where the displaced parts of walls were not maintainable, they have been dismantled. For the continuation of conservation activities, there was no complexity in term of shape and form. In the time of intervention, based on aerial photographs and available workshop's photos before the earthquake, the height of tower and crenellations were determined, and the slope of fortifications and its width from inside and outside were identified by consideration of the ruins remained (Jafarizadeh & Behzadifar, 2011).

After uncovering and cleaning the deteriorated parts of fortification, the restoration of Tower No. 2 and its adjacent fortifications included of all length of the lower part of fortification from the ground surface, outer part of Tower No. 2 and outer parts of fortification up to one meter remaining to below the crenellations.[337] As a result of these activities, the outer and inner parts of Tower No.1 and Tower No. 3 have been repaired and restored by normal traditional methods and adobe bricks were produced in the Citadel's workshop. Meanwhile, the operation of grouting and needling and anchoring, respectively in cracks with 2 cm width and more than 2 cm width were implemented (Jafarizadeh & Behzadifar, 2011). As Figure 4.55 shows, after doing interventions in the western part of Tower No. 2, a part of fortification is not totally

[337] Anywhere it was possible the historical debris were re-used for the reconstruction.

restored and finalized by thatch coating. The purpose was to give the visitors an opportunity to be able to have a comparison between new restored layers and original layers of the fortification. At present, the guard's room of the Tower No. 2 is not restored yet. In the case of crenellations, there are just two small sections in the western and eastern corners of the fortification that are restored like before the earthquake by using mesh made of palm fibers (SIS) and traction elements like fiberglass rods. Here SISs are employed in the crenellations in every five brickworks at lowest parts and every two brickworks in upper parts[338] along with using of fiberglass rods in every 1.1 m length.

Figure 4.43- The consolidation of foundation in inner part of the Tower No.2 and its adjacent fortification (Source: archive of RPBCH, 2010).

Figure 4.44- Consolidation and restoration of the outer part of Tower No.2 (Source: archive of RPBCH, 2010).

[338] Since the effect of Bam earthquake in height of buildings was more destructive, to reduce this effect during the future earthquakes, the SIS in the lower parts of the crenellations was employed with long distance instead of upper parts.

Figure 4.45- Reuse of usable ruins remained during the earthquake in restoration procedures of Tower No.2 (Source: archive of RPBCH, 2010).

Figure 4.46- The upper part of fortification between Tower No.1 and Tower No.2 during restoration works after debris removal (Source: archive of RPBCH, 2010).

Figure 4.47- (Top) restoration and stabilization of crenellations by palm fibers and fiberglass rods (Source: archive of RPBCH, 2010-2011); and (Down) the crenellations in the western side of Tower No.2 after complete restoration (Photo by Rouhi, 2015).

- Property No. 3: Tower No.1

▪ **Location-Geographic Features:** According to the Zonation Map which was proposed by the archeological group, Tower No.1 of Bam Citadel is located on zone (XIV and XV-F) and based on geographical features from Google Earth, it is located on (Latitude: 29° 6'47.27"N-Longitude: 58°21'59.97"E).

▪ **Period of Construction:** The same history realized for Tower No. 2 can be considered for Tower No. 1, i.e. pre-Islamic History.

▪ **Property Description:** Tower No. 1 is located in the south-west corner of Bam Citadel and it constitutes a part of Bam Citadel's enclosure wall. The basement of the tower stands from the top of a smooth scarp made of rocky outcrop. The original height of this tower is about 18 m, and the area occupied by the tower is around 12 m^2 and the thickness of its foundation is about 8-10 m. The architectural analysis shows that the original set up of the Tower was progressively expanded outwards, probably due to destructive events that required reconstructions or further protection of the Citadel (Porta & Santoro, 2010).

Table 4.5- Architectural Information of the Tower No.1 of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches or arched windows for the positioning of the archers of guards, Decorative latticework by adobe on openings, Adobe design in façade and Crenellations.
Types of Roofs	Closed barrel vaults.
Surface Coating Material	Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** As values formulated by 'Alois Riegl', "The founding value derives also from its visibility, as it is positioned close to the entrance gate to the old city, so that its shape can be assumed as having symbolic or iconic value".[339]

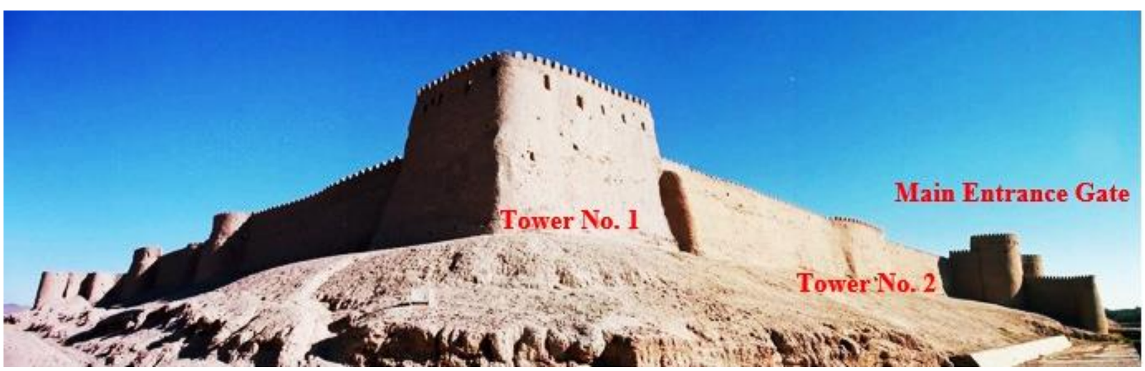

Figure 4.48- View from Tower No.1, Tower No.2 and Main Entrance Gate before the 2003 Bam earthquake (Photo by Omen 2002. Source: https://www.flickr.com).

[339] Porta, C.P., Santoro, V.M. (2010). Arg-E-Bam - Italian Iranian Post-Earthquake Cooperation Project Tower 1: Restoration and Seismic Improvement Measures, Italian Ministry of Cultural Heritage and Activities. (Unpublished)

▪ **Physical Condition after Earthquake:** The earthquake mainly caused the collapse of the top of this property, a height of about 5 m, and formation of several cracks and detachments in its outer and inner surfaces. A thorough analysis of the Tower prior to the reconstruction work showed that most of the damages, suffered by the construction, essentially involved the previous restoring interventions, and that the various detachments form the main body were therefore not original, also as regards the construction technique. Once the debris had been removed during the work, it was clear that the original core of the construction, though damaged, had survived, even if the various adjuncts had collapsed on the ground. Debris found around the base of the tower proved, in fact, to be added during the last hasty restorations, which had not been properly connected to the main shaft, and lost their precarious binding during the earthquake. Similar collapse mechanism were also observed for other buildings of the old city. Some restoration activities had in fact just been finished at the moment of the seismic shock. Moreover, debris originated by previous collapses were discovered stuffed in structural voids that enhanced the failure of the containing structures (Porta & Santoro, 2010). As can be seen in Figure 4.49, particularly on the front north of the Tower, the slide displacement of a brick block of about 1.5-2 m^3, with a slide displacement of around 1.5 m. The configurations of the bricklayers of parts of the structures were visible too, as direct consequences of the distortive action of the seismic shock. Fractures of remarkable dimensions fully show the progressive detachment of further portions of the south wall (Jung, 2007).

Figure 4.49- The damage induced to Tower No.1 durig the earthqauke, the highlighted part is the ruin remained after the earthquake (Sources: (Left) Jung, 2007; and (Right) Porta & Santoro, 2010).

▪ **Proposed Intervention Plan:** After signing an agreement between Iran and Italy for the reconstruction of Tower No. 1 of Bam Citadel, three teams of Italian archeologists and restoration experts under supervision of Giuseppe Proietti, head of the research, innovation, and organization department of "*Ministero per i Beni e le Attivita Culturali*", came to Iran to provide qualified technical collaboration during the post-earthquake phase. In this context, the first group, which consisted of four persons have had beneficial studies on Tower No.1 by using laser scanning instruments, so they provided some plan from the Tower. The second group arrived in Bam for stratigraphy of the Tower, and the third group started the restoration according to the plans provided and previous excavations.[340]

The key role of Tower No.1 in the city wall for both its static and architectural significance was a reference element for the intervention, which realized with respect to the original construction techniques and materials (mud bricks) and in compliance with the current Seismic Codes (Porta & Santoro, 2010). As Jung & Torrieri (2011), the goal of this project was: "1) to install adequate scaffolding and to insert the required props in order temporarily to shore up and stabilize the detached portions of earth walls; 2) to strengthen and to reinforce the tower according to the well known "Brandi approach", the Italian principle of conservation. This means not reconstructing a new tower, but proceeding to the conservation of the remaining portions, in order to make them recognisable, and assuring them a longer life span; 3) to provide a seismic retrofit of the structures."[341] In fact, the restoration measures in Tower No.1 were aimed at holding to traditional attitudes and values and being cautious of material consistency, which constitutes an essential document of the Bam historical reminiscence. Unavoidably, all activities also need to answer to the necessity that cannot be evaded such as architectural value, integrity and authenticity. In this regards for confirmation of Tower No. 1 with its origin, two main conservative necessities are taken into consideration; (1) using local constriction techniques, and (2) conservation of the body of structures which for a long time had been exposed to various deteriorative factors.

As the restoration intervention must humbly value the authenticity of the existing object, conceived also as a historical witness of the experienced events, it was decided not to intervene with the reconstructions of the missing upper parts, even though the upper profile of the wall limit had to be underlined, also accepting the challenge of a structural reinforcement. As regards the material, a cover protection layer of "Kahgel"[342] had to be provided to protect the earthen brick used in the wall from the weathering. The fragile actual outer surface - adobes and Chineh of various sizes - suffering heavy decay in the past, also needed to be restored. Restoration challenges came also from an actual static inadequacy of the resistant section of the

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[340] The Italian Government contributed to an initiative of revitalization in close co-operation with the Iranian Authorities, that brought to select an intervention area on the walls of the Old City, in the especially severely damaged area of the Main Entrance. Thus, the South West Tower No. 1, the main defending outpost of the City Wall, was chosen as objective of the Italian-Iranian cooperation in the restoring the ancient city of Bam. It was restored in three years, between 2007 and 2011, taking into account the seismic load condition (Porta & Santoro, 2010).

[341] Jung, M., Torrieri, v. (2011). Apporti Italiani Alle Problematiche Di Conservazione Promosse Dall'Unesco In Conseguenza Di Calamità Naturali: Arg-e Bam. Archaeological research of the joint Iranian-Italian Mission. Italian post-earthquake cooperation project of MiBAC. MINISTERO PER I BENI E LE ATTIVITÀ CULTURALI, BOLLETTINO D'ARTE, Estratto dal Fascicolo N. 6. Aprile-Giugno 2010 (Serie VII).

[342] Means 'thatch coating or mud-straw mortar'.

wall to support the present loads, due to the acquired inclinations. A re-compaction of the material and the cross tightening of the constitutive layers of the wall was then adopted as the main restoration approach. A proper supporting basement of the wall at its inner base was also provided in order to improve the overall stability. By the way, the interventions were aimed, as far as possible, at the achievement of the structural unity of the different parts constituting the structure of the Tower, with the purpose to ensure a unitary structural behavior of it, especially as regards the horizontal actions. The objective was pursued through the realization of horizontal ties performed with not invasive techniques based on the use of innovative materials. Taken into account the characteristics of the structure and the nature of the relative constitutive materials, Geotechnical Engineering strategy concepts were adopted, and in particular those referring to Soil Improvement. Fiberglass ties of 20 mm diameter were used in small diameter holes, approximately 60 mm, crossing the whole thickness, where possible. For the self anchoring ties and for hole injection, fine soil grout was adopted, physically and chemically compatible with the mud brick context. The architectural impact of the intervention was optimized and limited for the presence of the protection kah-gel layer. The re-use of the historical debris for the realization of the mural reinforcement and the re-composition of the walls follows the Recommendations and Guidelines of the International Committee, in the full respect of the physical-mechanical compatibility. Reconstructions have also been limited to the minimum compatibility, with an effective conservation of the surviving portions of the structures as regards mural reconstruction and static needs, as represented by the angular positioning of the Tower in the general layout of the city walls. The “global” interventions described above were used in association with ties interesting more modest volumes of masonry – “local” ties -, located on structural discontinuities on the west front of the Tower, surely caused by the seismic events (Porta & Santoro, 2010). In this project, to achieve adequate stability and integrity of certain sectors of the tower, 11000 reinforced adobe bricks by palm fiber with predefined dimensions (30x30x10cm), in six brick kilns by a team of four workers among which one master (Usta in Persian) were produced, this group produced 300 bricks a day. These homogeneity compatible bricks by their modified strength, elasticity and durability have positive aspects in reducing the weight and increasing the integrity of the restored property. The new reinforced adobe bricks were proposed for the inner face of the tower (lower part), which, due to their high compressive strength, was suitable for the formation of solid supports for the unstable sectors. In table.4, the laboratory tests that had been done on existing and reinforced adobe bricks in the local Mechanical Laboratory of RPBCH are shown.

Table 4.6- Results of test of adobe-mud brick in Tower 1 of Bam Citadel (Source: Porta & Santoro, 2010).

Sample	Dimension (Cm)	Compressive Strength (Kg/Cm2)	Bending Strength (Kg/Cm2)	Rain Fall (%)	Water Absorption By Capillarity (%)	Abrasive Strength (Cm2/Kg)
Debris Tower1	24×24×6	14.12	7.81	14.72	1.38	7.86
Debris 45(kg)Tower1	24×24×6	18.45	8.76	11.48	1.25	4.00

+1trays palm tree						
Debris 45(kg)Tower1 +1/2 trays palm tree	24×24×6	17.09	7.36	12.50	1.13	9.29

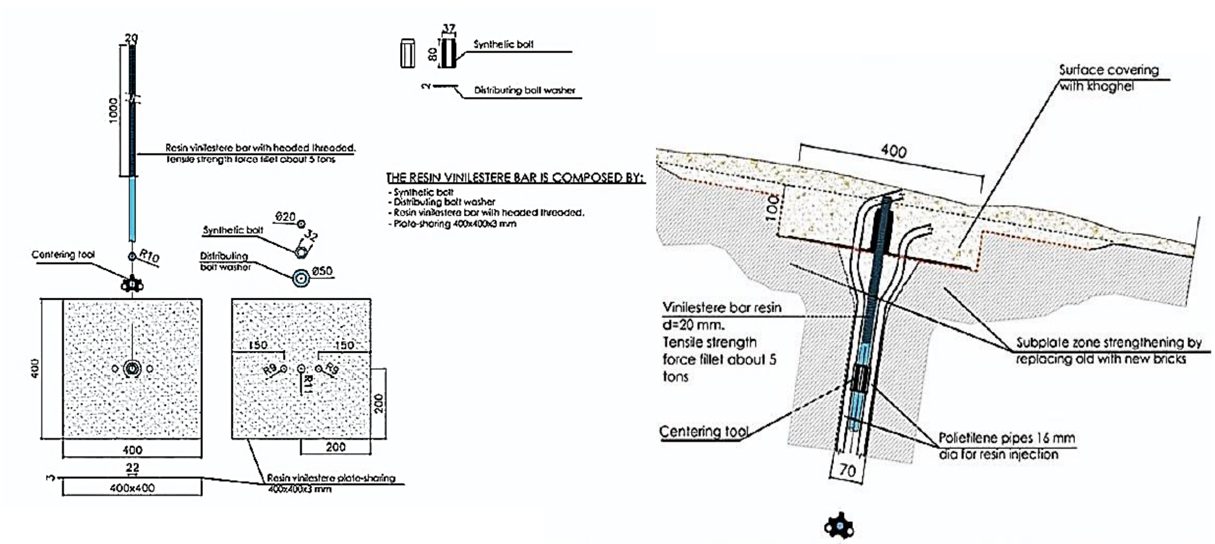


Figure 4.50- Detail of fibrerglass rod inserted on the body of Tower No. 1 (Source: personal archive of Prof. Santoro, from IGeS World srl - IGeS Ingegneria Geotecnica e Strutturale snc).

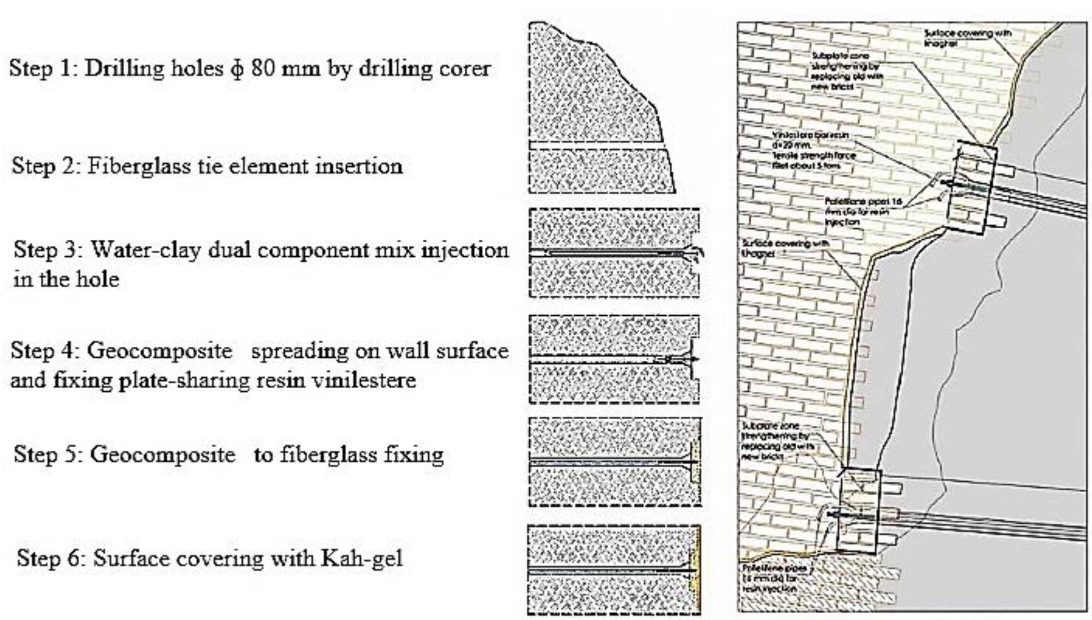


Figure 4.51- Execution steps of stabilization process in Tower No.1 (Source: personal archive of Prof. Santoro, from IGeS World srl - IGeS Ingegneria Geotecnica e Strutturale snc).

Figure 4.52- (a) after the finishing of the nailing, the inclination of the wall based on the original form of the ancient wall are executed (Source: archive of RPBCH, 2010); (b) consolidation and reconstruction of foundation by fiberglass mesh (Photo by Pandidar, 2010. Source: personal archive of Prof. Santoro, from IGeS World srl - IGeS Ingegneria Geotecnica e Strutturale snc); and (c) surface water management system during reconstruction (Photo by Pandidar, 2010. Source: personal archive of Prof. Santoro, from IGeS World srl - IGeS Ingegneria Geotecnica e Strutturale snc).

Figure 4.53- The drilling process for installation of fiberglass rod in the body of Tower No. 1, and the methods for injection of grout in empty space around rods (Source: archive of RPBCH, 2009).

Figure 4.54- The finished state of stabilization of the façade of Tower No.1 by fiberglass meshes and fiberglass rods before surface covering (Source: archive of the RPBCH, 2010).

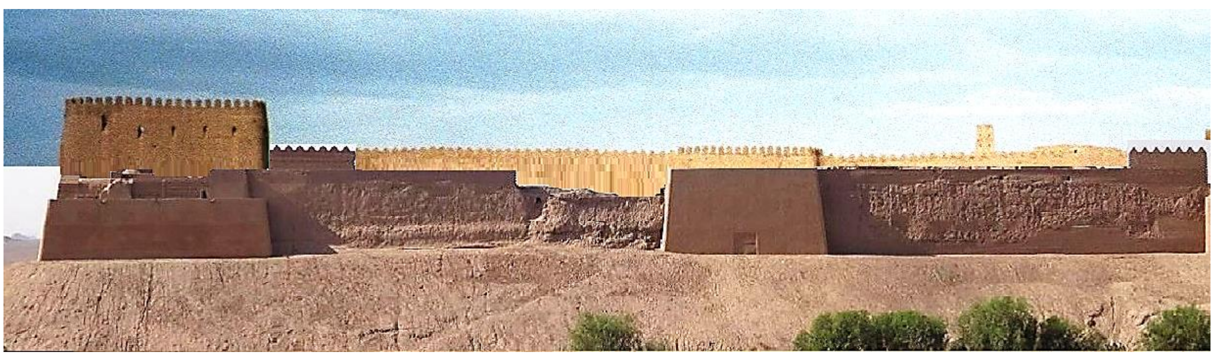


Figure 4.55- The difference between original and present state of Tower No.1, Tower No.2 and their adjacent fortifications (Designed by Author).

- Property No. 4: Bazaar

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Bazaar of Bam Citadel is located on zone (XIV to XII-F) and based on geographical features from Google Earth, it is located on (Latitude: 29° 6'49.40"N–Longitude: 58°22'3.26"E).

▪ **Period of Construction:** The Bazaar of Bam Citadel has all characteristics of a Bazaar in Safavid period (1501-1738 AD): shops with vaulted roof in both sides.[343] However, there are some parts which might have been built during the Qajar period (1794-1925AD) (Tayari, 2004).

[343] The Bazzar from planning point of view is the spine of Iranian cities since the Islamic era, and was fully developed during Safavid period (1501-1738 AD).

▪ **Property Description:** By passing from the Main Entrance Gate, a road in the north-south axis of Bam Citadel lead to the Bazaar, where the Citadel's entry gate begins and at the end of an open space. The Bazaar of Bam Citadel with almost 115 meters long and accommodations of 50 shops in a roofed space (the roof of Bazzar no longer existed)[344] indicates the flourish of Arg-e Bam in the past times. This Bazaar used to offer the necessities of life to the inhabitations (there were oil, cereal, bakery, spice, jewel shops and so on), and also a center for exchange of goods by merchants and traders travelling on the Spice Route, a sub-branch of the Silk Road. In the middle of the Bazaar, there is an intersection, which is covered by a dome in mud bricks (Chāhārsuq in Persian).

In both sides of current Bazaar, there are shops in small and medium sizes, the dimensions of the shops and merchants' compartments located at the south of the Chāhārsuq were different from those found at the north of the Chāhārsuq. In the Bazaar of Bam Citadel, each shop was built based on the type of service it wanted to offer. Adobe shops usually consisted of two or three room or chambers (Hojre in Persian). The first room of shop in front of Bazaar with niches, which were used: 1) as a stage to enter the second or main room of the shops; and 2) as a place to show off the goods to costumers. The difference between the ground of Bazaar's roadway and the ground of shops in the south of Bazaar was almost 10 cm, and by going to the north, this height increased as far as it reached to 60-100 cm (Jafarizadeh & Rasekh, 2011). In term of architecture, the shops do not have any special differences, but the only difference that can be mentioned is their differences in the number of room for storing goods.

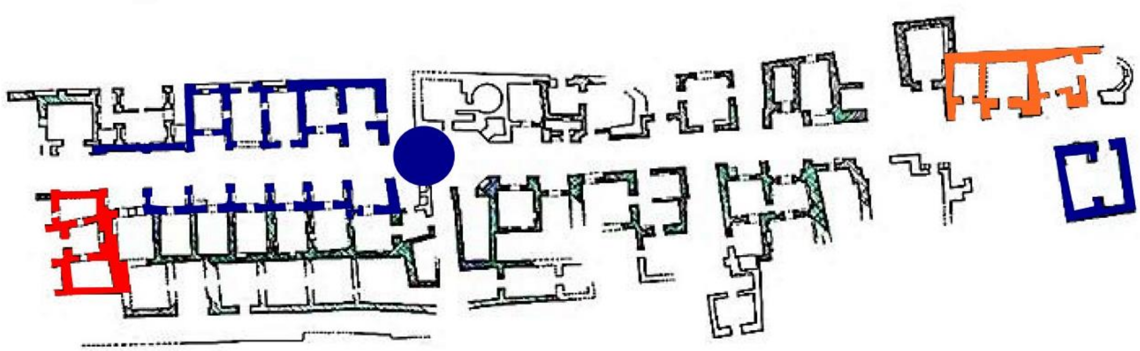


Figure 4.56- The plan of the Bazaar of Bam Citadel (Source: archive of RPBCH, designed by Author).

Table 4.7- Architectural Information of the Bazaar of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches and Decorative latticework by adobe and wood on openings.

[344] In fact, the whole alley of the Bazaar used to be vaulted much the same way as all other Persian bazaars (UNESCO, 2004).

Types of Roofs	Closed and opened barrel vaults, Domes, Dominical and Semi- dominical vaults.
Surface Coating Material	Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** The Bazaar in the Citadel of Bam like other Iranian historical cities was linked with the culture and civilization of Iranian people. In this case, the Bazaar of Bam Citadel as an example of Iranian traditional Bazaar can exactly determinate the role of Bazaar in a small community. However, with an attention to the location of Bazaar and the access roads of Bam Citadel, it can be understood that this property had a very significant role in connecting different parts in the city. For example, everyone after passing from the Main Entrance Gate should pass Bazaar to go to any other section. To go to the Friday Mosque, Takyieh, Public Bath, Payambar Mosque, Governor's Quarter and other public buildings, the inhabitants of the town had to have a passage from the Bazaar. About the commercial value of the Bazaar, we can mention the important location of Bam Citadel in the sidetrack of Silk Road. From the past, this property was recognized as a place for commercial exchanges between traders and merchants from all around the world. Although the flourish of Bam Citadel's Bazaar was along the function of Silk Road in the area, even after it, the Bazaar continued its commercial role in the region. The main architectural element of Bazaar that attracted everyone's attention to itself was a big domed roof named "Chāhārsuq" in its center. As another example of Bazaar's aesthetic value, it can be pointed to the quality of arranging of the shop's roofs along each other, where they created a beautiful image of their continuation. Sometimes during the past conservation activities, several shops of Bazaar were rehabilitated to be used as a place for the promotion of local culture and custom.

▪ **Conservation History before Earthquake:** According to the reports, the conservation of the Bazaar of Bam Citadel by restoration and consolidation of some shops in 1977 had been started. From 1979-1980 AD, the work had continued by some conservation and restoration on the structures of Bazaar. Then in 1983, all along the consolidation of the foundations, restoration of shops and their walls, in order to clarify the different historical layers of the monuments, the foundations of the structures were uncovered. After a 10-year pause, in 1993, the Bazaar was mapped in detail; some archaeological research were conducted to evaluate the chronology of the site; some conservation work were carried out at the Bazaar and its adjacent alleys; and the Bazaar's pavement was renovated. In 1994, the restoration of one of the houses at the Bazaar, wherein the office of the director would be installed was finished. In this year, also the restoration of two shops in the Bazaar were finished, these shops were then turned into shops for selling of the publications on the Arg, and the restoration of pavement in main paths between the Bazaar and the Friday Mosque was continued. In 1996, five shops in Bazaar were restored. In 1998, the restoration and complete renovation of three shops in the Bazaar, west of the Tekiyeh, had been finished, and the restoration of the Chāhārsuq was started. In the years between 1999 and 2000, the restoration of another five shops and Chāhārsuq of Bazaar were almost completed, and the conservation works in the structures at the end of the Bazaar and renovation works of the pavement of the main alley and the adjacent paths going through the Bazaar was continued.

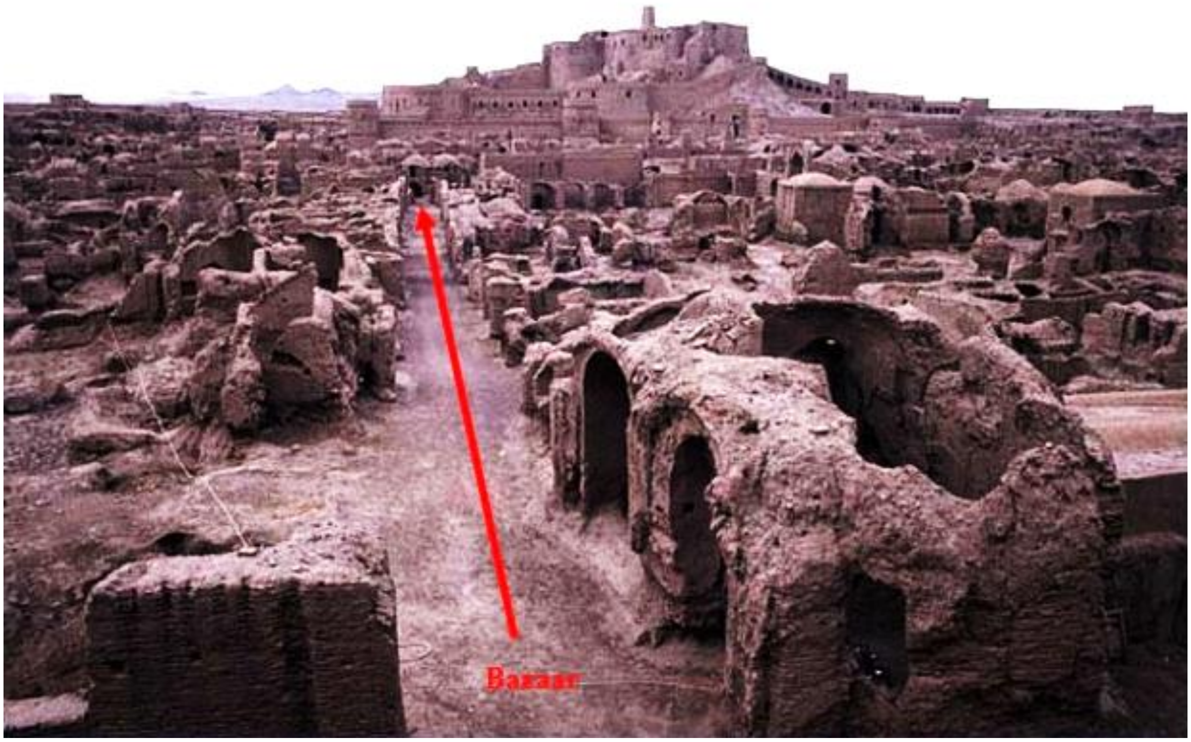


Figure 4.57- View from the Bazaar of Bam Citadel before starting of restoration works before the earthquake (Photo by Kamran Adl, 1976. Source: archive of ICHHTO).

Figure 4.58- The renovation of the Bazaar's pavement, and uncovering and consolidation of wall's foundation between Bazaar and Main Entrance Gate (Source: personal archive of Prof. Tayari, 1993).

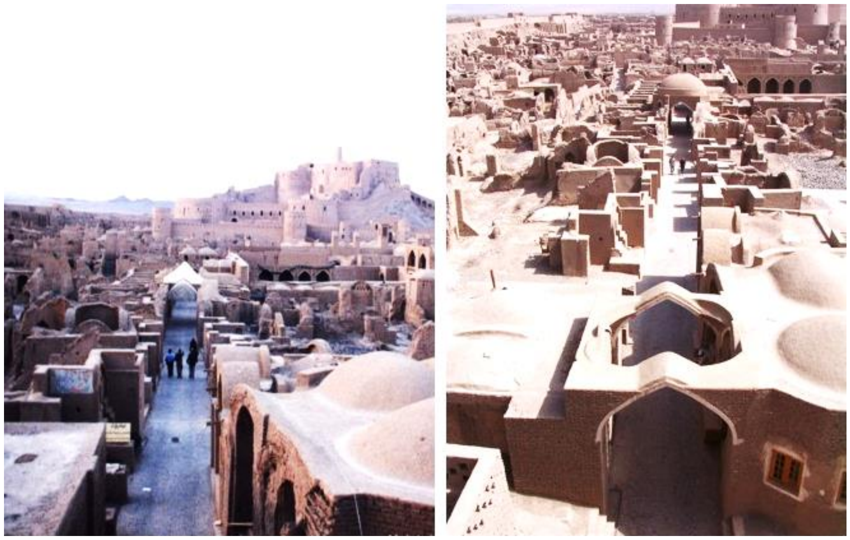
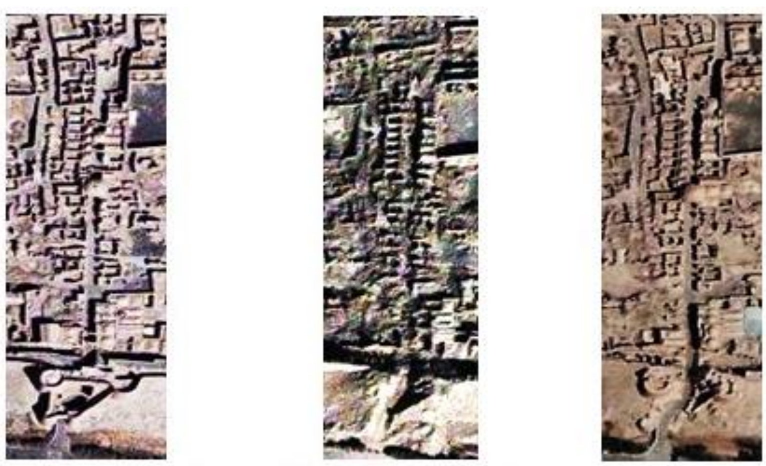


Figure 4.59- (Left) the Bazaar of Bam Citadel under restoration works (Photo by Andaroodi, 1999. Source: archive of Bam3DCG); and (Right) the Bazaar of Bam Citadel after total restoration (Photo by Tadashi Yasuda, 2001. Source: archive of Bam3DCG).

▪ **Physical Condition after Earthquake:** As can be seen in Figure 4.60-61, the percentage of damage in different parts of Bazaar and its alleys were different from one point to another. The damage in the southern part of Bazaar was in a range between 60-80%, around Chāhārsuq, due to the complete collapse of its roof, the damage was at the highest degree 80-100%, and in the northern part of Bazaar, it was in the lowest range from 5-25%. However, in most of the shops, walls showed a good behavior against the earthquake, and a few numbers of them were disintegrated.



2003 before earthquake   2003 after earthquake   2016

Figure 4.60- Aerial pictures from the Bazaar taken in subsequence years (Source: Digital Global and Google Earth).

Figure 4.61- The Bazaar of Bam Citadel after the 2003 Bam earthquake (Photo by Ahmadi & Boroomandi, 2003. Source: archive of ICHHTO).

▪ **Proposed Intervention Plan:** In this property, intervention activities are being executed carefully and there was no major problem for its continuation. Until now, major restoration has been implemented in the Chāhārsuq and northern part of Bazaar and to some extent, they back to their previous shapes as before the earthquake. Meanwhile, there are some parts remained to be reconstructed and restored. There is a plan to use and revive some shops in order to sell and present handicrafts. About the proposed intervention plan, here we are confronted with four different methods of intervention works:

I) At first, to start interventions in the Bazaar of Bam Citadel, an intervention plan was prepared for an adobe shop by the University of Isfahan in collaboration with the Mie University of Japan from 2008 to 2010. This intervention plan was like a pilot project, the result of which was intended to be generalized to other adobe shops, but it has never happened. In this case, the adobe shop was located at the end of the Bazaar with an irregular plan of about 5.5×10.5 m² (red lines in Figure 4.56). As the intervention plan was prepared, some points in the exterior parts of the plan of this shop for vertical consolidation with wooden bars by height of 330 cm were selected. For strengthening of the conjunction of shop's walls and its foundation, the wooden bars were installed in heights of about 80 cm underground. Then in every 25 cm distances, they were pinned by wooden or steel nails on the walls (Hejazi & Mehdizadeh, 2015).

II) The second plan was related to the first and second categories of measures carried out in Bam Citadel, means initial action and normal conservation works, which have been executed through using of adobe bricks produced in the Citadel's workshop (blue lines in Figure 4.56). The operation steps are listed below:

- Debris removal

- Performance of scaffolding
- Performance of protecting buttress
- Dismantling of shattered portions
- Consolidation of foundations
- Alignment of gypsum form
- Restoration an reconstruction of walls, roofs and arches
- Mud and straw plaster

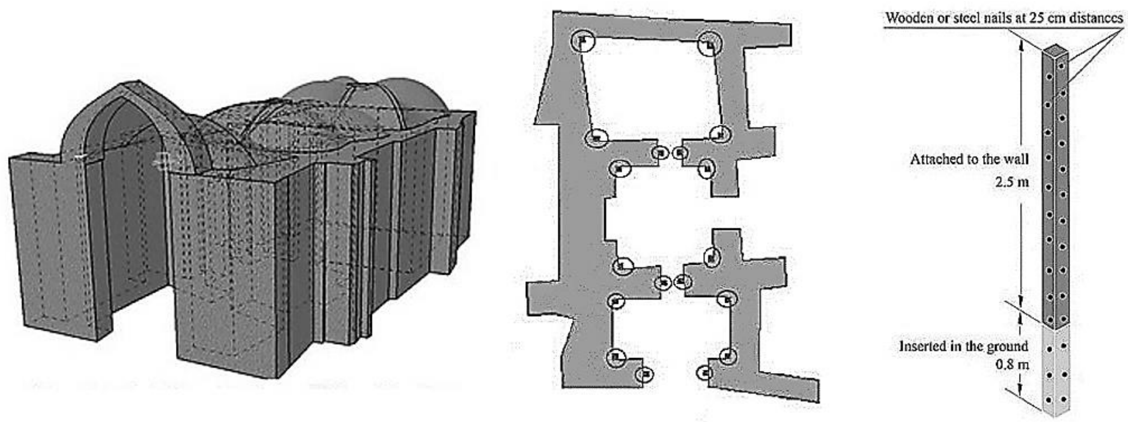


Figure 4.62- Model of the adobe shop stiffened by vertical wooden elements (Source: Hejazi and Mehdizadeh, 2015).

Table 4.8- Mechanical properties of pinewood selected (Source: Hejazi and Mehdizadeh, 2015).

Bulk density (Kg/m3)	600
Modulus of elasticity in the direction of fibres (MPa)	8000
Poisson's ratio	0.47
Allowable compressive stress in the direction of fibres (MPa)	3
Allowable tensile stress in the direction of fibres (MPa)	6

Figure 4.63- The Chāhārsuq and north-west part of the Bazaar after debris removal, and during restoration works (Source: archive of RPBCH, 2008).

Figure 4.64- The Chāhārsuq and north-west part of the Bazaar after complete restoration (Photo by Rouhi 2015).

III) The third one like the second one was implemented by RPBCH, but the difference was in the use of new tension elements for roofs such as palm fibers and fiberglass meshes used prior to the injection process, which became post-tensioning elements with back plates in two sides of load-bearing walls (brown lines in Figure 4.56).

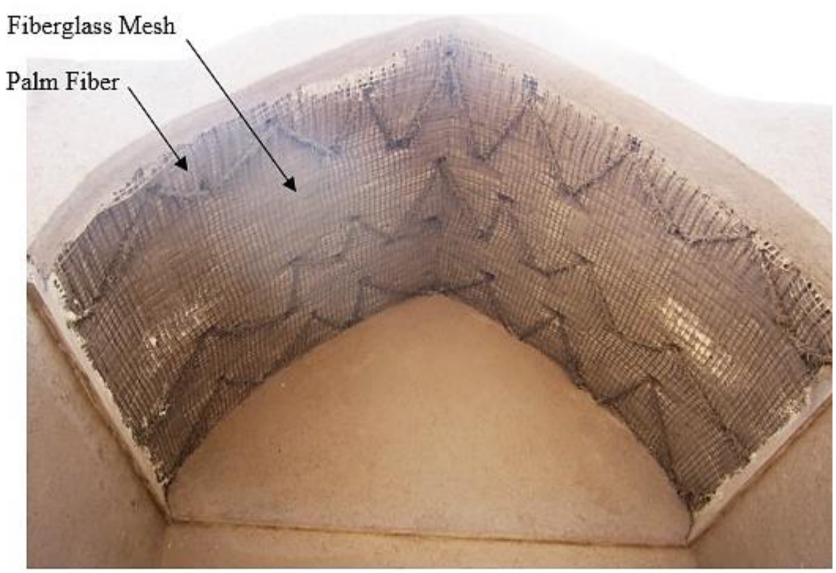


Figure 4.65- The quality of restoration works in a room (south-east of the Bazaar) by palm fibers and fiberglass meshes (Photo by Rouhi, 2015).

IV) The last one was some slight preventive measures carried out in southern part of the Bazaar by mud and straw plastering in deteriorated parts (other shaded lines in Figure 4.56).

Figure 4.66- The condition of an adobe shop (north-east of the Bazaar) after slight preventive measures (Photo by Rouhi, 2015).

- Property No. 5: Tekiyeh

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map that was proposed by the archeological group of Bam Citadel, the Takyieh is located on zone (XIV. XIII. XII and E. F. G), at the end of the Bazaar’s northern-east, and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'50.42"N – Longitude: 58°22'4.11"E).

▪ **Period of Construction:** The construction of this property dates back to different periods of the history; the eastern part is the oldest one, probably founded in 10th or 11th century, the western part and central terrace can date back to Safavid and Zand periods, and the stories in the southern side belong to Zand Period and early of Qajar Period (Frahbakhsh, 2008).

▪ **Plan Description:** The Tekiyeh has four entrances: its main and old entrance is located in the northeast; the second one is located in the southeast side towards the Friday Mosque; and two others of which are located at the southern side. The Tekiyeh consisted of a large rectangular courtyard flanked by rooms in all sides. The western side of the Tekiyeh with its impressive architectural style is diverse from other sides, the stage where religious theaters have been held is located in this part. At the time of ritual ceremonies, related to the Shia Muslim, people have sited and viewed the ceremonies under covered room all around the central courtyard. At first, the Tekiyeh consisted of three pulpits; one in its eastern side and two others in its southern side. Now the only pulpit of Takyieh, which is remained from that time, is shown in figure179. This pulpit is exactly located between two rooms in the eastern side of Takyieh under a two-story building with wonderful iwans.

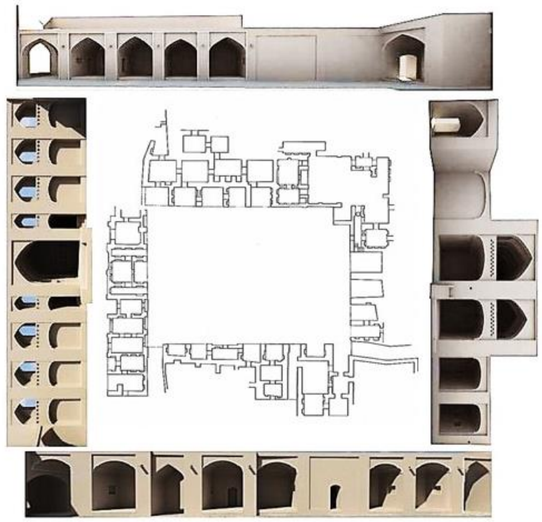


Figure 4.67- Plan and sections of the Tekiyeh of Bam Citadel (Source: archive of Bam3DCG, designed by Author).

Table 4.9- Architectural Information of the Tekiyeh of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches, Theater stage, Pulpit, Iwans, Decorative latticework by adobe on Iwans and central courtyard.
Types of Roofs	Opened barrel vaults, Domes and Semi-domes.
Surface Coating Material	Gypsum decoration, Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** During the history after being haunted, the religious places of Bam Citadel (such places like Tekiyeh, Friday Mosque and Payambar Mosque) have very important role in keeping the whole of complex alive. Before the earthquake, in some days related to the followers of Shia Muslim (on Monday, Friday and other special days), religious ceremonies and festivals took place in these places.[345] Before Islam, the Tekiyeh for its vicinity to Bazaar was probably used as a caravanserai, wherein merchants and traders exchanged their goods. After Islam, the caravanserai changed its usage as a place for doing religious ceremonies. Since

[345] After a brief period of suspension, the Imam Hussain mourning ceremonies were again held at the Tekiyeh of Arg with the presence of 2000 people during the Moharram month of 1977 AD (UNESCO, 2004).

during the Zand dynasty (1750-1794 AD) religious theater gained a very important role in Iran, for this purpose, in the western side of Takyieh, a stage was erected for the related religious program. The western side of the Tekiyeh in two floors is recognized as the most visible part of this property. The theater stage is exactly located in the middle of Tekiyeh's façade. Symmetrically, in each side of the theater stage, there are four under walled arches in the first floor and four open barrel vaults with iwans in the second floor. The western side of the Tekiyeh, where theater stage is located is recognized as the most visible part of this property. This part is built in two floors; the theater stage is exactly located in the middle of its façade.

▪ **Conservation History before Earthquake:** From 1977 until 1982-1983 AD conservation, restoration and consolidation measures in different parts of the Tekiyeh, more specially in eastern side, were taken by simple traditional methods. In 1993, the pavement of one of the alleys between the Tekiyeh and the Mosque was renovated. Then in the next year, restoration works including the removal of additional parts, consolidation of foundations, restoration of rooms, vaults and arches in the west wing and north-west, north-east and south-east corners were completed. Between the years 1995-2003 AD, the Tekiyeh was the object of the following activities: renovation and repair of the structures in the upper floors, including their arches and vaults; renovation and conservation inside the rooms; renovation of the plaster covering of the rooms; restoration of the west portico, northern corridor and the southern entrance. Meanwhile, in the 1999, the second congress of architecture and city planning was held in the Tekiyeh with participation of more than 1200 specialist researchers.

Figure 4.68- View from the Tekiyeh before beginning of restoration works (Photo by Fariba Farzan, 60s of the 20th century. Source: archive ICHHTO).

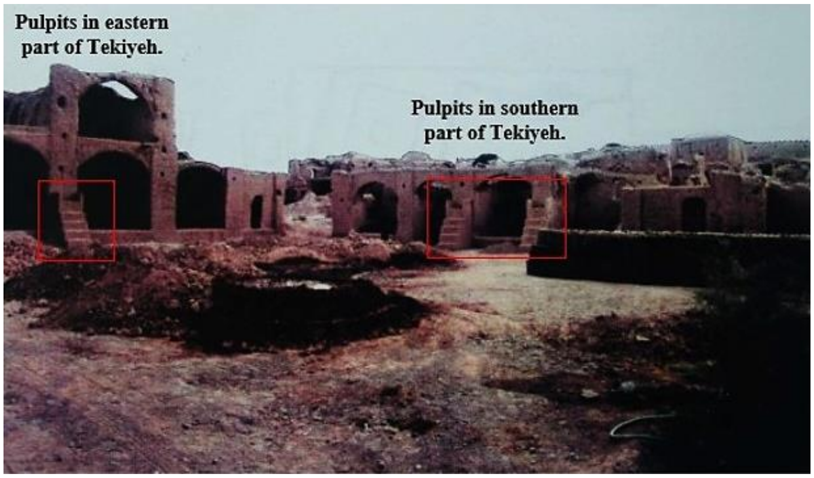


Figure 4.69- The Tekiyeh of Bam Citadel under restoration works. As can be seen in this photo, there was two pulpits in the southern part and one pulpit in the eastern part of Tekiyeh, in the next period during the restoration works the two southern pulpits were canceled from the plan (Source: archive of ICHHTO, in the late 20th century).


Figure 4.70- (Left) the eastern part of the Tekiyeh under restoration works (Photo by Arfaei, 1997. Source: archive of ICHHTO); and (Right) the western part of the Tekiyeh under restoration works (Photo by Louyot, 2003. Source: archive of Bam3DCG).


Figure 4.71- The eastern and western parts of the Tekiyeh after complete restoration (Source: archive of RPBCH).

▪ **Physical Condition after Earthquake:** The damage state in Takyieh of Bam Citadel was almost slight compared with that in other parts of the Citadel. However, the rate of damage in parts, where the property were built on two floors were more than other parts (eastern and western parts) due to complete collapse of the second floors. In other parts, except for partial collapse and cracks in some parts of the property, no special damage has been reported.

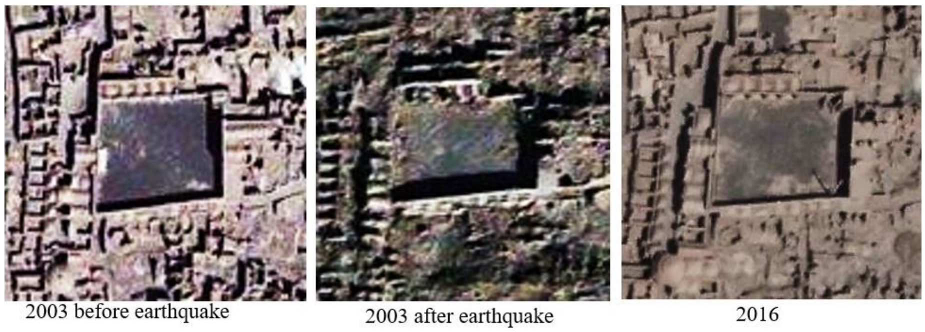


Figure 4.72- Aerial pictures from the Tekiyeh taken in subsequent years (Source: Digital Global and Google Earth).

Figure 4.73- Aerial photo of the Tekiyeh of Bam Citadel after the 2003 Bam earthquake (Photo by Farhangi, 2003 (Source: archive of ICHHTO).

Figure 4.74- The eastern part of the Tekiyeh after the 2003 Bam earthquake (Source: archive of RPBCH).

▪ **Proposed Intervention Plan:** Since the state of damage in the Tekiyeh of Bam Citadel was less than other properties. Also, regarding the high religious and local importance of Tekiyeh for the people of Bam, and in order to provide an example for future steps, this property was one of the first properties which was cleaned and taken under restoration activities (between the years 2005 until 2011). "Debris removal started from the eastern side. Simultaneously, the recovered materials were sorted and classified. Most of the debris were accumulated in the western part of the site, where the access would be easier" (UNESCO, 2004). This property, before the earthquake had been well documented, so there was no major problem for its restoration. Presently, the restoration of this property has been finished, and it is continuing to its religious function as before the earthquake.

In this property, Iranian experts from RPBCH prepared the intervention plan, in which after debris removal, performance of scaffolding and performance of protecting buttress, all western and northern sides were almost reconstructed, and some repair, stabilization and preventive measures have been implemented in the southern and eastern sides of the property. Each repair technique that has been developed for stabilization and seismic improvement of the Tekiyeh is listed below (Rouhi, 2016c):

- The southern side of Tekiyeh: since the damage was so slight in this part, the procedures were mostly focused on protective and preventive measures with some restoration measures in the necessary parts, (see Figure 4.75).

Figure 4.75- View from the southern part of the Tekiyeh (Photo by Rouhi, 2015).

- The northern side of the Tekiyeh: for the stabilization of roofs, the palm rops and palm meshes are used. For more detail, on the outer part of roofs, some diagonal grooves were created along with some holes between their outer and inner parts for insertion of palm ropes and sewing the roofs. Then, ropes were tied on wooden plates by passing from the side's load-bearing walls. Finally, palm meshes and clay and straw mortar (Kahgel) covered the outer part of the roofs. In this part, the walls were stabilized by new technique, so walls were vertically stabilized by natural tension elements of palm. In this case, after vertical drilling of walls until 150 cm under the wall's foundations, the palm cables with a thickness larger than palm rops were inserted. For the fixation of palm cables, their lower parts consisted of a metal hook and their upper parts were fastened by metal interfaces on the wooden plates, and the end holes were injected by compatible mud-grouts. In addition to those works, walls have been also reinforced in their width by palm cables and back plates.

Figure 4.76- (Left) drilling of walls vertically for insertion of palm ropes; and (Right) creation of grooves in outer surface of roofs for placement of palm rops (Source: archive of RPBCH, 2008).

Figure 4.77- (Left) stabilization of the roofs by their wrapping out with palm meshes (Source: archive of RPBCH); and (Right) the quality of the sewing of inner and outer parts of roofs by palm ropes (Photo by Rouhi 2015).

Figure 4.78- (Left) the northern part of the Tekiyeh after complete restoration; and (Right) the quality of the tying of palm cables on the back plates, and the quality of the passing of palm cables from inside of load-bearing walls (Photos by Rouhi, 2015).

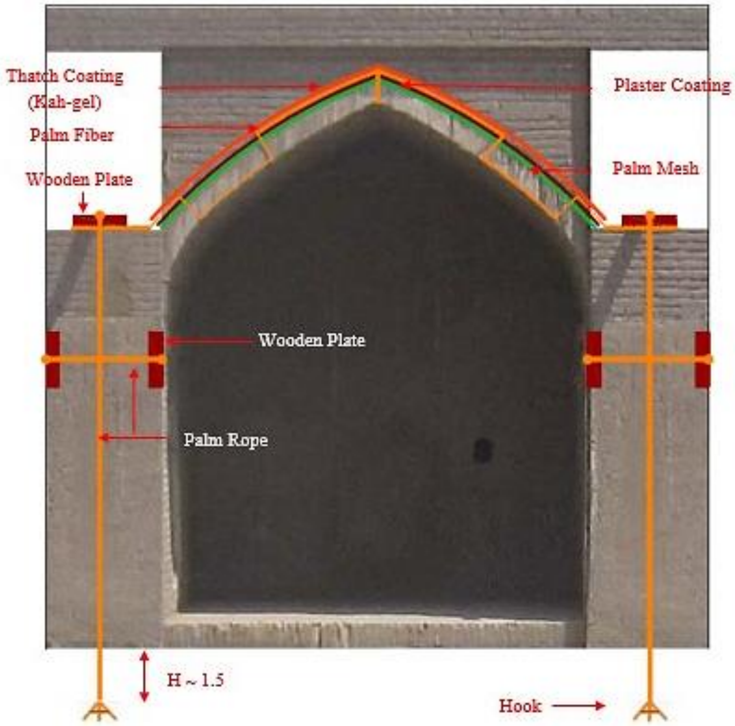


Figure 4.79- Schematic picture from intervention plan proposed for northern side of the Tekiyeh (Designed by Author).

- The eastern side of Tekiyeh: in this part, the only stabilization activity was the employing of the fiberglass rods in the length of walls horizontally without any back plates, see Figure 4.80. In this part, the restoration and reconstruction activities have been limited just on the first floor.

Figure 4.80- Stabilization of load-bearing walls in the eastern side of the Tekiyeh by insertion of tensile elements (Photo by Rouhi, 2015).

- The western side of the Tekiyeh: in this part, due to the high height of the walls, the only main stabilization work was carried out in two main load-bearing walls of the theater stage. So far, after drilling the walls horizontally, in the length of walls, cables weaved by palm fibers were inserted and later they were fastened by ‘metal interfaces’ on the ‘teflon plates’. Once the tension elements were inserted into the walls, they were grouted in place (see Figure 4.81).

Figure 4.81- The western part of the Tekiyeh after total restoration (Photos by Rouhi, 2015).

- Property No. 6: Friday Mosque

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Friday Mosque of Bam Citadel is located on zone (XIII and XIV- I to J) and based on geographical features from Google Earth, it is located on (Latitude: 29° 6'49.04"N– Longitude: 58°22'10.30"E).

▪ **Period of Construction:** Generally, Mosques as the main symbol of the Islamic faith were built in Iranian cities by the 7th century as the main spaces for communal worship. After the advent of Islam in Iran, Muslim went through structural changes in order to meet the requests of Muslim communities. In many cases, the Zoroastrian fire temples were transformed into mosques or were demolished if people resisted (Kheirabadi, 2000).[346] Ebn Ḥawqal and other travelers from the 4th/10th century visited a large fortress in the middle of the town, containing

[346] Kheirabadi, M. (2000). Iranian cities. Texas: Syracuse University Press, p. 64.

one of the city's three mosques, which was reputedly impregnable (Le Strange, Lands, pp. 299, 312).[347] According to Pope Arthur, the Friday Mosque of Bam was built during the Safavid Period (9th century).[348] However, it seem more likely that this mosque was built much later when the majority of people converted to Islam, and so it was built over the foundation of a fire temple. After archeological investigations associated with the earthquake debris removal, it became possible to estimate the exploration of the evolution of the Friday Mosque into its present form. In the north side of this property, there was a 'Mihraab' or 'Alter', which date back to 1747. After a comparison between Friday Mosque of Arg-e Bam with other Mosques in Iran, it can be understand that this mosque is so old, in which there is no common artistic decoration that existed in traditional Iranian Mosques. In this Mosque, different layers of construction could be seen in the remains of a certain ancient building: the ruins of Safavid wall, a Mihraab of the Timurid period, the gallery dating back to the Seljuquid time, the Safavid redecorations, adornments belonging to the Zand's Dynasty, the Qajar- dating stone-pebbled pavements and even the latest Pahlavi amendments (Behzadi, 2004).

▪ **Plan Description:** The area occupied by the Friday Mosque is about 2464 m². At the beginning part of Bazaar and in the southern side of the Tekiyeh, there are roads that lead to the Friday Mosque of Bam Citadel. To enter the Friday Mosque, the main doorway was opened in its south-western side. The Mosque in its earliest form faced to the east, but later its internal arrangement was reconfigured to the south west towards Mecca. The Friday Mosque had a courtyard surrounded by three prayer halls (Shabestan in Persian) and four iwans (porticoes), which later changed to three on the west, two in the north and one in the south sides. There are archaeological evidences that show Shabestans of Friday Mosque had not been built at the same time. The columns and the length of the arches between the columns support the hypothesis of the different time of construction.[349] On the southeastern side of the mosque, there is a well; which is much venerated by the population in Bam as a shrine that is known as "Chāh-e Sāheb-e Zamān" or the "Well of the 12th Imam". This shrine consists of a well with almost 20 m height and an area occupied about 1×2 m².

Table 4.10- Architectural Information of the Friday Mosque of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches, Shabestan (prayer halls), Pulpits altar, Azan tower, Windrowers, Iwans, Central courtyard, Decorative latticework by wood and adobe in openings.
Types of Roofs	Opened and closed barrel vaults, Domes and Semi-domes with holes in upper parts

[347] It was probably one of the oldest mosques ever built in Iran.
[348] For more details about the Bam's Mosques, see Pope. A. survey of Persian art, Vol. III, p. 128.
[349] As my personal interview by Prof. Tayari, during Saffarid, Saljughid, Safavid, Afshar and Ghajar periods some changes was performed in Friday Mosque.

Surface Coating Material	Chalk Mogharnas, Gypsum decoration, Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

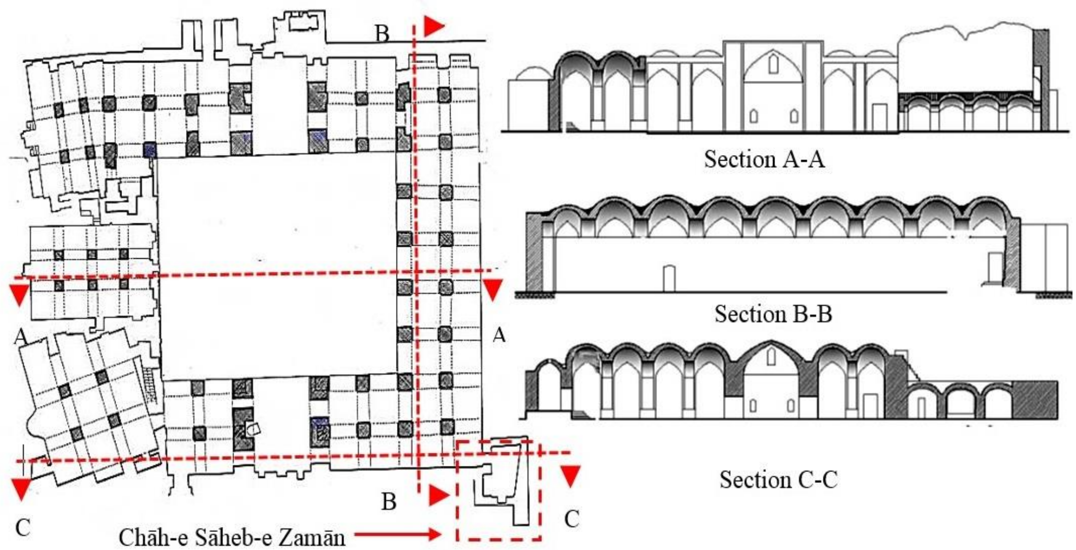


Figure 4.82- Plan and sections of the Friday Mosque of Bam Citadel (Source: archive of RPBCH).

▪ **Property Values:** From the beginning of Islam, the Friday Mosque (this type of Mosque sometimes called 'Congregational mosques' or 'Jame Mosque') refers to the main Mosque of a town, city or village, and is usually the place of gathering for "Eid Prayers" and "Friday Prayers". The Friday Mosque of Bam Citadel as a place where the Muslim in the city of Bam could came together for pray, as well as a center for information, education, and settling dispute has very important religious value among the people of Bam. The Friday Mosque of Bam Citadel as one single historical property of Bam city always was in the center of interest. In this context, by the change of federal government in the city, decisions were made to protect Friday Mosque and to keep it alive. After the earthquake, extensive archeological studies have been conducted. As a result of these surveys, more than 230 pre-historic pottery pieces were found. However, in this property, we could see a process of development of a religious place in an ancient city of Iran. Therein, a combination of architectural elements and their placement around the courtyard and inside of the Friday Mosque very well visualized a spiritual place in the city.

▪ **Conservation History before Earthquake:** During the history, this property has been under several changes, there is no clear evidence of the date of these changes, but up to the time of the earthquake, the Friday Mosque was under some restoration. The conservation activities in this property had started in 1977. Until 1982, the main structures of the Mosque were restored and consolidated; some parts of the mosque that were covered by rubbles had been uncovered, and maintenance of conservation was carefully executed. In 1983, the foundations of structures at the Friday Mosque had been uncovered in order to clarify the different historical layers of the property. Then in 1993, this Mosque was faced with vast conservation activities, such as:

the Friday Mosque was mapped in detail; the pavement of one of the alleys between the Tekiyeh and the Mosque was renovated; the southern prayer hall of the Mosque was restored; the investigation for finding the original soil of the Mosque's hall was carried out; and repairs were taken in damaged roofs and the 'Prayer Niche' (Mihrab in Persian). In 1994, like 1993 vast conservation activities had been performed in Friday Mosque of Bam Citadel; the restoration of pavement in main paths between the Bazaar and the Mosque was continued, restoration works at the southwest prayer hall was completed, so it had been readied for people's use, and pillars in the north-west prayer hall and repair of its pavement were finished. Then between the years 1996-2002, some measures in different parts of the Friday Mosque of Bam Citadel had been taken: the southern prayer hall was renovated, including its façade (1996); research was conducted on different architectural phases of the Mosque and restoration measures were carried out in the eastern prayer hall (1998); the restoration work in the south-west prayer hall was completed (1999); conservation works were executed in different parts (2001); and some conservation works were implemented in the shrine of Saheb al-Zaman (2002).

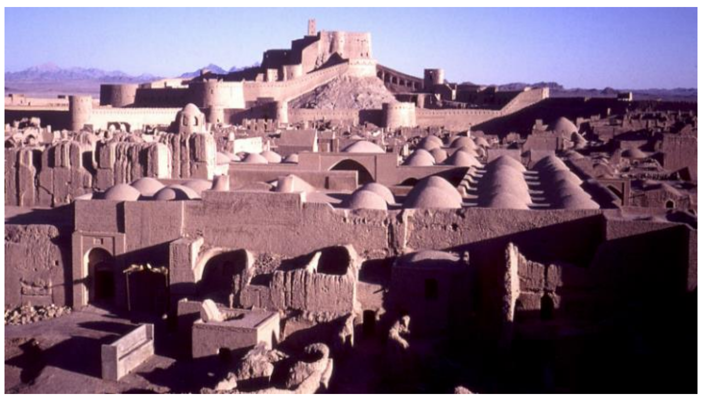


Figure 4.83- Bird view from the Friday Mosque before the 2003 Bam earthquake (Photo by Louyot, 2001 (Source: archive of Bam3DCG).

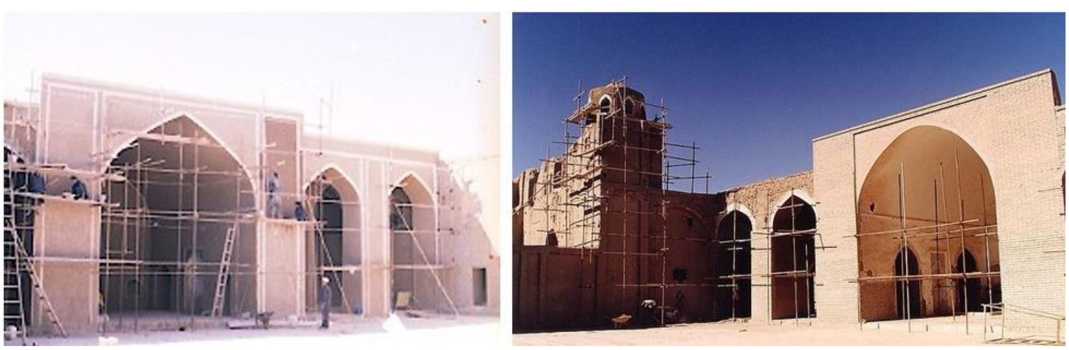


Figure 4.84- (Left) new plastering of the façade in around of central courtyard of the Friday Mosque (Source: personal archive Prof. Tayari); and (Right) the restoration works in the Azan Tower of the Friday Mosque (Photo by Ingham, 2002. Source: https://www.flickr.com).

▪ **Physical Condition after Earthquake:** This property was badly destroyed after the 2003 earthquake. Almost all of the bases of pillars were crashed, and roofs were fell down, and nothing remained by the earthquake except ruins.

2003 before earthquake 2003 after earthquake 2016

Figure 4.85- Aerial pictures from the Friday Mosque taken in subsequent years (Source: Digital Global and Google Earth).

Figure 4.86- (Left) aerial photo from the Friday Mosque of Bam Citadel after debris removal (Source: Annual Report of Arg-e Bam Research Foundation, 2008); and (Right) the quality of protective and preventive measures on the remains of pillars after the earthquake (Source: http://shahrkhabar.ir, 2013).

▪ **Proposed Intervention Plan:** Because of the high religious value of the Friday Mosque among people of Bam, who wanted the mosque regain its function as before the earthquake, but until now no special work has been performed except of the reconstruction of the "Well of the 12th Imam". In this property, the main problem is the extent of destruction, almost nothing, but some pillar bases are remained. In Iran, there is an organization, which deals with restoration of religious places as named "Sazman-e Owqaf", which by getting some fund has significant help to the related projects. In the case of the Friday Mosque of Bam Citadel if it were to benefit from this financial support, at first it is crucial that its intervention plan be prepared.

As a brief explanation of the works carried out in the Friday Mosque: the debris remained after the earthquake have been removed; in the northern wall and in places where were necessary, the construction of scaffolding and performance of protecting buttress are implemented; to prevent more deterioration of ruins remained, the preventive measures have been taken; the small pilgrimage place of the Friday Mosque is reconstructed as before the earthquake by application of the normal traditional methods.

Figure 4.87- The “Well of the 12th Imam” after complete reconstruction (Photos by Rouhi, 2015).

- Property No. 7: Mirza Na’eim School

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Mirza Na’eim School of Bam Citadel is located on zone (XII and XIII–I to J) and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'50.46"N – Longitude: 58°22'9.85"E).

▪ **Period of Construction:** This type of arranging of the buildings in an ensemble has roots in the Islamic culture and societies. The ensemble was built by Haji Seyyed Mohammad Mirza Na’eim, a mystic and astronomer who was one of the most prominent figures of Bam probably at the end of the Safavid period (early 18th century.) (UNESCO, 2004).

▪ **Plan Description:** Adjacent to Friday Mosque is the Mirza Na’eim Ensemble. The plan of Mirza Na’eim Ensemble consisted of two sections of interior (living quarter for Mirza Na’eim and his family) and exterior (studying quarter for the students) with several intertwined courtyards.[350] The school of Mirza Na’eim as part of Mirza Na’eim Ensemble is located in the southern-west part of this Ensemble. The main possible way to get access this school was

[350] The tomb of Mirza Na’eim was located in one of ensemble’s courtyard in the north-west side.

located in its southern side. The Mirza Na’eim School consisted of a central courtyard with rooms in all its four sides. The most visible part of the Mirza Na’eim School was its southern side with large iwan, and a one-directional windrowers with 12 wings.

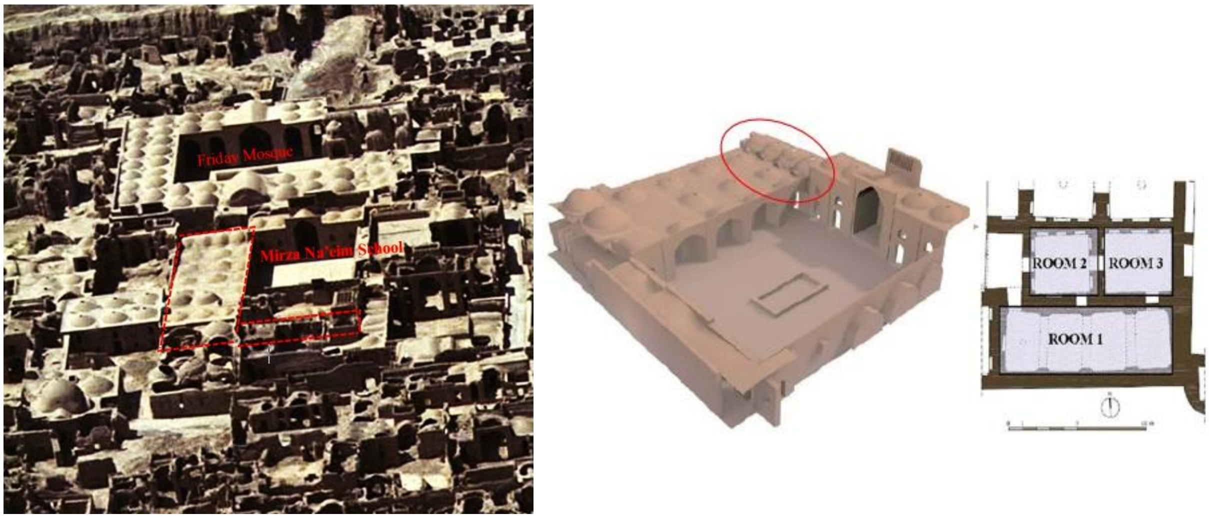


Figure 4.88- Bird view from the Mirza Na’eim Ensemble and Friday Mosque of Bam Citadel, and the plan of Mirza Na’eim School and rooms which were studied by Italian group (Source: (Left) archive of RPBCH; and (Right) archive of Bam3DCG, designed by Author).

Table 4.11- Architectural Information of the Mirza Na’eim School of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Heater, Under walled arches, Decorative latticework by wood and adobe in openings, Wind towers, Central courtyard and Pool.
Types of Roofs	Different types of barrel vaults, Dominical and Trought vaults.
Surface Coating Material	Gypsum decoration, Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** After Friday Mosque of Bam Citadel, the Mirza Na’eim Ensemble is recognized as the most important monument in the public quarter of the Citadel. The school of Mirza Na’eim, as a part of this Ensemble, before introducing of its architectural values, it gives us an evolution of thought in a small ancient Iranian community; this property with its social, educational, architectural, cultural and historical values precisely shows the importance of acquisition of knowledge among past Iranian people.

▪ **Conservation History before Earthquake:** The conservation history of Mirza Na’eim School can be divided into three main dates; 1993, 1994-1995 AD and 1996-1997AD. In the following section, the conservation activities related to each category are described in details:

- 1993: conservation work at different structures had been performd, such as; uncovering of its original soil; stabilization of roofs; new plastering of the façade; excavation to find the base of courtyard; consolidation of foundations in necessary parts of the property; restoration of roof's slope and thatch coating; replacement of troubled adobe-mud brick, domed and vaulted roofs.
- 1994-1995: continuation of the restoration of Mirza Na'im School, including plastering of the rooms in the east and north wings of the property for construction of the bedroom; restoration works at the southern iwan of Mirza Na'im School and its adjacent rooms; restoration of the buildings located in the north-east corner of Mirza Na'eim School for service purposes; installation of gutters in essential parts; complete renovation of pavement in the Mirza Na'im School; restoration of the pool in the center of Mirza Na'eim School.
- 1996-1997: by the following activities, the conservation of the Mirza Na'eim School was finished: maintenance of conservation; restoration of the entrance of one of the houses to the east of Mirza Na'eim including renovation of its plaster; restoration in one of the structures located at the east of Mirza Na'eim School known as a coffee-house.

Figure 4.89- The restoration works had been carried out in subsequence years in the southern part of the Mirza Na'eim School before the 2003 Bam earthquake (Source: persional archive of Prof. Tayari).

▪ **Physical Condition after Earthquake:** The Mirza Na'im Ensemble was damaged to a noticeable degree; the house was completely destroyed, the stables was nearly completely damaged and the only standing part was the eastern part of Mirza Na'eim School where was faced with partial collapses. According to FINAL REPORT TO UNESCO 2007 about the activities and analysis taken in the Mirza Na'eim School (2007), adapted by the Italian group, the seismic damages occurred in this property are clearly related to: 1) overturning of some facades due to out of plane actions where poor connection existed between the building walls and the floors or roof; 2) separation between different leaves of the same wall (e.g. chineh and adobe); 3) large cracks in the chineh walls (probably some of them were present also before the earthquake); 4) damages to vaults and domes according to the different typologies."[351]

2003 before earthquake 2003 after earthquake 2016

Figure 4.90- Aerial pictures from the Mirza Na'im Ensemble taken in subsequence years (Source: Digital Global and Google Earth).

[351] Final Report to UNESCO, "UNESCO CONTRACT BAM CITADEL, MIRZA NAIM SCHOOL", responsible: Prof. L. Binda from DIS – Politecnico of Milan, June 2007. (Unpublished).

Figure 4.91- Damage induced by the 2003 Bam earthquake to different parts of the Mirza Na'eim School (Source: personal archive of Prof. Luigi Marino).

▪ **Proposed Intervention Plan:** In October 2 to 4, 2006 following the visit by Prof. Binda and Prof. Modena from Bam site, a meeting was held between Iranian authorities and Italian group for discussion about the possibilities of working on the Mirza Na'eim School and the contribution given by the Italian team composed by Prof. Luigia Binda, Prof. Claudio Modena, Prof. Carlo Blasi, Prof. Vincenzo Petrini and Prof. Luigi Marino, within the UNESCO Contract. As result of the meeting, the Iranian authorities informed the Italian group that due to the very low budget from the UNESCO Contract, it did not seem possible that the Italian delegation could embark on a real project of intervention on this property or on others, even smaller; the result could only be at the end a guideline for the solution of some typical problem found in Mirza Na'im School and common to other parts of Bam (Binda & Modena 2006).[352] In the meantime, on behalf of the Italian team, Guido Licciardi, a PhD student in Cultural Heritage

[352] Final Report to UNESCO, "UNESCO CONTRACT BAM CITADEL, MIRZA NAIM SCHOOL", responsible: Prof. L. Binda from DIS – Politecnico of Milan, June 2007. (Unpublished).

Preservation at the School of the Politecnico of Milan, which had previously studied about Bam Citadel was missioned to stay for a certain period at the site with the following tasks (UNESCO Contract Bam Citadel, Mirza Na'im School, 2007):

- Complete the architectural survey of the Mirza Na'im complex and add information on its conservation state;
- Organize a preservation workshop with local technicians and workers, in order to study, teach, and apply suitable methods for protecting and preserving ruined mud architectures respecting their authenticity;
- Organize training activities directed to the staff working for the Iranian Authorities.

The comprehensive survey made by G. Licciardi was useful for the Italian team to carry out an assessment of the state of conservation of the Mirza Na'eim complex. This included a better knowledge of all building techniques found at the site; of the conditions of the architectures before and after the earthquake; of architectural and structural damages caused by the earthquake; and of all decay currently affecting the area. The survey allowed also to study some local traditional system which could be considered as used since the old times to improve the structure response against the earthquake were disclosed (e.g., lightening vaults namely *cunù*, see Figure 4.92; and horizontal wooden reinforcements, see Figure 4.93). This knowledge could be of great importance for the design of future intervention for the improvement, preservation and restoration of the site because it was highly sustainable both from an environmental and economical point of view (UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).[353]

Figure 4.92- Traditional lightening vaults to increase the building's strengthen against the earthquake discovered on the roof during one of the mission carried out by Milan Polytechnic (Photos by Milan Polytechnic, 2006. Source: UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).

[353] In fact, the representation found by Italian team had constituted the general framework for the plan, which wanted to be proposed by them.

Figure 4.93- Traditional horizontal wooden reinforcements to increase the building's strengthen against the earthquake discovered on the north wall during one of the mission carried out by Milan Polytechnic (Photos by Milan Polytechnic, 2006. Source: UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).

At first, to start practical activities by Italian team in Mirza Na'eim School, during a mission held in December 2006, the local authorities asked G. Liccirdi to develop a suitable method for protecting restored structures and preserving those ruined architectures which were not to be not rebuilt, but simply preserved due to their materials' and historical authenticity (as defined by the 'Nara Chart'). The method was supposed to have the following features (UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007): 1) easiness; 2) warranty of success; 3) economic sustainability; 4) environmental sustainability; 5) flexibility to all situations found within the site; 6) preservation of all signs of the earthquake to keep that historical page readable onto the structures fully respecting the history of the site; and 7) respect of all International and UNESCO Charters and Recommendations in the field of protection and preservation of cultural heritage. All of those selected materials had a very low impact, respectful of local culture, and easily available on site: clay, sand, straw, water and cotton fabric.

In brief, the sequence of actions comprising this method is listed below (UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007):

▪ wetting of top of the remaining walls to ensure a proper connection between existing and new materials;
▪ structural reinforcement of existing walls, through either new bricks crossing old and new structures, and execution of water injections to join all cracked fragments;
▪ placement of wet cotton fabric to separate old and new structures with a physical layer, leaving a trim that is directly visible allowing people to recognize the intervention;
▪ integration of collapsed parts in order to have only one horizontal layer, respecting the 1964 Charter of Venice on the preservation of cultural heritage. All new materials were suggested and analyzed by the laboratory established nearby the site by the local Authorities;

▪ realization of a continuous layer made of mud bricks arranged in such a way to keep rainfall water away without flowing on the surfaces of the structures; execution of a small step made of clay to allow rainfall water dripping without eroding the surfaces of walls;
▪ laying of a finishing layer of mud mortar added with straw to protect the preservation and create a surface that could be replaced in the next years without making again all previous work phases; and carving of the year 2006 in Gregorian and Persian calendar and placing of pictures showing the Institutions involved in the activity.
The next two pictures show the structure where the workshop was held, before and after the intervention works, see Figures 4.94 and 4.95.

Figure 4.94- Ruined building beside the Mirza Na'eim complex. Before the preservation was carried out by Milan Polytechnic (Photos by Milan Polytechnic, 2006. Source: UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).

Figure 4.95- Ruined building beside the Mirza Na'eim complex. After the preservation was carried out by Milan Polytechnic (Photos by Milan Polytechnic, 2006. Source: UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).

After the preliminary preserving works, on February 5 to 12 2007, Prof. L. Marino and V. Pertrini had a visit to Mirza Na'eim School. As a result of site visit, three rooms in the south-eastern corner were selected for proposing intervention plan (Figure 4.88 (Right)). As having a description from the pilot project, the aim of the project was to propose some preliminary actions for the repair and reconstruction of the damaged parts of the three chosen room, according to the following program (UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007):

1. Vaults and arches: The collapsed vaults in Room 1 are the only elements which should be reconstructed. Details on the technique of construction are not given here, since the Iranian technicians and masons are very well skilled in this type of construction;

2. Partially collapsed vaults (Room 1 and 3): the missing parts should be reconstructed. (Room 3): This vault has to be repaired and completed. After positioning of a provisional structure in timber, a tentative to recover the settlement should be made by using the provisional structure to force it. In case the tentative should fail demolition and reconstruction of the settled part has to be done. Also the missing parts of the top of the walls should be reconstructed with the use of adobe;

3. Rendering and plasters: an operation to be carried out in room 1, 2 and 3 is a complete control of the plaster; the parts which are detached have to be demolished, while the parts which have still good bond with the masonry should be left untouched. The missing parts should be reintegrated with new materials. For the repair clay and straw should be used similar to the existing plaster. We also suggest covering the last layer of the plaster only with clay so that the plaster can be protected from external attack (insects);

4. Tie beam: in order to improve the "box" behavior of the load bearing (and shear) walls it would be appropriate to introduce tie beam along the perimeter of the room in coincidence with the spring of the vaults. Two different alternative techniques are proposed:

a) Insertion of timber tie beam in the case of the collapsed vaults; details of the connections between the beam of the longitudinal and transversal walls (Figure 4.96). In the case of the transversal wall where the vault is still present, this solution can be adopted by inserting the beam from the top of the wall with a small demolition. The beam should be distributed along the perimeters. The timber tie beam can be of two types: 1) half cut trunk of a palm tree as found in Bam in some buildings; 2) a beam with square section joined (Figure 4.97);

b) Use of the Polypropylene pipes suggested by the Soil Engineering Services (Tehran). See the material presented by them to the Expert Meeting in March 2007 at Pardis Faculty of Fine Arts, Tehran. These pipes should be inserted on both sides of the walls as tie beam instead of the timber ones along the whole perimeter of the room. The pipes can be inserted in niches excavated on the two sides of the wall where possible. The connection between the tie beam at the corners of the walls can be made through a timber cubic element to which the pipes are screwed. In Figure 4.98, the positions of the beam are represented in the plan; and a drawing of the detail of connection is presented;

5. Repair of cracks: the cracks should be injected using a properly prepared grout made by simple clay or a mix made by clay and lime. A careful study of the w/b ratio, of the ratio clay/lime, of the grain size distribution of the aggregates and of the injection pressure (very low) has to be carried out before applying the technique and after studying carefully the dimension and distribution of the cracks;

6. Missing materials or parts of the wall surface: where small parts of Chineh are missing a sort of mould should be prepared and clay should be injected inside in order to reconstitute continuity and regular surfaces of the walls;

7. Transversal connectors: where connection is missing in the section of the wall (e.g. separation between Chineh and adobe parts) Propylene pipes should be inserted transversally after coring the walls carefully. The connectors can be positioned at a distance of 70 to 80cm. The connectors could be perforated and be used also as injectors of a fine grout made by clay and lime in order to obtain a sort of bond between the connectors and the wall. They can be fixed also to the wall at the end on both sides; in Figure 4.99, two different solutions are presented.

8. Niches: Niches which can weaken the walls should be closed. In particular the two niches between room 1 and 2 and room 1 and 3 have to be closed after demolishing the thin wall. The filling can be made with adobe. A connection of the adobe with the rest of the wall can be made.

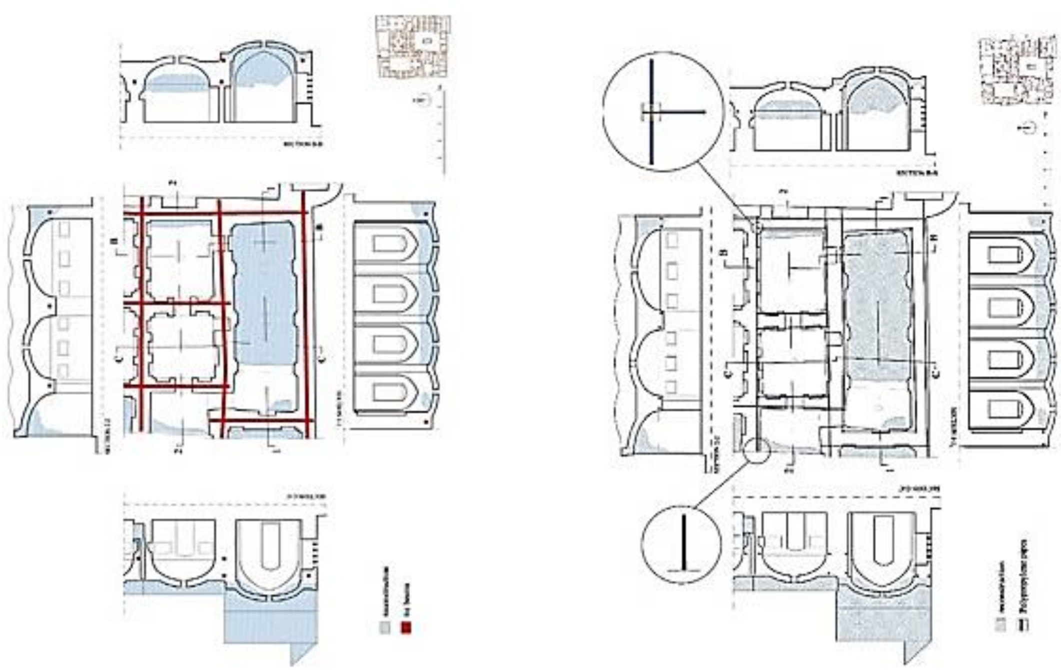


Figure 4.96- (Left) positioning of the timber beam; and (Right) positioning of the Polypropilane pipes (Source: UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).

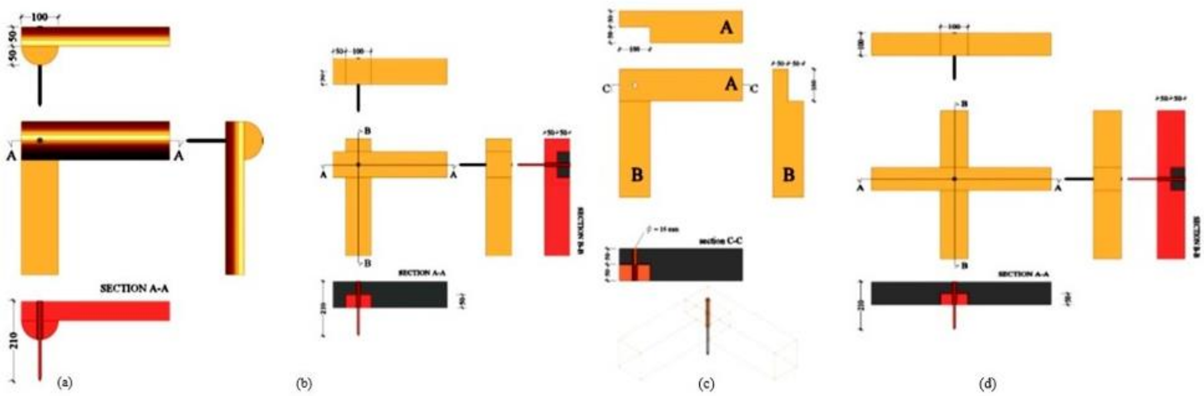


Figure 4.97- Details of the timber beam: solution 2 (Source: UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).

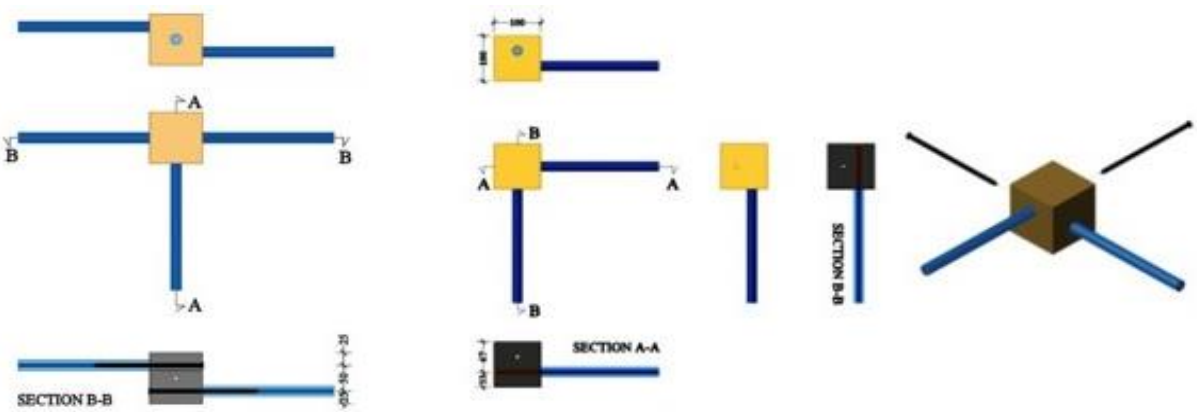


Figure 4.98- Details of the pipes connections (Source: UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).

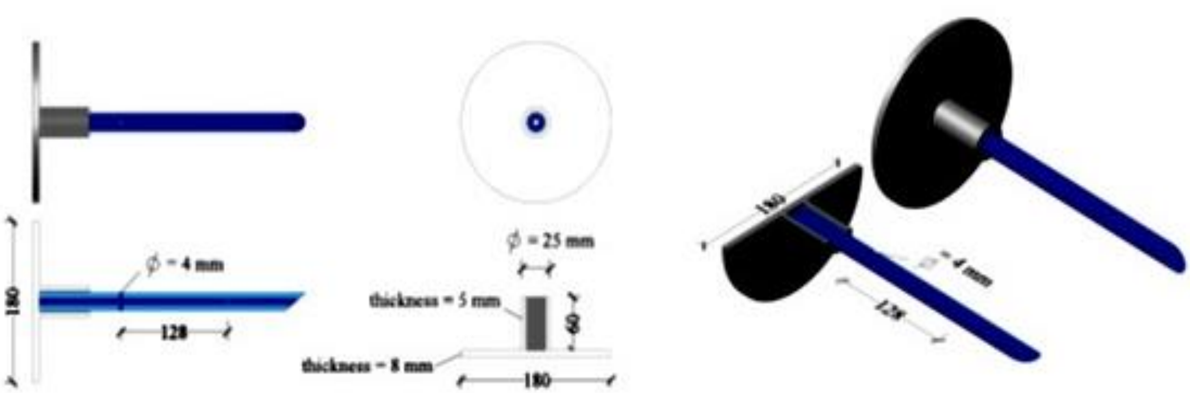


Figure 4.99- Details of the connection between the pipes and the wall (Source: UNESCO Contract Bam Citadel, Mirza Na'eim School, 2007).

- Property No. 8: Sistani House

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Sistani House of Bam Citadel is located on zone (XII to XIII-F and G) and based on geographical coordinates from Google Earth, it is located on (Latitude yard 1: 29° 6'52.25"N– Longitude yard 1: 58°22'4.78"E and Latitude yard 2: 29° 6'52.30"N – Longitude yard 2: 58°22'5.51"E).

▪ **Period of Construction:** It probably belonged to the Sistani family during the Zand period (1750-1794 AD) (Bam 3DCG, 2016).

▪ **Plan Description:** The Sistani House as one of the noble's mansions is located in the middle of Bam Citadel. This single storey building occupies an area about 673 m² (Khakzad, 2011). The access to Sistani House is possible by the main entrance door located almost in the middle of house's western wall. It consisted of two independent courtyards in the eastern and western parts, which are bordered with "Winter Room" in the north, and "Summer Room" in the south. The western courtyard with eleven rooms in its sides was larger than the eastern courtyard with four rooms, and the access between two courtyards was possible with a low corridor. Because of the security reasons, there were no window in the outer walls. The characteristic elements of this property were its four-sided windtowers as traditional air-conditioning system.

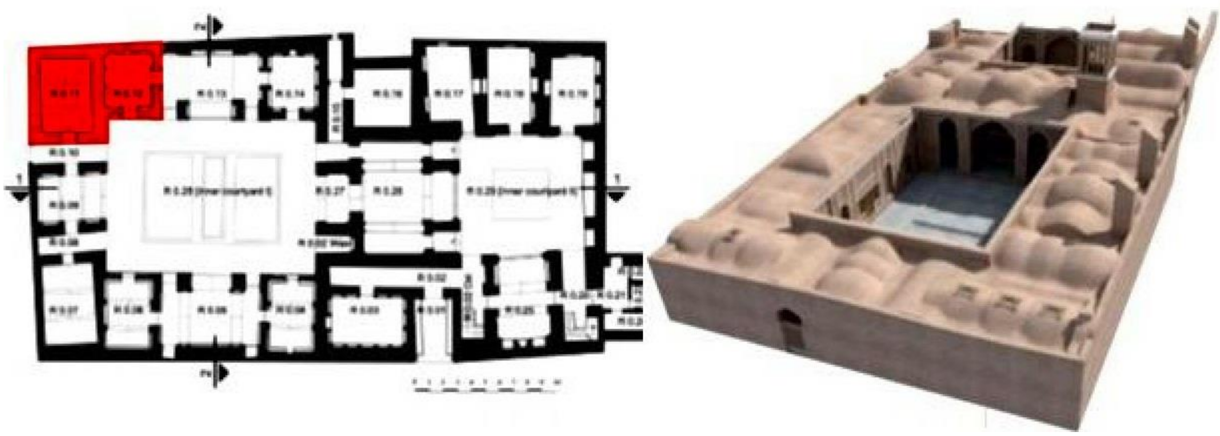


Figure 4.100- Plan and 3D view from the Sistani's House of Bam Citadel (Source: archive of Bam3DCG, designed by Author).

Table 4.12- Architectural information of the Sistani House of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Heater, Under walled arches, Decorative latticework by wood and adobe in openings, Windrowers, Central courtyard and Pool.
Types of Roofs	Different types of barrel, Dominical and Trought vaults

Surface Coating Material	Gypsum decoration, Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** In term of architectural value, Sistani House is one of unique houses within the Citadel, which displays several very typical features of traditional Iranian desert dwellings. It has all of typical Persian traditional architectural elements that belonged to the upper mediate social level family. Due to its strategic importance location in Bam Citadel, before the 2003 earthquake this house was used as a technical office that served the basement for research and restoration office within the Citadel. On the one hand, this ideal location provides the possibilities for the experts to protect and control easily, supervising the restoration project every day and on the other hand, the number of room could serve the technical team as an office (Jäger and Fuchs, 2008).

▪ **Conservation History before Earthquake:** Regarding conservation history of Sistani House before the earthquake, there is no detailed information, but according to the available documents, the only known restoration of this building is the one that initiated in 1979 and ended in 1995.

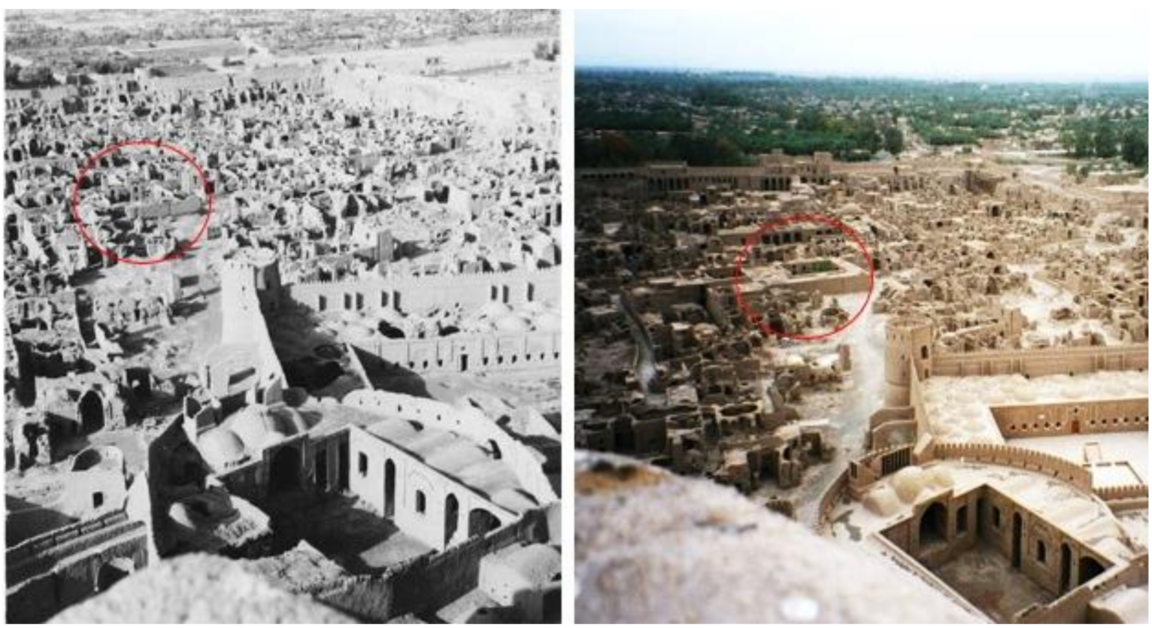


Figure 4.101- Bird view from Sistani House before beginning of restoration works and after complete restoration before the 2003 Bam earthquake (Source: (Left) Photo by Ershad, 1961. Source: archive of ICHHTO; and (Right) Mitsuteru, 2001. Source: archive of Bam3DCG).

▪ **Physical Condition after Earthquake:** After 2003 Bam earthquake, this Iranian traditional residence house suffered severe destruction, so most of the roofs and walls were completely destroyed. The half north (north towards west) and western side of the Sistani House faced with total destruction, but damages were more slight in other sides.

2003 before earthquake 2003 after earthquake 2016

Figure 4.102- Aerial pictures from the Sistani House taken in subsequent years (Source: Digital Global and Google Earth).

Figure 4.103- Sistani House after the 2003 Bam earthquake (Photos by Andaroodi, 2003. Source: archive of Bam3DCG).

▪ **Proposed Intervention Plan:** As part of the international efforts for reconstruction of some of the key properties of Bam Citadel, the Dresden Technical University of Germany together with Jaeger Consulting Engineers Ltd. contributed in a comprehensive research, restoration and reconstruction plan of the Sistani House. In order to develop a strengthening methodology for Sistani House, two rooms in the northwest corner were chosen as a pilot project.

The central idea of the proposed measures was to find a sensitive balance between the demands of an earthen world cultural heritage site as well as the demands of modern retrofitting techniques preventing in an area of strong seismic activity with the aim to create an earthquake resistant building technology. This project was the result of the conceptual design and the consideration of the pros and cons of the different variants for dealing with the remains (Jäger, Fuchs, & et al., 2007). At first step towards complete rehabilitation of the Sistani House, the project started in the second half of 2006 with material tests for retrofitting technologies, which had to guarantee that the reconstructed parts will not collapse once more during the next possible earthquake of the same intensity. Therefore, German group began its actual work on the selected rooms of the Sistani House in the summer of 2007 and finished it in April 2008. Now the work is ongoing by the same method with Iranian experts from RPBCH. The following steps listed below are measures that have been implemented in Sistani House through intervention plan proposed by Dresden University of Germany:

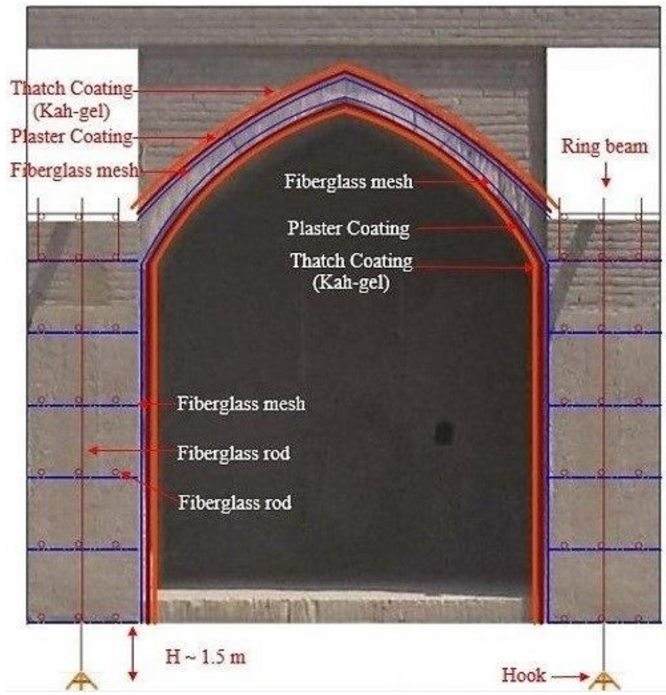


Figure 4.104- Schematic picture from intervention plan proposed for the Sistani House of Bam Citadel (Designed by Author).

(I) Debris removal: this step was carefully and attentively supervised and organized by staffs of the Dresden University to gather as much information as possible about the actual process of the damages and the former layout of the house. As Jäger and Fuchs (2008) noted, "The supervised rubble removal also offered some information about the building history of the Sistani House, as the debris revealed a surprisingly high density of findings integrated into the masonry. A remarkably high number of fragments of ceramic vessels were also found."

(II) Production of reinforced adobe bricks by palm fibers: any new approach in Sistani House had to start from enhancing the capability of adobe building to react flexibly to seismic motion without the immediate loss of coherence. The team of the Technical University of Dresden conducted a wide range of practical tests for improvement of mechanical property of adobe bricks in the laboratories of the Dresden University and Bam's site to find the best additive material. After running a test row on different materials, it was decided to propose "palm fibers" as suitable material for reinforcing of adobe bricks. Tests have proved a considerable increase in compression and tensile strength of reinforced adobe bricks. The palm fibers have the additional advantage of abundant local availability; palm fibers are a side product of the extended date growing gardens as the material is normally simply burned. In this way to prepare palm fibers as additive material to adobe mortar, the thick edge of palm leaves were separated and then the remained softer leaves were cleaned. In the next step, they were cut out to smaller parts for putting inside of machine designed for chopping of palm leaves. Afterwards, the palm fibers were mixed with other ingredients. As mentioned by Jäger & Fuchs (2008) about the rate of materials' combination, "The results enabled us to name the exact quota of the ingredients clay and sand (70: 30) and fibers (0.6% of the weight of the sand-soil compound)." In this case, according to the statistics presented by the RPBCH, over 25000 reinforced adobe bricks with palm fibers for being used in reconstruction operations of Sistani House, which were produced in Bam Citadel's workshop.

Figure 4.105- (a, b and c) the process of the producing of reinforced adobe brick with palm fibres in Bam Citadel's workshop (Source: Jaeger & Fuchs, 2008); and (d) test specimens for grouting material in the laboratory of the Dresden Technical University (shrinkage of the grouting material in the borehole) (Source: Jaeger & Fuchs, 2008).

III) The grouting of cracks: for cracks with less than 2 cm wide, the operation of injection grouting had been employed. In this case, to reduce the demand of water in mixture and create a paste-like consistency with which the cracks become superficially closed, the grout consisted of some ingredients as cement, lime or fluids added to the mixture such as potassic and sodium water glass and soda. For the performance of this process, a plastic pipe with the diameter of the neck of the injection pump was inserted into the crack in regular intervals of about 25 cm in order to create openings for the following injection of the grouting suspension. Because of high daily temperature of the region, and to prevent the suspension to dry up quickly, the grouting was only carried out in the early morning and late afternoon. The higher pressure considered for grouting was by using two bars (Jäger and Fuchs, 2008).

(IV) Needling and anchoring: for cracks with larger than 2 cm width, the technique of needling and anchoring were applied. The anchors were placed in boreholes and fixed with the chosen grouting material (Jäger & Fuchs, 2008).

Figure 4.106- Tension elements employed in Sistani House (Source: Annual Report of Arg-e Bam Research Foundation, 2008).

(V) Reinforcement of walls vertically: at first, for the reinforcement of walls in Sistani House, fiberglass rods had to be inserted vertically. To this end, scaffolding was installed alongside the walls upon which the core-drilling machine for the vertical boreholes was mounted. These were drilled in an interval of about 100 cm with a width of 10 cm, which reached down to depth of 1.5 m below the ground level. The vertical anchors consisted of three glass fiber rods with a diameter of 8 mm. On their lower end, the bundle of three rods was spliced up; it was inserted into a block of fine concrete that tied the vertical anchor to the ground. The rest of the borehole was filled with the same clay suspension that was used for the grouting in the consolidation phase. The vertical anchors reach up to the highest parts of the walls (Jäger and Fuchs, 2008).

Figure 4.107- The quality of the insertion of fiberglass rods in walls, each fiberglass rods are consisted of three rods in an unique set (Source: archive of RPBCH, 2008).

(VI) Reinforcement of walls horizontally: in this case, every 0.50 m in height, a layer of fiberglass mesh was inserted into the horizontal joint in the masonry. In addition to that, a horizontal rod of fiberglass was fixed to the vertical anchors (Jäger and Fuchs, 2008).

Figure 4.108- The strengthening of walls horizontally with fiberglass meshes in the Sistani House (Source: archive of RPBCH, 2008).

(VII) Increasing roofs fixed end and wall through the installation of ring beam: inserting ring beam is among the methods of stabilization that can have positive effects on the seismic resistance of earthen structures while preserving their integrity. These ring beams are located under the floor, as shown in Figure 4.109. On the height of the impost of the vaults, a ring beam composed of six fiberglass rods (width 0.60 m, height 0.30 m) is constructed and bricked up (Jäger and Fuchs, 2008). Specific elements, including glass fibers and mud grout compatible with the old parts of the wall, are inserted into these beams for reinforcement (Vatandoust et al., 2008).

Figure 4.109- Enhancing the integrity of roofs and walls through construction of ring beam in Sistani House (Source: archive of RPBCH, 2008).

(VIII) Reinforcement of roofs: to improve the inner integrity of the roofs, it was decided to wrap the transversal arches, as well as the sectroids of the vaulted roofs with the same fiberglass that has been used for the horizontal joints. Then, the traditional adobe surface coating covered the meshes.

Figure 4.110- Stabilization of the roofs in the Sistani House with installation of fiberglass meshes (Source: archive of RPBCH, 2008).

- Property No. 9: Payambar Mosque

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Payambar Mosque of Bam Citadel is located on zone (XI and XII- E to F) and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'51.95"N – Longitude: 58°22'2.74"E).

▪ **Period of Construction**: There is an altar which its dates back to the Safavid period (1501-1736 AD).

▪ **Plan Description:** Even so, the primary archaeological theory indicates that this mosque was a part of a bigger mosque such as the Jaame-Mosque southeast of the Citadel. More documents and records are needed to approve this theory (Mokhtari et al., 2008b).This small mosque is located at the end of Bazaar's north-west, in front of Sistani House. The area of Payambar Mosque is around 128m² in a trapezoidal cross-section. Because of the distance between Bazaar and Friday Mosque, this small mosque in the past was regularly used to pray by the traders and passengers. However the erratic parts in the process of fabrics design made evolution in the area, this special instance has survived originally during the past years (Mokhtari et al., 2008b). As photos remained before the 2003 earthquake, it can be seem that to enter the Mosque, there were two doorways which both opened in the northern side of the mosque, one for males and another for females. The internal space of Payambar Mosque can be divided in two sections: one bigger than the other, the big one with a column in its center was probably used by males and the small one was used by females, the spaces between two halls is linked by a under walled arch.

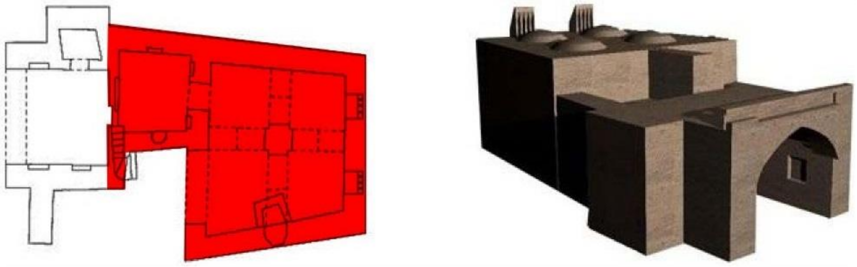


Figure 4.111- Plan and 3D view from Payambar Mosque of Bam Citadel (Source: archive of Bam3DCG, designed by Author).

Table 4.13- Architectural information of the Payambar Mosque of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arch, Prayer hall, Altar, Windrowers and Decorative latticework by wood in doorway.
Types of Roofs	Domes and Semi-dominical vault.
Surface Coating Material	Mud and Sieved straw, and Mud and Straw Plaster.

▪ **Property Values:** This Mosque with its simple architectural elements gives a strong sense of spirituality to its visitors. By the promotion of Islam and the increasing of the number of Muslim who entered the Citadel for trading in the Bam's ancient Bazaar, and also because of the long distance between Bazaar and Friday Mosque, the need to build new Mosque in the vicinity of the Bazaar and Caravanserai was felt. In fact, the Payambar Mosque of Bam Citadel with its small size was built to meet the above-mentioned necessities.

▪ **Conservation History before Earthquake:** There is no precise report regarding the previous conservation activities of the Payambar Mosque before the 2003 earthquake. In this case, I have just found a picture that shows the intervention works in process in 1990 (Figure 4.112 (left)).

Figure 4.112- (Left) restoration activities in Payambar Mosque of Bam Citadel (Source: archive of the RPBCH, 1990); and (Right) view from Payambar Mosque before the earthquake (Photo by Louyot, 2003. Source: archive of Bam3DCG).

▪ **Physical Condition after Earthquake:** The Payambar Mosque was severely destroyed during the 2003 earthquake. Through the earthquake, this religious property sustained a damage more than the other properties; all the western and northern parts of the Payambar Mosque were fully destructed. The central column of the Mosque, which suffered all of loads transferred by the four domed shape roofs, could withstand by cracks in its lower part, but the domes were completely shattered.

Figure 4.113- Aerial pictures from the Payambar Mosque taken in subsequence years (Source: Digital Global and Google Earth).

Figure 4.414- The state of damage in the Payambar Mosque after the 2003 Bam earthquake, view to south-west, 2007 (Source: Annual Report of Arg-e Bam Research Foundation, 2008).

▪ **Proposed Intervention Plan:** The intervention plan of Payambar Mosque that was proposed by Iranian experts form RPBCH can be known as the best example for simultaneous use of engineering restoration outcome and traditional restoration knowledge. The central focus on intervention plan of Payambar Mosque was inspired from experiences acquired from previous intervention pilot projects in other monuments of Bam Citadel, such as Tekiyeh, Bazaar, Sistani House and Barrack. So far, a special attention has been dedicated to traditional methods by using local materials (palm fibers and palm meshes). The concern in this technique was the seismic loads of the dominant force for destruction of adobe-mud brick properties that would be reduced.

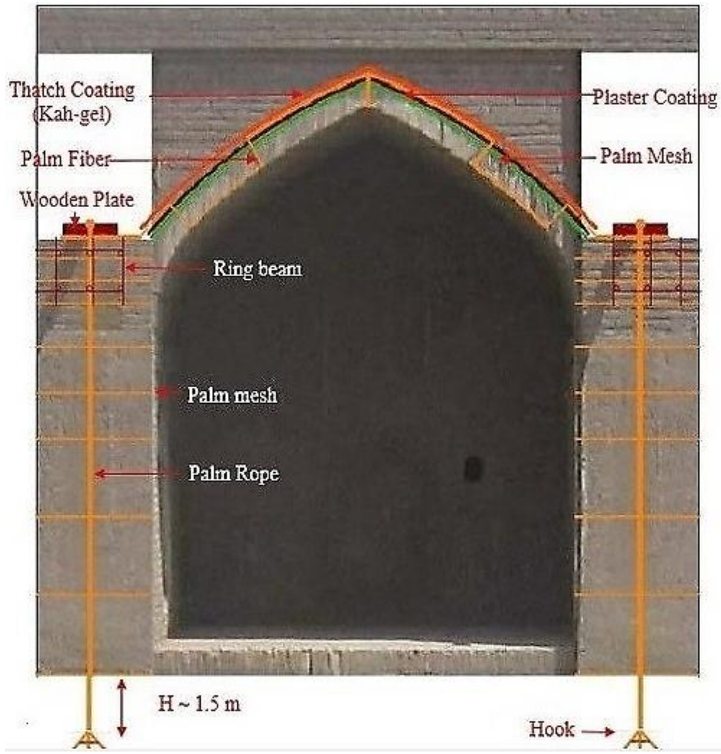


Figure 4.115- Schematic picture from intervention plan proposed for the Payambar Mosque of Bam Citadel (Designed by Author).

During reconstruction phase, to keep the authenticity and integrity of the property, the damaged parts of the mosque had been reconstructed based on the original location of the walls extracted from available documents and ruins remained after the earthquake. The following steps listed below are measures that have been implemented in Payambar Mosque through intervention plan proposed by the RPBCH:

(I) Debris removal: in each monument of Bam Citadel, in parallel to debris removal, all works have been operated by supervision of archeologists. After removal of the debris, the archaeologists started the excavation, and found that there were causeway, catch basin and clay pipe in the 80 cm lower than the ground level, which were buried and prevented up to now. According to the archaeological investigations, it might have been built under the remains of early construction (Mokhtari et al., 2008b).

(II) Strengthen of walls with simple traditional measures: at first, after replacement of some kinds of deteriorated adobe bricks, to meet specific structural inadequacies, the thickness of walls in some areas that were vulnerable to the forces of the seismic loads was to be increased.

(III) Reinforcement of walls vertically: to provide any required bending resistance in the monument, the structure was connected to the ground with some innovative method by embedding local tension elements “palm cables”. The Figure 4.116 exactly shows the details of drilling procedures by halter for inserting vertical elements to the foundation soils at depths of 150cm. In this case, vertical elements were installed along a certain line by maximum distance of around 110cm that is reduced to 60cm in the compulsory points at the center of main walls.

Figure 4.116- (Left) drilling of the remained pillars for insertion of vertical elements (palm cables); and (Right) drilling of new reconstructed part of walls for insertion of palm cables (Source: archive of RPBCH).

(IV) Reinforcement of walls horizontally: on the other hand, to provide shear resistance in the structure, the natural horizontal elements produced by local producers palm mesh was to be inserted as tension elements from within thickness, by going towards upper parts of the wall, the operated distance between palm meshes, between brick lines, were decreased (Figure 4.117 and 4.118). Meanwhile, to install natural fibers between rows of adobe bricks, a simple tool was used to stretch the meshes during their operation.

(V) Increasing roofs fixed end and wall through the installation of ring beam: by copying from intervention plan executed in Sistani House, the same method that was used for increasing the junction between walls and roofs in Sistani House had been employed in Payambar Mosque of Bam Citadel.

(VII) Reinforcement of roofs: after doing all of the above-mentioned steps, to reinforce and to increase the integration of roofs, a layer of palm mesh was wrapped out on outer surface of roofs. Meanwhile before setting up palm meshes, the roofs were sewed out by palm rops. At the end, the traditional clay-and-straw mortar plaster (Kah-gel) was used to cover the palm meshes.

Figure 4.117- The process of palm meshes insertion between the layers of adobe-wall in the Payambar Mosque of Bam Citadel (Source: archive of RPBCH, 2008).

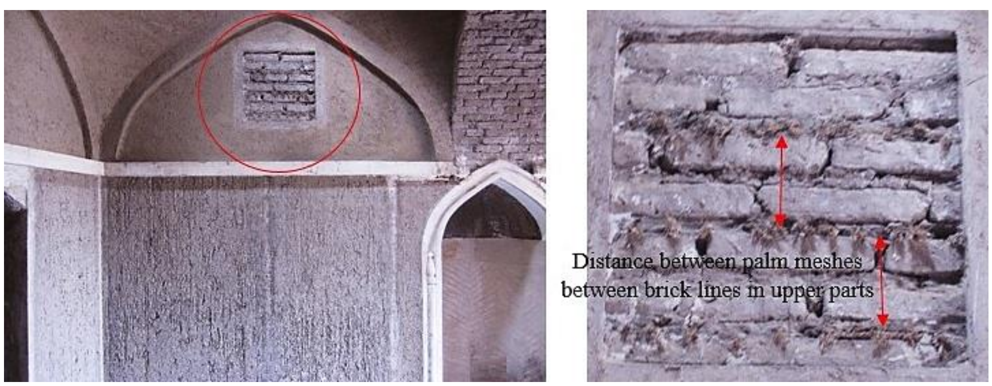


Figure 4.118- As pilot frame embedded on the Payambar Mosque, the palm meshes used on the walls are recognizable (Photos by Rouhi 2015).

Figure 4.119- Creation of grooves in outer part of roof for its stabilization with palm rops (Source: archive of RPBCH, 2007-2011 AD).

Figure 4.120- The Payambar Mosque after complete restoration (Photos by Rouhi, 2015).

- Property No. 10: West Sabat House (Jewish House)

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the West Sabat House (Jewish House) of Bam Citadel is located on zone (IX and X - H) and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'55.34"N– Longitude: 58°22'7.55"E).

▪ **Period of Construction:** The West Sabat House is one of the oldest traditional houses in Bam Citadel. Based on reports of cultural heritage organization of Iran, it probably belonged to a Jewish family, which has evolved since the pre-Islamic times, i.e. Parthian, Sassanian and Qajar periods (Tohidi, 2014).[354] Since the city of Bam from ancient times is known for the production of silk and cotton garments, probably the collecting of mentioned goods by Jewish families who had lived until 1978 in Bam was being accomplished through Spice Road, sidetrack of Silk Road, all over the world (Tohidi, 2014).

▪ **Plan Description:** One of the loftiest buildings in Bam Citadel that belongs to one of Jewish families in Bam Citadel is West Sabat House or Jewish House. This house is located in the main residential quarter of the historic town that occupied along the Jewish passageway (Sabat-e Johudhā in Persian) to the east of the Stable and the extreme north of the town before the second fortified wall quasi in front of Second Entrance Gate. The access to the West Sabat House is possible with two roads that both end on the Sabat-e Johudhā passageway. West Sabat House consisted of a relatively large house with a central courtyard flanked by two series of room in two floors (UNESCO, 2004). Its western part is the oldest part (Tohidi, 2014), and its southern part grabs viewer's attention by a row of five windtowers and charming balconies. As the main architectural elements of the West Sabat House before the earthquake we can mention to the restored windtowers in its southern part, and rooms with iwans all-around of the central courtyard.

[354] Tohidi, M., Argname. Kerman: The Center of Kerman's Studies, pp. 41–42, 2014. (Published in Persian).

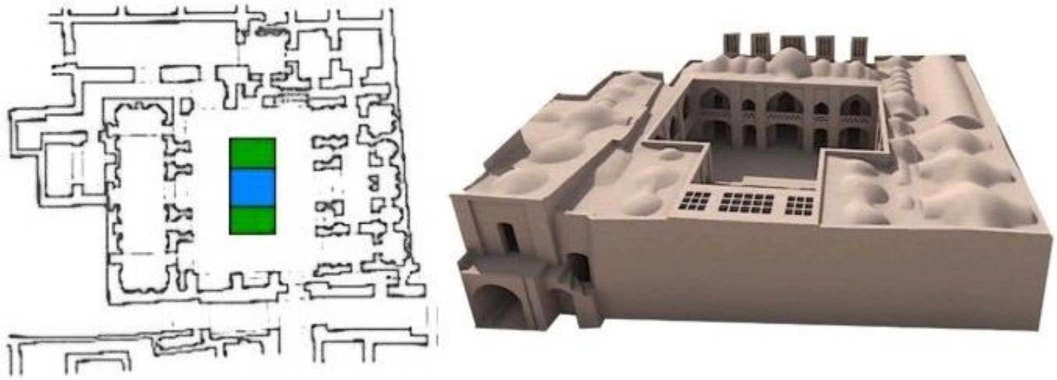


Figure 4.121- Plan and 3D view from the West Sabat House of Bam Citadel (Source: archive of Bam3DCG, designed by Author).

Table 4.14- Architectural information of the West Sabat House of Bam Citadel (Jewish House) (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arch, Heater, Windrowers, Iwans, Decorative latticework by adobe and wood on openings and Iwans, Central courtyard and Pool.
Types of Roofs	Barrel vaults, Domes and Semi-domes.
Surface Coating Material	Gypsum decoration, Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** The West Sabat House as one of the noble's house in Public Quarter of Bam Citadel well illustrates how in a small urban community, groups with different religions and income levels had been living together. On the other hand, it also reveals how the location of Bam Citadel in the sidetrack of Silk Road attracted Jewish families to have residence in Bam Citadel for a long time, even after the advent of Islam.

▪ **Conservation History before Earthquake:** In 1994, the restoration activities in West Sabat House by investigating on architectural phases and uncovering of its original ground, removal of rubbles, stabilizing foundations in all levels, and restoration of some of the galleries of the first floor was started. In 1995, the roof of the south hall was restored and plastered; the pillars in the upper story above the south hall were renovated; the entrances in the upper story and the gallery in the south of the house were restored. In 1996, the West Sabat House was also repaired in its west wing and its kitchen was restored. Meanwhile conservation works in some parts have been taken. Then in1998, the walls and foundations were consolidated; the plaster of the rooms had been renovated; the gallery in the first floor was renovated; the modern comfort and service facilities were setting up. Finally, in 1999, the restoration of West Sabat House with restoration of its bath and windtowers was completed.

▪ **Physical Condition after Earthquake:** The earthquake severaly damaged the West Sabat House. All the southern, western and eastern sides of the property were totally demolished, but the end wall of the southern side of the building withstood against the earthquake. The northern side of this property faced less damage, so some of the roofs were partially collapsed.

▪ **Proposed Intervention Plan:** As 'State of Conservation report of Bam and its Cultural Landscape' (ICHHTO, 2015) indicates, the conservation and restoration plans of Jewish House have been accomplished. But so far, not much work has been performed except of debris removal and some preventive measures such as installation of scaffolding, performance of protecting buttress and coverage of remains which were in immediate danger of erosion by wind and rain.[355]

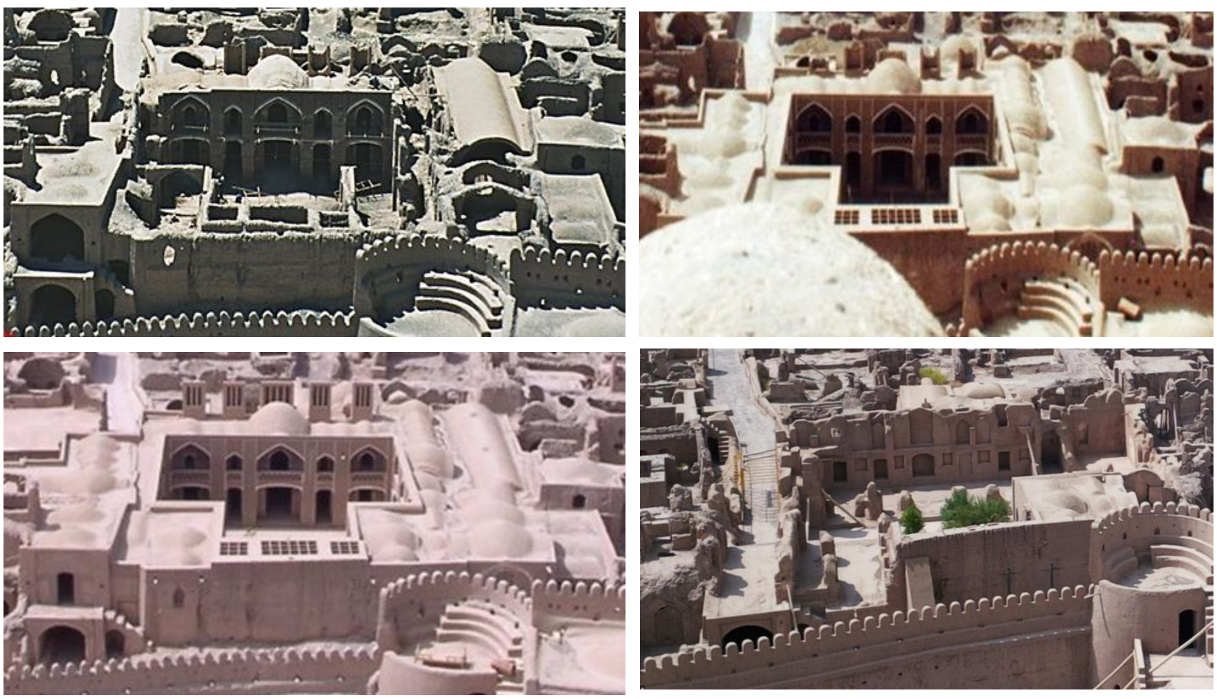


Figure 4.122- Bird view from West Sabat House of Bam Citadel (Photos by Stephan, 1996. Source: https://www.flickr.com; Andaroodi, 1999. Source: archive of Bam3DCG; and Yasuda, 2001. Source: archive of Bam3DCG; and Rouhi, 2015).

- Property No. 11: Caravanserai

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the Archeological group, the Caravanserai or School of Bam Citadel is located on zone (IX

[355] Since in normal condition adobe surface needs a regular annual maintenance, this work in damaged adobe structure by the earthquake must be carried out with a high care to prevent possible environmental causes of erosion in the next futures.

and E to F) and based on Geographical Coordinates from Google Earth, it is located on (Latitude: 29° 6'56.25"N – Longitude: 58°22'2.55"E).

▪ **Period of Construction:** As Nourbakhsh (1974) mentioned, "The architectural style of this building is from the Seljuk (1041-1187 AD) or Ilkhanat (1256-1335 AD) periods and is older than the stable (Bam3DCG).

▪ **Plan Description:** In the south of Konari Quarter behind the Stable lies Caravanserai or School.[356] The direction of its placement is from south to north, and the most convenient way to get access to this property is possible by the Bazaar's main street and a road that is located in the southern part of the Stable. Until now, the real function of this property has not been defined; some believe that it was used as a caravanserai and other believe that it was used as a school.[357] By the way, this property is flanked in a two-storeys building with a central courtyard. All four sides of this property consisted of rooms with iwans; even in the upper part of the Caravanserai's entrance, a number of rooms were built. In addition, the open spaces located at the northen and westen sides of the property most probably served for keeping packed animals.

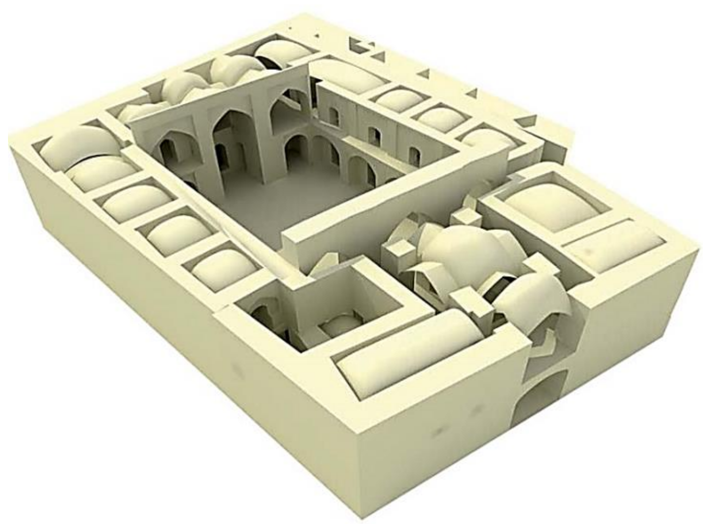


Figure 4.123- 3D view from the Caravanserai of Bam Citadel (Source: archive of Bam3DCG).

Table 4.15- Architectural information of the Caravanserai or School of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique

[356] There is an assumption that this structure could function as an accommodation place for the students.
[357] In Iranian traditional cities, Caravanserai as a custom office was built close to the Bazzar to provide lodging and commercial exchange facilities for traders of the caravans.

Architectural Elements	Niches, Under walled arch, Heater, Iwans, Decorative latticework by adobe and wood on openings and Iwans and Central courtyard.
Types of Roofs	Barrel vaults, Domes and Semi-domes.
Surface Coating Material	Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** Although there is no exact information about this property, this traditional building as a public one in a corner of Bam Citadel has many social and cultural values. Based on the requirements of time, public buildings of Bam Citadel have continuously faced with some changes; for example, some public buildings of Bam citadel, which we now know as Mosque, Tekiyeh, Caravanserai, School and so on, certainly before their current usage used to have other functions, so they served services to the citizen of Bam. In the case of small Caravanserai of Bam Citadel that has also the traces of a school, we can well understand the requirements of the time and conformity with them; it might that by the development of commercial activities this property reoriented its function from school to a caravanserai.

▪ **Conservation History before Earthquake:** There are some reports in 1978, 1979 and 1980 about conservation and restoration works in different structures of the Caravanserai, then until 1996, the restoration activities in this property was stopped. During these years, the north-west entrance, roofs and the octagonal piece had been restored. Then until 1999, the vaults and arches had been renovated; the foundation were consolidated; the troubled plasters and adobe-mud bricks had been replaced.

Figure 4.124- The Caravanserai of Bam Citadel during restoration works (Photo by Liagollen Signalman, 2001. Source: https://www.flickr.com/).

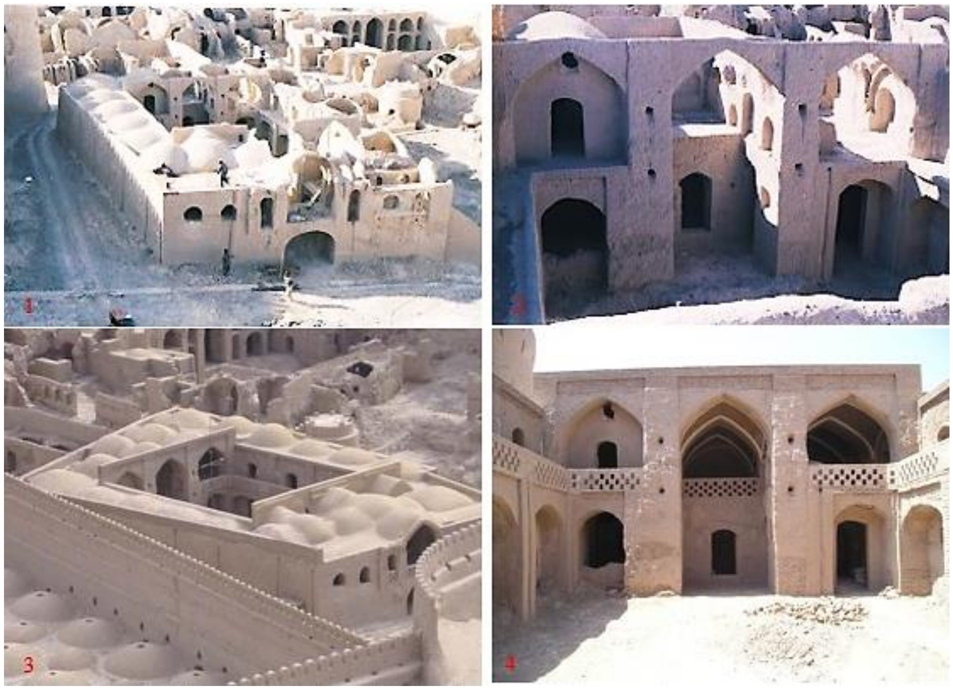


Figure 4.125- (Top) the Caravanserai of Bam Citadel during restoration works (Source: personal archive of Prof. Tayari 2002); and (Down) the Caravanserai of Bam Citadel after the complete restoration (Photo by Ahmadi and Boroomandi, 2003. Source: archive of ICHHTO).

▪ **Physical Condition after Earthquake:** In the Caravanserai of Bam Citadel, the rooms in the second floor of its northern, eastern and southwestern sides were thoroughly collapsed, and the damages in northern side even reached to the first floor with partial and total collapse of the roofs. The damages in the eastern and southern parts of the property were much less than other parts, so the property in these parts was able to withstand against the earthquake.

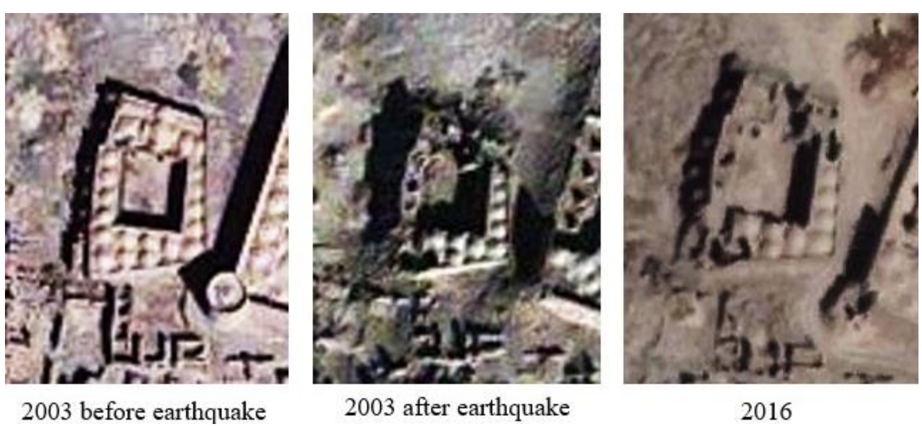


Figure 4.126- Aerial pictures from the Caravanserai taken in subsequent years (Source: Digital Global and Google Earth).

Figure 4.127- The ruins of the Caravanserai of Bam Citadel after the 2003 Bam earthquake. (Source: (Top) Langenbach, 2004; and (Down) Chopin, 2007. Source: archive of Bam3DCG).

▪ **Proposed Intervention Plan:** Due to lack of budget, priorities assigned and neglect of authorities, this property has been abandoned. After debris removal, there has not been executed any stabilization work for vulnerable parts, and preservation and protection of the ruins remained from erosion. Considering the fact that the most of the buildings inside the Citadel have been badly damaged by the earthquake, and the detached walls and their layers are exposed to wind and rain, the top priority for most of them is to apply a kind of coverage (either mud and straw or something else) on the exposed areas, and stabilizing the unstable parts and elements (Khakzad, 2011).

Figure 4.128- The current condition of the Caravanserai of Bam Citadel (Photos Chopin, 2007. Source: archive of Bam3DCG).

- Property No. 12: Second Entrance Gate or **Second Gate**

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Second Entrance Gate and Second Defensive Wall of Bam Citadel is located on zone (IX – G and H) and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'56.53"N – Longitude: 58°22'7.11"E).

▪ **Period of Construction**: The Second Gate of Bam Citadel was erected in the Seljuk period (1073-1307 AD) (Behzadi, 2004).

▪ **Plan Description:** In Arg-e Bam, the section for common people was separated from the governor's section by a high fortification. This fortification consists of three towers from the east (it is connected by the main city wall) to the west (it is terminated by the Stable) and the main gate in two stories. A steep passage with bedrock leads through the second further impressive gateway into Governor's Quarter. The Second Gate is located in a strategic location in Bam Citadel and is considered as an inspection check point, for the District of the Governor as the most important part of the Citadel (Mokhtari et.al, 2008c). The Second Entrance Gate is a two-story building wherein its ground floor was consisted of two rooms in each side of gateway. In the upper floor, there was a large room for guards.

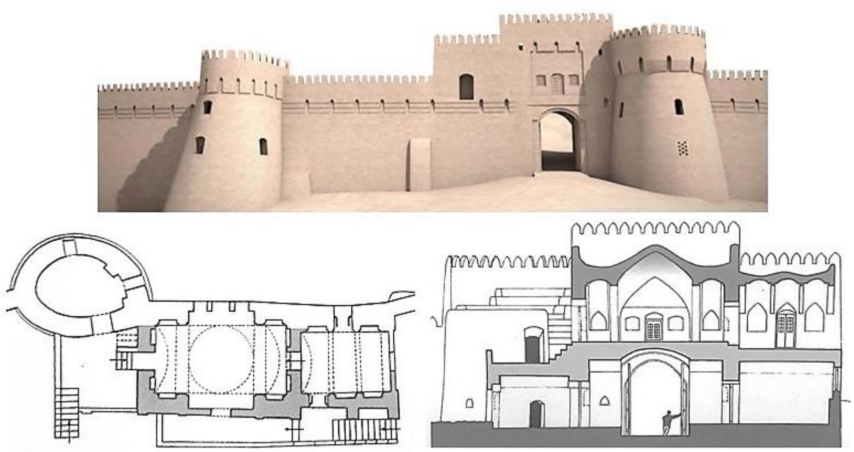


Figure 4.129- Plan, sections and 3D view from the Second Gate of Bam Citadel (Source: (Top) archive of Bam3DCG, designed by Author; and (Down) archive of RPBCH).

Table 4.16- Architectural information of the Second Entrance Gate of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches, Iwan, Decorative latticework by wood and adobe on openings and Iwans Adobe design in façade, Crenellations, Watchtower and Huge gateway.

Types of Roofs	Opened and Closed barrel vaults, Domes and Semi-domes with holes in upper parts.
Surface Coating Material	Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** The Second Entrance Gate as a strategic place in the center of the Citadel has great performance both during wars and during Bam Citadel's touristic activities. In the past times, this area acted as the last defensive wall for protecting the Citadel and the governor's families. For the tourists and researchers, this place has also a strategic value, where they can have a break after the visit of the Public Quarter and before engaging the visit of the Citadel. Sometimes before earthquake, this property was used as a traditional Iranian teahouse to give some services to the tourists.

▪ **Conservation History before Earthquake:** There is no definite information with regard to the conservation history of the second defensive wall and its entrance gate, but the only reported work in this area is related to 1994, 1996 and 2002.

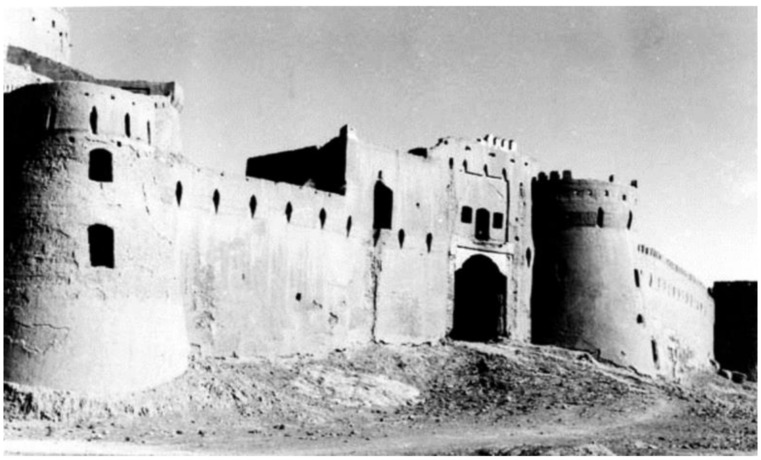


Figure 4.130- The Second Entrance Gate before beginning of the restoration works (Source: archive of ICHHTO, 1965).

Figure 4.131- The eastern and western parts of Second Gate under restoration works (Source: (Left) photo by Afrai, 1997. Source: archive of ICHHTO; and (Right) personal archive of Prof. Tayari, 2002).

Figure 4.132- The Second Entrance Gate and its west side after total restoration (Source: archive of RPBCH).

▪ **Physical Condition after Earthquake:** One of the famous monuments in the Bam Citadel that cracked seriously and collapsed more than 10% during the earthquake in 2003 is called the Second Gate (Mokhtari et al., 2008c). Along the length of the second defensive wall, there have been collapses, detachments and cracks; the upper parts of wall with their crenellations were crumbled, towers in the eastern and western parts almost faced with total collapse, and the tower in junction with the Second Gate sustained collapses in its upper part and cracks in its façade.

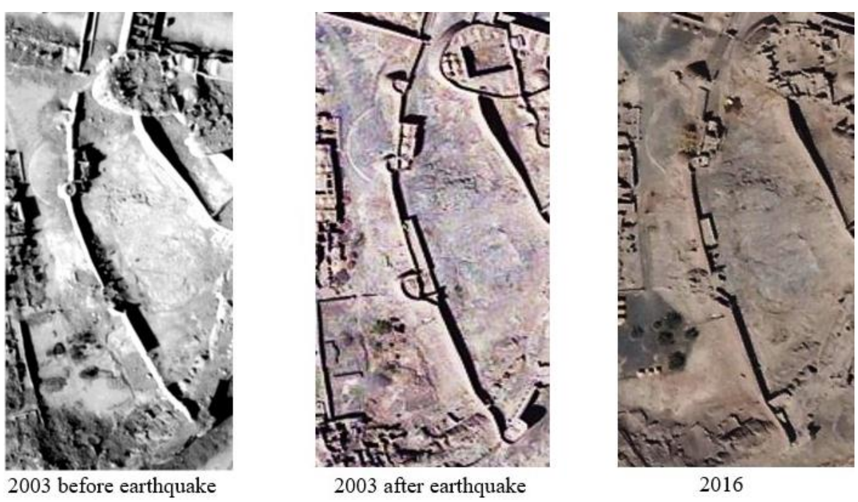


Figure 4.133- Aerial pictures from the Second Entrance Gate taken in subsequence years (Source: Digital Global and Google Earth).

Figure 4.134- The Second Gate and its west side after the 2003 Bam earthquake (Photo by Elam Andaroodi, 2004. Source: archive of Bam3DCG).

Figure 4.135- The northern part of Second Entrance Gate before and after the 2003 Bam earthquake (Source: archive of RPBCH).

▪ **Proposed Intervention Plan:** Along the second defensive wall, the restoration measures related to the eastern part of the wall, except of its tower, the western part of the wall with its tower and the tower of the Second Gate have been completed. During the restoration of these parts, all activities have been followed by a great accuracy through using advanced but normal traditional methods, it has been tried to reuse the detached parts as much as possible.

In the case of the Second Gate, CRAterre- ENSAG (France) institute, considering the authenticity and integrity of the property, proposed an intervention plan by introducing some locally available natural material as the tensile elements. These materials include bamboos and palm tree fiber rope (Annual Report of Arg-e Bam Research Foundation, 2008). The intervention plan has not yet fully started, but preventive measures against rain and wind have been taken. For evaluating the real response of the structure in the proposed plan, the 3D-nonlinear dynamic analysis (ANNSYS) in real seismic recorded data is performed by positioning bamboos in the walls, roofs and domes. In addition, to obtain the quantitative values for simulation and for optimizing the reinforcement, the deficiency and characteristics of the proposed reinforcement were tested in sample test wall built at scale 1:3 on the shaking table. According to the results obtained from all numerical and experimental tests, the employing of bamboo as tensile elements will strongly improve the seismic response capacity of the structure against further similar earthquakes.

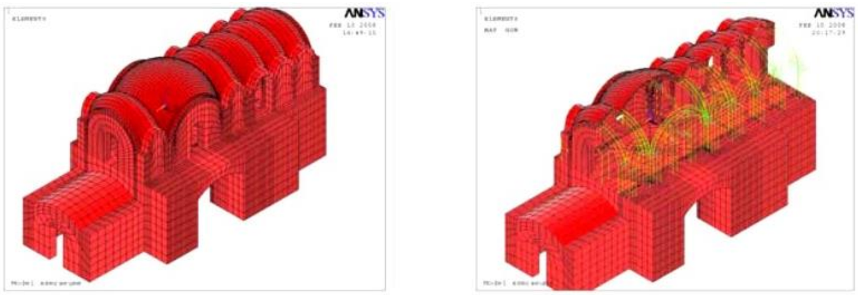


Figure 4.136- Analytical modeling of Second Gate, without bamboo (left) and with bamboo (right) (Source: Mokhtari et al., 2008c).

Table 4.17- Natural frequencies of eight primary modes shapes of Second Gate with / without bamboo (Source: Mokhtari et al., 2008c).

Mode shapes	Without Bamboo	With Bamboo (diameter =1.6 cm)
1	3.5	8.5
2	4.5	11
3	4.8	11.6
4	6.3	15.3
5	6.6	16.1
6	7	17
7	7.7	18.7
8	7.8	19

Figure 4.137- Sample models of Bamboo insertion inside of walls (Source: Annual Report of Arg-e Bam Research Foundation, 2008).

The final outcomes for positioning of Bamboos are listed as follow (Mokhtari et al., 2008c):

- The distance of the bamboo must be limited to the specific values,

- The rate of bamboo diameter must be between 1.5 cm and 3.0,
- In meeting point between new part of the structure with the original walls, the overlapping of the bamboo elements needs to be considered for transferring the tensile forces on connection parts,
- In connection points that is described in last note, the drilling diameter needs to be at least three times of the bamboo diameter (for example for reed with diameter between 2 and 3 cm the drilling diameter must be around 8 cm),
- The injection material must not shrink, because it reduces the shear resistance between the walls and bamboos elements, for more detail refer to the achieved tests in Recovery Project of Bam's Cultural Heritage,
- In areas, where it is needed to prolong the bamboo element, the minimum required length connection is 15 times of reed diameter,
- The used reed elements must have the same diameter and using the bamboos with various diameters should be avoided,
- Avoiding leaving the bamboos without cover because of decreasing decay ratio,
- Using the bamboos in domes needs specific considerations and may need to implement some pilot project onsite.

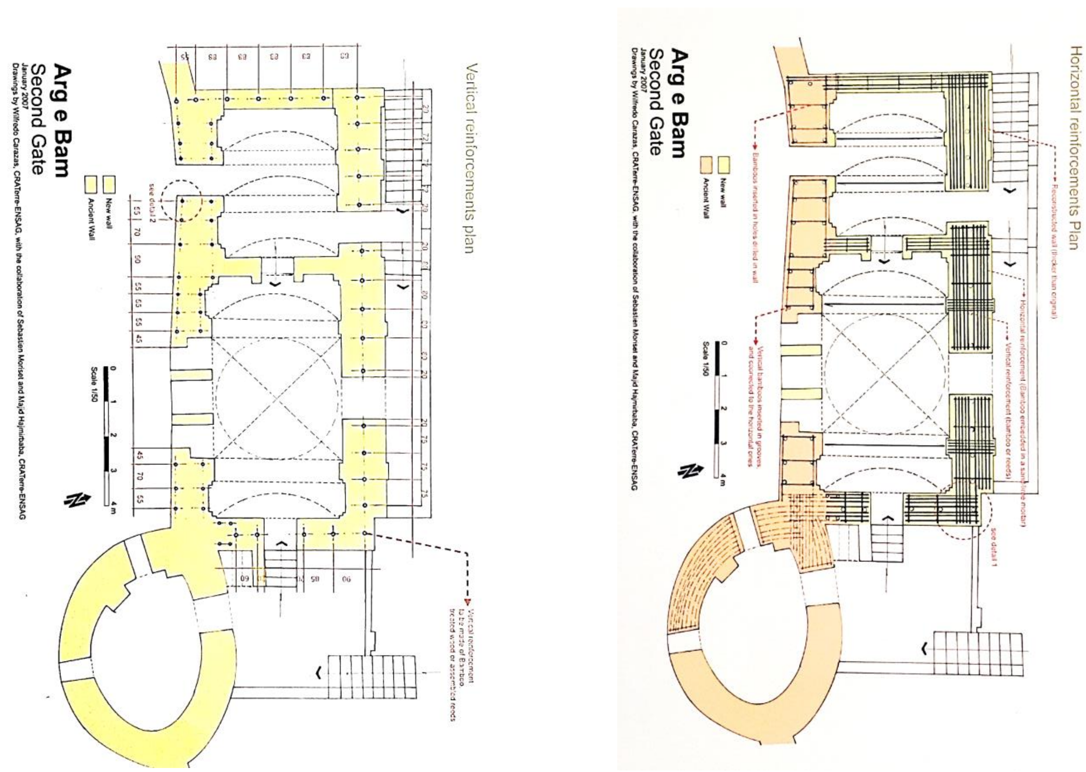


Figure 4.138- Proposed conservation plan for vertical and horizontal reinforcement of the Second Entrance Gate (Source: Annual Report of Arg-e Bam Research Foundation, 2008).

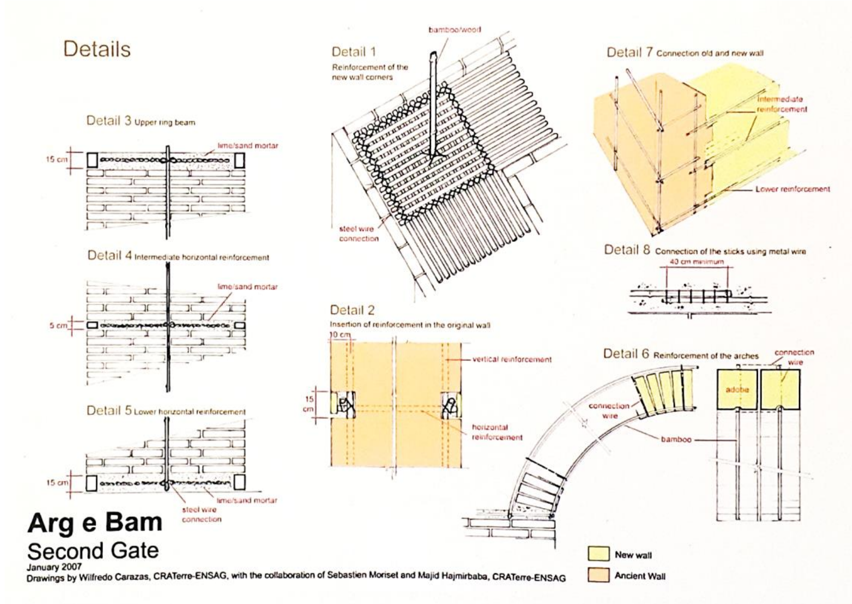


Figure 4.139- Details of the placement of reeds in the structures of the Second Entrance Gate (Source: Annual Report of Arg-e Bam Research Foundation, 2008).

Figure 4.140- Views of the present state of the Second Entrance Gate (Photo by Rouhi 2015).

Meanwhile, the project was also phased in five sectors along with recommendations for its total restoration (Annual Report of Arg-e Bam Research Foundation, 2008):

- Keeping the ground floor structure
- Dismantling the weak walls
- Widening the northern wall
- Increasing the thickness of arches supporting the roof
- Reducing the trust on the side walls
- Improving the connection between the walls
- Keeping the decoration visible

- Property No. 13: Stable

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Stable of Bam Citadel is located on zone (VIII to X – F and G) and based on geographical coordinates from Google Earth is located on (Latitude: 29° 6'56.23"N– Longitude: 58°22'4.42"E).

▪ **Period of Construction:** As Nourbakhsh (1974) mentioned, this property was probably built during the Turkish or Mongol rulers [Seljuk (1041-1187 AD), Ilkhanat (1256-1335 AD) or Teimorid (1370-1507 AD) periods] (Bam3DCG). The most important historical events related to the Arg-e Bam occurred in the Stable. As was said, the arrest of the romantic Lotf-'Ali Khān, the last Zand pretender to the Persian throne, took place in late autumn 1794 AD. The prince was handed over to his unmerciful foe, Aghā Mohammad Khān Qajar, who killed him under torture. Aghā Mohammad Khān founded the Qajar dynasty, which ruled over Iran until 1925 AD (UNESCO, 2004).

▪ **Property Description:** After passing from the Second Entrance Gate, to the west, there is a larger square on the south devoted to the Stable. The governor's Stable occupies an area with a 60 × 70 m² is one of the largest structures within the Citadel. As Bastani Parizi (1984) noted, the Stable has a capacity of around 200 horses (Bam3DCG). There were roofed winter stables in the west, east and south sides. In the central courtyard, the Stable has a water reservoir with 28 meters depth. In the two south corners of the Stable, there were two wake-up towers.

Table 4.18- Architectural information of the Stable of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Stalls, Under walled arches, Iwan, Decorative latticework by wood and adobe in openings and Iwans, Adobe design in façade, Crenellations, Watchtower and Water reservoir.
Types of Roofs	Closed barrel vaults, Domes with holes in upper parts.

Surface Coating Material	Gypsum Decoration, Chalk Trim, Mud and Sieved Straw and Mud and Straw Plaster.

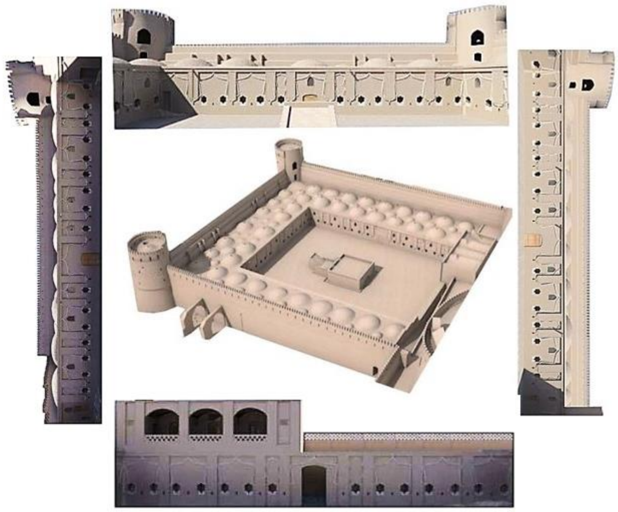


Figure 4.141- 3D view from the Stable of Bam Citadel (Source: archive of Bam3DCG, designed by Author).

▪ **Property Values:** In term of architecture, the Stable is recognized as one of the best architectural and cultural properties in the strategic part of Bam Citadel. In this property, where horses were kept for use in times of need, a fusion of architectural elements and requirements could be well seen for giving better services to the horses. Example of this fusion can be seen considering the water reservoirs in the center of Stable's courtyard with its fantastic architecture, and covered and non-covered rooms with stalls everywhere. Before the earthquake, this property was one of the best preserved parts of Bam Citadel that functioned as exhibition halls.

▪ **Conservation History before Earthquake:** The annual report of conservation activities prformed in the Stable of Bam Citadel is listed below:

1977-1980: conservation, restoration, consolidation and maintenance of conservation.
1981: restoration work at Stable including the uncovering the original soil, restoration of the north and south walls, fallen roofs, southern side, and some of the halls.
1993: conservation work at Stable; restoration of the Stable including its foundation, repair and renovation of its façades with Kahgel (pisé) plaster.
1994: setting up plans for the restoration of the water reservoir inside the Stable; continuation of the restoration work in the Stable concerning, consolidation and plastering of walls; repair of the entrance gate of the western stables and the ground of the eastern stables; restoration of

the water reservoir inside the Stable, removal of rubbles, consolidation of foundations, restoration of staircases, entrances, and vaults.

1995: in the Stables, a drainage system was set up; the original ground of the Stable was uncovered and then paved. The southern hall was restored and its pavement was renovated with plaster and pisé; the roof of the reservoir was restored; restoration and renovation of the entrance of the east hall; plastering the troughs; renovation of the north entrance of the east hall including its door; restoration of the western and eastern staircases in the reservoir and its plaster; renovation and repair of the roof of the reservoir, and the roof pavement; restoration of the courtyard; the electricity was set up in the Stable.

2002: conservation work in the Guest House to the west of the Stable.

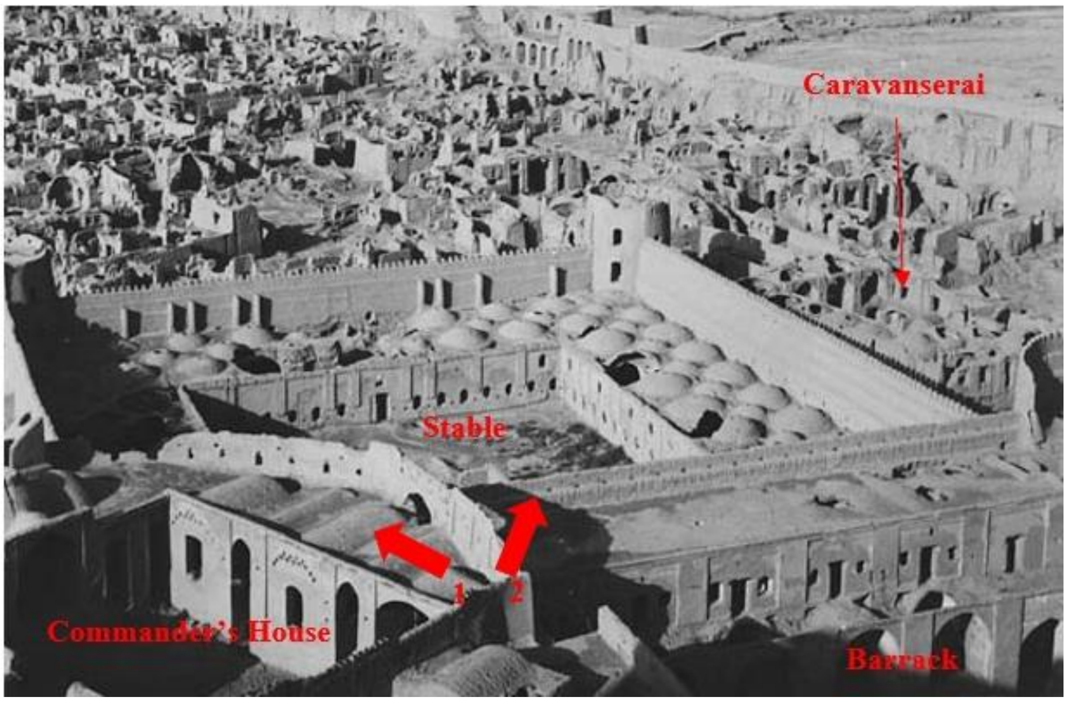


Figure 4.142- Views from Stable of Bam Citadel before beginning of restoration works (Photos by Ershad 1961. Source: archive of ICHHTO).

Figure 4.143- (Left) the Stable of Bam Citadel after the restoration of its roofs (Photo by Ershad, 1986. Source: archive of ICHHTO); and (Right) the Stable of Bam Citadel after its complete restoration (Photo by Richard Cheval, 2000. Source: https://www.flickr.com).

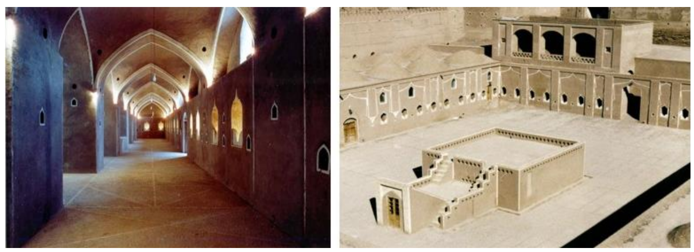


Figure 4.144- (Left) inside of the Stable when it was a dormitory for visitors (Source: personal archive of Prof. Tayari); and (Right) bird view from water reservoir and northern part of the Stable (Source: archive of ICHHTO).

▪ **Physical Damage after Earthquake:** The enclosure walls of Stable along north, east and west had sustained mid-height, out-of-plane flexural damages; the damage in eastern side was more than that in the other sides. Meanwhile, towers in the south corners of the Stable from the middle were shattered. Furthermore, all domed roofs in the east and west sides of the Stable were faced with total collapse; some pillars along western part have remained after the earthquake, but along eastern part, even pillars were detached from their bases. Among roofs, damage in southern part was much less, although there have seen roofs which were collapsed totally. In the northern side, the typology of damages was mostly gable end-wall collapse, out of plan wall damage and partial collapse of the roofs. The only part which was almost intact during the earthquake was the water reservoir.

2003 before earthquake | 2003 after earthquake | 2016

Figure 4.145- Aerial pictures from the Stable taken in subsequence years (Source: Digital Global and Google Earth).

Figure 4.146- Different parts of the Stable of Bam Citadel after the 2003 Bam earthquake (Photos by Moosavi. Source: archive of ICHHTO; and Elham Andaroodi. Source: archive of Bam3DCG).

▪ **Proposed Intervention Plan:** After the earthquake, debris have been removed, and now preventive measures are in process in different parts of the Stable by realization of a continuous layer made of clay-and straw mortar (Kahgel) in such a way to keep rainfall water away without flowing on the surfaces of the structures. Yet, there is no further planning for total restoration and reconstruction of the property. The intervention and stabization measures, which were performed in a small-restored part of the Stable, are listed below:

- Injection grouting of cracks by the Soils Engineering Services Consulting Eng. (SES) through using different formula of ingredients from what was proposed by German group for the Sistani House. The grouts varied from Portland cement to lime cement to lime and pozzolan.

- Replacing the vertical tensile elements (fiberglass rods) on the walls prior to the injection process become post-tensioning elements. The same material for crack grouting was used for holes injection. At the end of vertical elements insertion, the all length of walls has been stabilized by a layer of concrete.

- Stabilization of walls and roofs by using a mesh made of artificial fibers (fiberglass mesh). The mesh sheets are applied to the inner part of walls and roofs and outer part of roofs of the structure with special joints that prevent the structure from collapsing during the next earthquake. Finally, a layer of clay-and straw mortar (kah-gel) covers the fiberglass meshes. It should be noted that, in the time of structure reconstruction, a layer of fiberglass mesh was to be added in every 0.5 m height of walls.

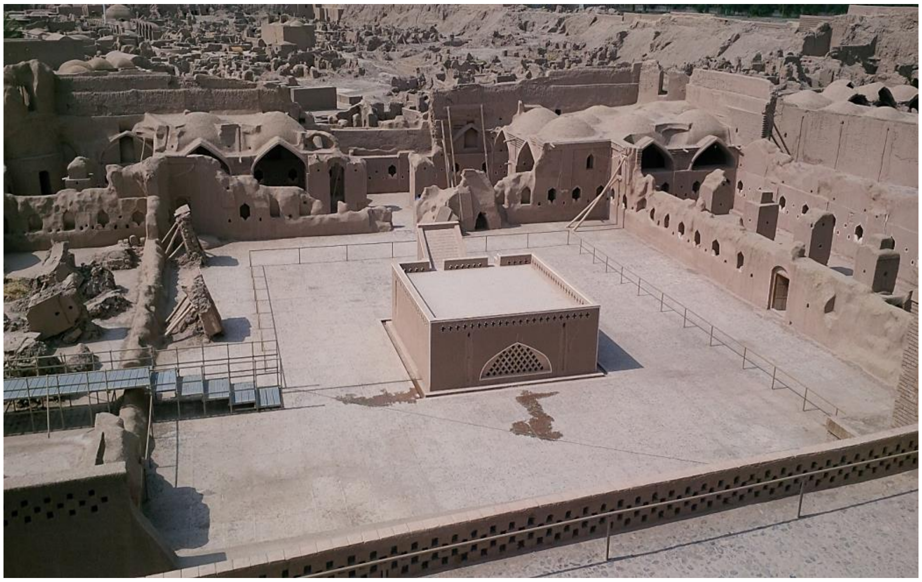


Figure 4.147- View from the present state of the Stable of Bam Citadel (Photo by Rouhi, 2015).

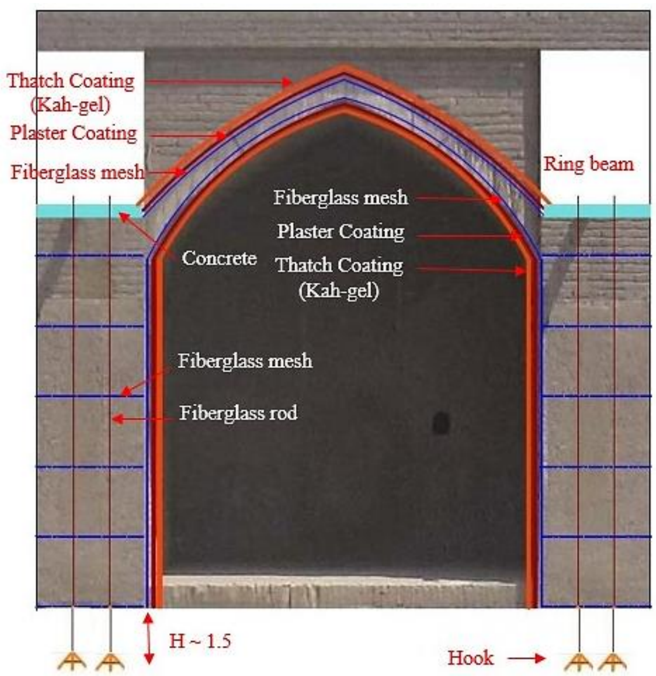


Figure 4.148- Schematic picture from intervention plan proposed for the Stable of Bam Citadel (Designed by Author).

- **Property No. 14: Barrack**

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Barrack of Bam Citadel is located on zone (VII to VIII – F and G) and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'56.53"N – Longitude: 58°22'7.11"E).

▪ **Period of Construction:** As Nourbakhsh (1974) mentioned, this property is probably from the Seljuk (1041-1187 AD), or Teimorid (1370-1507 AD) periods (Bam3DCG).

▪ **Plan Description:** The same road, after passing the Second Entrance Gate, which leads to the Stable, also ends to the Barrack of Bam Citadel; the Barrack is exactly located at the north side of the Stable in a higher level. This place was known as an armory where arm were kept and military reservists were trained or headquartered. As photos shown, during the Qajar Period the Barrack was also used as a storage place for artillery. The height Barrack is almost 9 m in the Citadel, 15 m lower than the Governor's Residence. The total area of this property is 5967 m², the area of the first floor is 1412 m² and at the second floor is 1420 m² (Annual Report of Arg-e Bam Research Foundation, 2008). The Barrack is a two-story building with a central courtyard and rooms in all its four sides, unlike the other two-story buildings within Bam Citadel, in the second floor of Barrack there are no iwans with net-like adobe work. All room's openings in the Barrack open towards the central courtyard and there is no window installed in the rooms. Rooms in the second floor of Barrack's southern side have other doorways like openings which were just used to have a view from the public Quarter of Bam Citadel. In the southern side of the Barrack's central courtyard, there is a mud platform, which was used by the commander of Bam Citadel to observe military parades and to do military speech for soldiers. In this part on the east of mud platform, there is also one of the main three wells of the Governor's Quarter. A corridor on the left side of Barrack leads to a steep slope which goes up to the windmill that used to grind grain for the inhabitants; this mill continued to function until about a century ago (Wazīrī, Joḡrāfīā).[358] Owing to the region's perpetually strong north wind, the mill was always in operation. According to E'temād-al-Saltana, the mill was last repaired in the time of Ebrāhīm Khan Sarhang As'ad-al-Saltana by Mohammad-Qāsem Khan Bamī. The millstones were about 10 ḏaṛʿ (ca. 3 m) in diameter and about 75 cm thick (Etemad Al Saltaneh, 1993).[359] A remarkable peculiarity of the site is its acoustic effect; words spoken even in a low voice from the platform are easily heard all around the yard. It approves the idea that precise calculations were carried out during the construction (Shad, 2014).

[358] Waziri Kermani, A.A. (1974). Joḡrāfīā-ye Kermān. Tehran: Bastani Palizi Publications. (Published in Persian), p. 94

[359] Etemad Al Saltaneh, Mohammed Hassan bin Ali. (1993). Merat al baldan. Tehran: Tehran University Press, p. 293. (Published in Persian).

Table 4.19- Architectural information of the Barrack of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches, Adobe platform, Adobe design in façade, Crenellations and Central courtyard.
Types of Roofs	Closed barrel vaults.
Surface Coating Material	Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

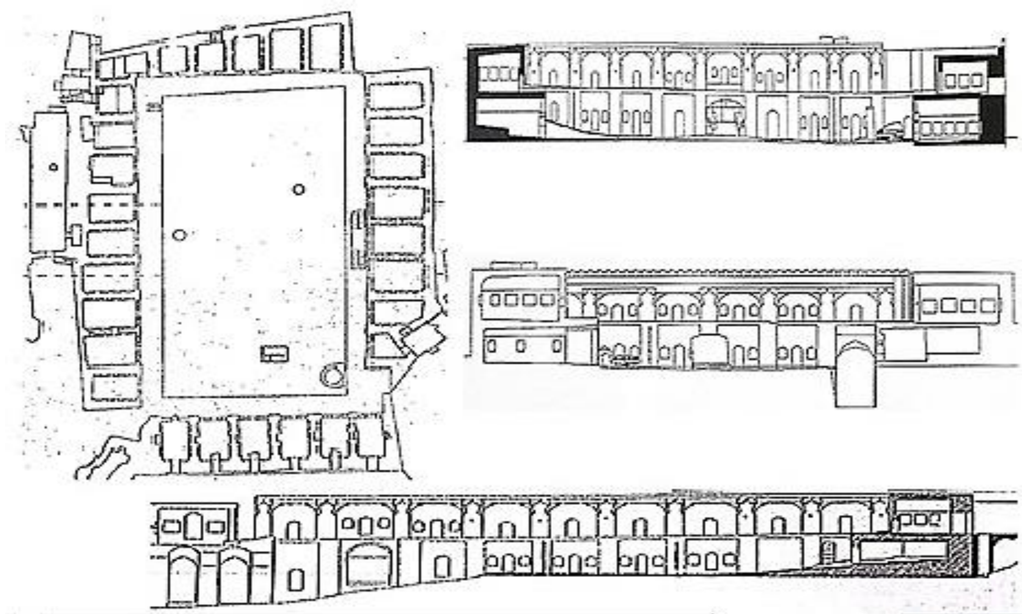


Figure 4.149- Plan and sections of the Barrack of Bam Citadel (Source: archive of RPBCH).

▪ **Property Values:** The Barrack, as the second largest property in Bam Citadel, was the most important military sector of the Citadel. The historical documents prove that the political events affected the architecture of the building during its lifespan (Shad, 2014).

▪ **Conservation History before Earthquake:** The annual report of conservation activities in the Barrack of Bam Citadel is as following:

- 1978: maintenance of conservation of the Barrack.
- 1979: restoration work at Barrack.
- 1980: conservation work at Barrack.
- 1993: restoration of the camel stables within the garrison which covers an area of 200 square meters; conservation work at Barrack; conservation work in the enclosure of the Barrack; repair and renovation of the façades of the Barrack.
- 1994: restoration work in the Barrack.

Figure 4.150- View from north-east side of the Barrack before the earthquake (Photos by Kamran Adl, 1976. Source: archive of ICHHTO); and Darren Steven, 2001. Source: archive of Bam3DCG).

Figure 4.151- Bird view from the Barrack of Bam Citadel before the earthquake (Photo by Ahmadi and Boroomandi, 2003. Source: archive of ICHHTO).

Figure 4.152- Aerial pictures from the Barrack taken in subsequence years (Source: Digital Global and Google Earth).

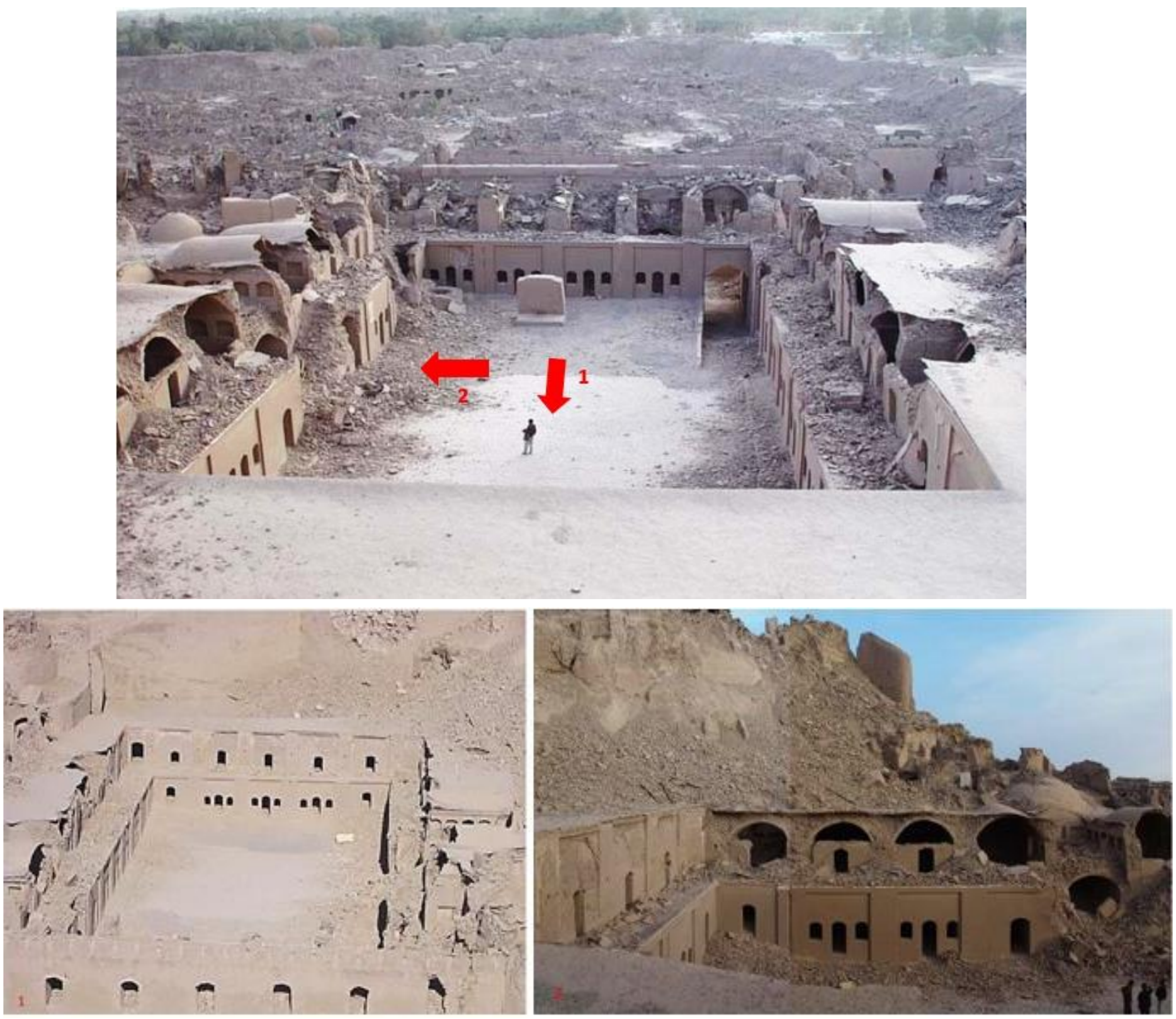


Figure 4.153- View from different parts of the Barrack after the 2003 Bam earthquake (Photos by Ahmadi and Boroomandi, 2003. Source: archive of ICHHTO).

▪ **Proposed Intervention Plan:** The intervention work in this property began in the first half of 2006 and finished in 2010.[360] The building has been mostly repaired after the earthquake, and there was no major problem. During the proposed intervention plan by RPBCH, the restoration activities started after some emergency, and protective measures included debris removal, construction of scaffolding and performance of buttress. The main strategy for the restoration of structures within Barrack was implementing repairs that address specific structural inadequacies, such as decreasing or lightening the weight of specific parts of the structures to reduce loads, increasing wall thickness and closing doorways and shelves for transferring power, arch weight and increasing arch's security. For the lightening of the structures, some procedures have carried out, which are exposed in following:

- removal of ruins including of detached parts, troubled adobes, thatch coating, soil plaster coating
- construction of connecting two vaults in ration the other.
- construction of honeycombed shape's roofs for lightening of roofs.

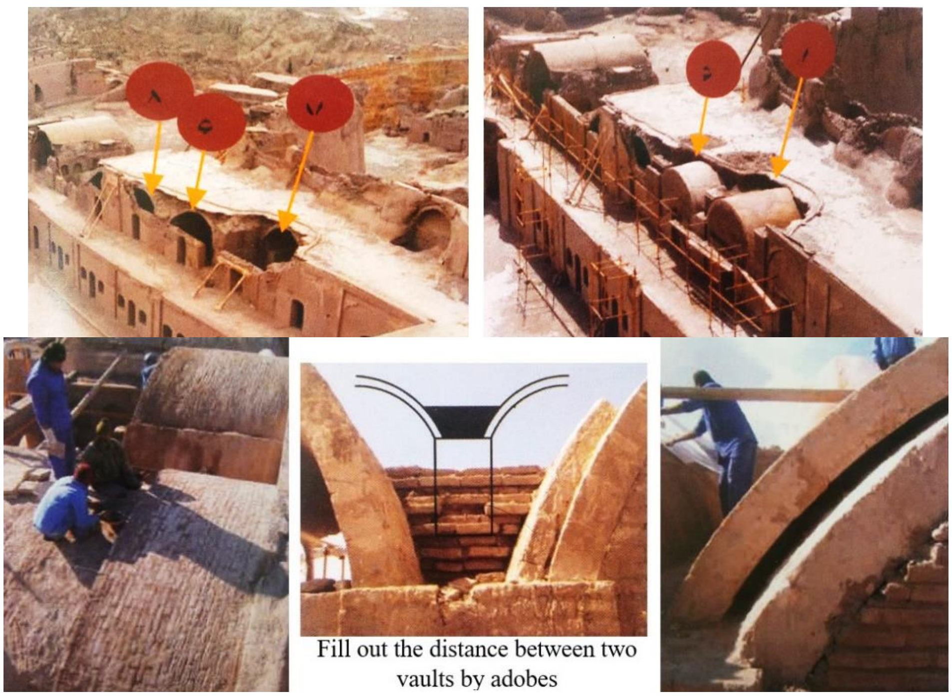


Figure 4.154- (Top) The restoration of vaulted roofs in the western part of Barrack by conjunction of new adobes to the old ones; and (Down) construction of connecting two vaults in ration the other for strengthening the roofs against dead load (Source: Annual Report of Arg-e Bam Research Foundation, 2008).

[360] For the long time both before earthquake and after its total restoration after earthquake, there is no plan for the building future function, always it was act as a visiting area.

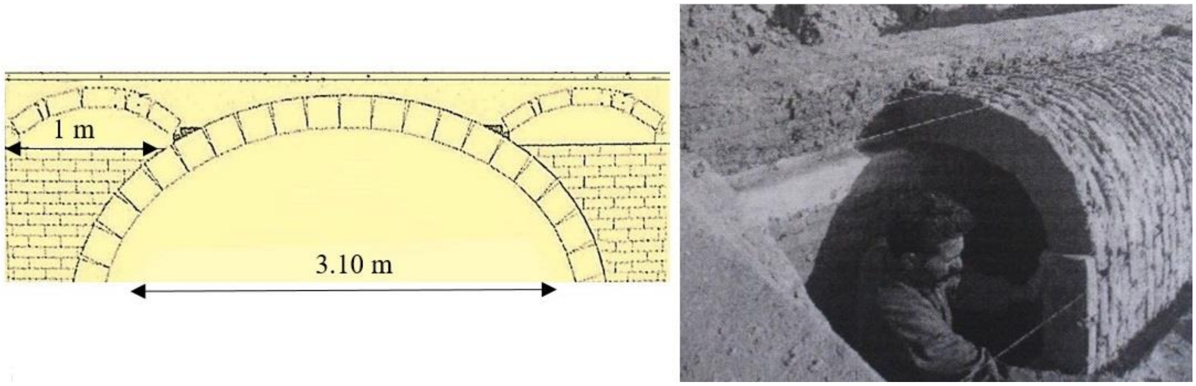


Figure 4.155- Construction of honeycombed shape's roofs for lightening of roofs (Photos by Farahbakhsh 2007).

Figure 4.156- Present state of the Barrack of Bam Citadel after complete restoration (Photo by Rouhi 2015).

- Property No. 15: Commander's House

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the archeological group, the Commander's House of Bam Citadel is located on zone (VIII – G and H) and based on geographical coordinates from Google Earth, it is located on (Latitude: 29° 6'57.47"N – Longitude: 58°22'5.93"E).

▪ **Period of Construction:** As Nourbakhsh (1974) mentioned, like the Stable and Barrack, this property is probably from the Seljuk (1041-1187 AD), or Teimorid (1370-1507 AD) periods (Bam3DCG).

▪ **Property Description:** Next to the Barrack's southeastern side, in a higher level, there was a large house that belonged to the commander of the Citadel. The characteristic element of this building before the earthquake was its iwan at the south side with three-directional windtowers, each in different directions.

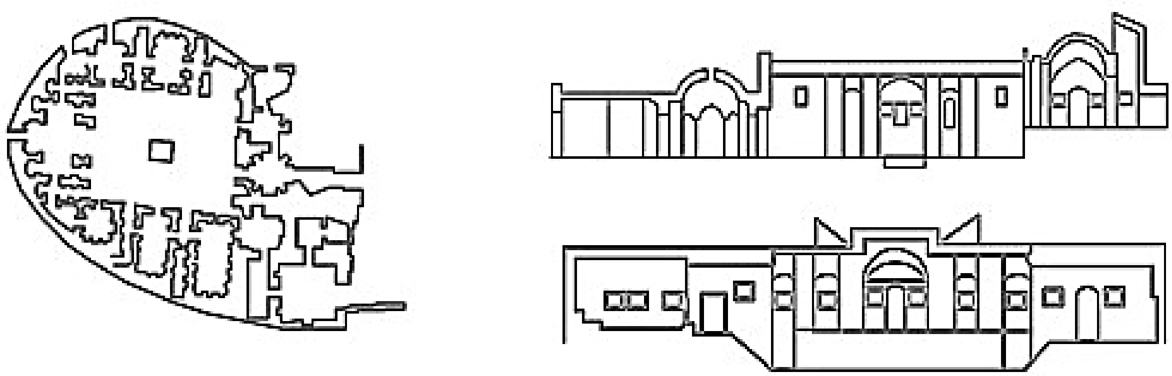


Figure 4.157- Plan and sections of the Commander's House of Bam Citadel (Source: archive of RPBCH).

Table 4.20- General information of the Commander's House of Bam Citadel.

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches, Iwans, Wind towers, Decorative latticework by adobe on walls, Crenellations and Central courtyard.
Types of Roofs	Closed barrel vaults and domes.
Surface Coating Material	Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** In this house, we can precisely notice the importance of placement of different parts of Bam Citadel in a complex. According to the responsibility of the Citadel's commander, its house was located at the slope of a cliff, in a higher level than the other parts of Bam Citadel except of Governor's Residence, where he could have the best view from the Public Quarter, Stable and Barrack.

▪ **Conservation History before Earthquake:** The annual report of conservation activities in the Barrack of Bam Citadel is as following:

- 1978: maintenance of conservation of the Commander's House.
- 1993: conservation work in the roof of the Commander's House, and parts of the house.

Figure 4.158- The progress of restoration process between years 1961 to 2003 in the Commander's House of Bam Citadel, as we can see, it is understandable that restoration works in the Commander's House had been started before Stable (Photo by Ershad, 1961. Source: archive of ICHHTO); GettyImages, 1975. Source: http://www.gettyimages.it); and Fabienne Louyot, 2003. Source: archive of Bam3DCG).

▪ **Physical Condition after Earthquake:** This property totally collapsed by the earthquake. There is not remained anything except of some damaged pillars.

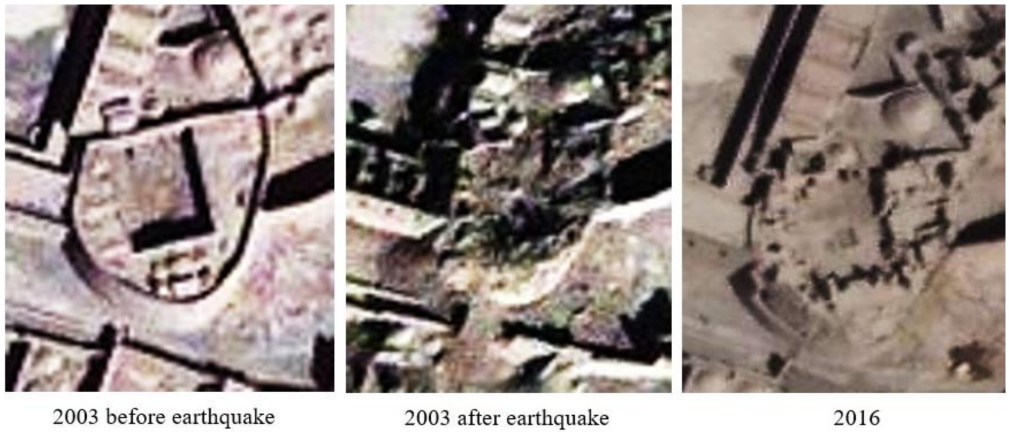


Figure 4.159- Aerial pictures from the Commander's House taken in subsequence years (Source: Digital Global and Google Earth).

Figure 4.160- The Commander's House, Stable, Barrack and Caravanserai after the 2003 Bam earthquake, (Photo by Hesam Mosavi, 2003. Source: http://www.tripmondo.com).

▪ **Proposed Intervention Plan:** Due to the extent of damage and also due to lack of enough documents regarding the Commander's House, no intervention plan has yet been prepared. But until now, the debris have been removed and protective and preventive measures have been considered.

Figure 4.161- Present state of the Commander's House of Bam Citadel (Photo by Rouhi 2015).

- Property No. 16: Governor's Residence

▪ **Location-Geographic Co-ordinates:** According to the Zonation Map which was proposed by the Archeological group, the Governor's Residence of Bam Citadel is located on zone (V to VIII – G and H) and based on Geographical Coordinates from Google Earth its different buildings are located on (Governor's House in Latitude: 29° 6'59.08"N– Longitude: 58°22'7.60"E; Watchtower in Latitude: 29° 6'59.14"N – Longitude: 58°22'7.24"E; Chahar- Fasl in 29° 7'0.52"N– Longitude: 58°22'6.80"E; and Governor's Bath in Latitude:29° 7'1.32"N – Longitude: 58°22'7.11"E).

▪ **Period of Construction:** About the exact date of the Governor's Residence, there is no exact information. As Tayari (2004) noted, 'by referring to the architectural style of Governor's House and Chahar Fasl, they could have been built in the Safavid period (1501/1502-1722 AD) some changes had been done during the Zand (1750-1794 AD) and Qajar (1794-1925 AD) periods'. Contrary to the Tayari's theory, Nourbakhsh (1974) proposed another date for construction of the Governor's House and Chahar Fasl. According to this theory, 'if the barracks and house of the commander were built during the Seljuk (1041-1187 AD) or Teimorid (1370-1507 AD) periods, one can assume the Governor's House and Chahar-Fasl were built at the same time'. He also continues, 'Following the theory that this section of the Citadel is the core and most ancient part, the plan of the Chahar-Fasl edifice might resemble “Chartaghi” or four-vaulted edifices belonging to historical periods before Islam in Persia (before 651 AD)’ (Nourbakhsh, 1974).[361] In the meantime, the watchtower of Governor’s Residence might resemble the fire tower of pre-Islamic temples. There might have been an older tower that was replaced with this newer one. The shape of this tower resembles the fireplaces of Persepolis (Achaemenid (550-330 BC) period) (Nourbakhsh, 1974).[362]

▪ **Property Description:** From the east of the Barrack, a corridor that has an upward slope leads to the Governor’s Residence or Seat of Government. This area with rather a complex organization consists of four main structures into two encompassing fortified walls which take the form of two terraces in the south-eastern part; Governor’s House, Chahar-Fasl (Four-Seasons House), Governor’s Bath and Watchtower.

The Governor’s Residence was built in three floors. The first floor with dark and small room was originally used as storage room, but based on the Author personal interview with Mr. Tohidi, this part was later used as a jail for political figures and rebels against the state. The second floor was used for the servants and kitchen and the last floor was the Governor’s residence. In the Governor’s House, where the king met all his people and he dined, consisted of a small central courtyard with two iwans and rooms around. It was also divided in two sections; summer section in the south and winter section in the north. On the north-west corner of the Governor’s House, there was a large square Watchtower or Kolah-Farangi (pavilion), which is referred to as the highest watchtower of the ancient Citadel of Bam. Probably the watchtower was an essential part of the fire-temple in ancient times. This tower apparently once consisted of seven stories, three of which were destroyed by Fīrūz Mīrzā during the Qajar period.[363] The tower was used to send signals with fire at night and smoke during the day to the surrounding countryside, and thus came to be known as the “Fire Tower” (Atash-Khāneh). The name may also be related to a fire temple and a place where a sacred flame was tended.[364]

The Chahar-Fasl or Four-Seasons House was located in the center of Governor’s residence, which was pilgrim place for its Zoroastrian fire temple. According to some archeologists, this part is the most original and the oldest part of the Arg-e Bam (dating to early Sassanid times). In plan, the Chaharfasl consisted of four corner rooms round a domed central hall; vaults connected these rooms to each other and its center being opened to the four sides. The building in its present form before earthquake belongs to the Safavid period (Behzadi, 2004). Initially, Iranians took this plan for their temples and later applied it to the house and garden. This type of building was common in the first half of the twentieth century (Mehdi-Pour, 2004). This

[361] Bam3DCG, “Virtual 3D Reconstruction of Bam Citadel”. Retrieved from http://dsr.nii.ac.jp/Bam3DCG
[362] Ibid.
[363] Bāstāni Pārizi, “Bam: ii. Ruins of the Old Town”, p. 8.
[364] Ibid, p. 651.

space provided a beautiful view of the area, and was used by the ruler's family of Arg-e Bam and to entertain their honored guests. It could be used during all seasons as the name implies (four seasons), and its residents could enjoy whatever breeze blowing.

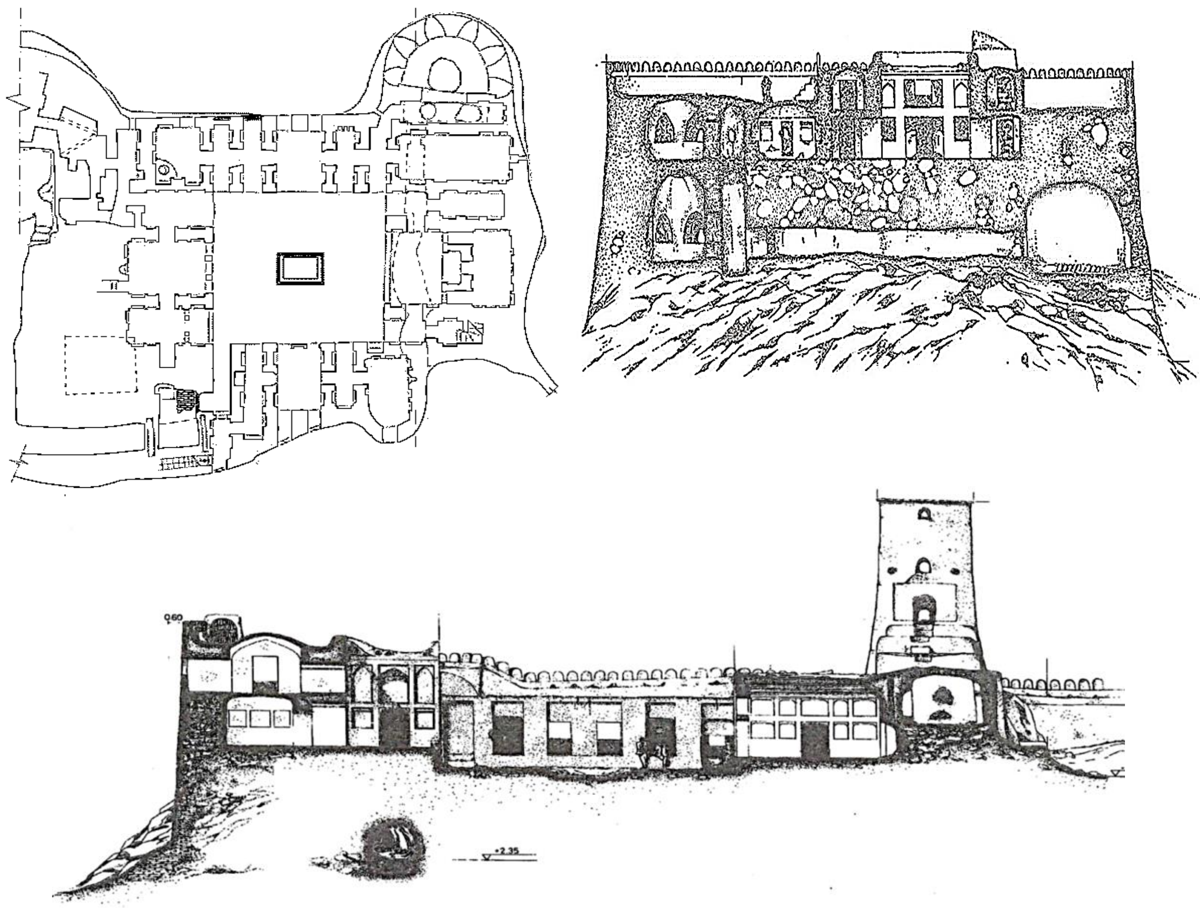


Figure 4.162- Plan and sections of the Governor's House of Bam Citadel (Source: archive of ICHHTO).

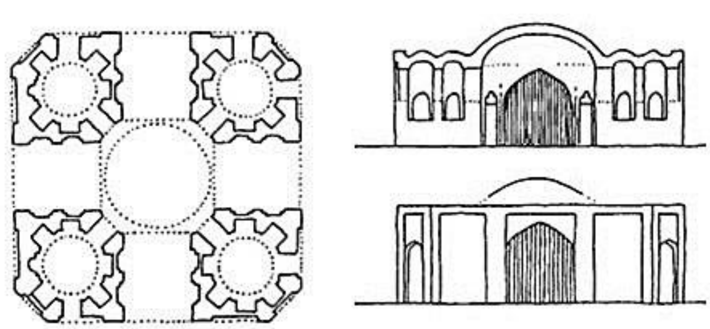


Figure 4.163- Plan and sections of the Four Season House of Bam Citadel (Source: archive of RPBCH).

As Pottinger, who visited the governor's house in 1810, writes regarding this section:

"…The room we entered was a very handsome square one, with a recess and bow window on each side, the floor was covered with rich Persian carpets, and around the walls Numuds, or felts, for sitting upon. It was painted a pure white glite moulding, and had all together a very magnificent but not gaudy effect."[365]

In addition, Sir Percy Sykes who visited the Arg-e Bam in 1896 described the Chāhārfasl as follows:

"From the roof of the building, we enjoyed a wonderful view. Looking back, Kuh-i-Hezar with its mantle of freshly fallen snow riveted our gaze, and on each side of the valley the hills showed up against the turquoise sky, the Shah Sowaran range to the south forming another vision of beauty. Below us lay the date-groves of Bam, and we could trace its river to the north-east […]"[366]

The ruins of Governor's Bath are located at the extreme north end of the Governor's Residence. In the vicinity of Bath lies a well with 40 m depth, which provided the necessary water of the Bath as well as the district. The walls of Bath even before the earthquake were gone, but the base and the deep square bathing pool was still detected with a low step down into where the water lines were etched into the hard rock.

Table 4.21- Architectural information of the Governor's Residence of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arch, Heater, Iwans, Windrowers, Decorative latticework by adobe and wood on openings and Iwans, Crenellations and Central courtyard.
Types of Roofs	Barrel vaults, Groined vaults, Domes and Semi-domes.
Surface Coating Material	Gypsum decoration, Chalk trim, Mud and Sieved Straw and Mud and Straw Plaster.

▪ **Property Values:** The Governor's Residence of Bam Citadel as the initial core of the formation of Bam city, and through its dramatic landscape has a very important value among other parts of the complex. Upon the Governor's Residence, there is a sweeping view over the ruins of the town, and beyond the walls, there is the oasis with its wealth of palm trees. The visual preeminence of the tower above the ensemble of the old city has probably been a distinguishing trademark of the Arg-e-Bam silhouette for many Centuries in the past, as the caravans travelling along the Silk Road, still praised the ingenious water canalization system of the city (Porta & Santoro, 2010).

[365] Pottinger, H. (1816). Travels in Beloochistan and Sind. London: Thames and Hudson, p.196.
[366] Sykes, P.M, Ten Thousand Miles in Persia, p. 218.

▪ **Conservation History before Earthquake:**

- 1980: conservation work at governor's house.
- 1993: conservation work at the Chahar-Fasl; Restoration of the Chahar-Ffasl including the renovation of its façades with Kahgel (pisé) plaster.
- 1994: uncovering the ground levels of the south-east tower in Governor's Residence and its substructures in the aim of doing restoration work at the tower; Restoration work in the Chāhārfasl building including replacement of the damaged plaster in the porticos and outside façades, consolidation of walls, repair of the plaster of vaults.
- 1996: restoration work in Governor's Residence and its enclosure walls.
- 1998: conservation work in Governor's Residence, replacement of the plaster, consolidation of foundations.
- 2000: consolidation work in Governor's Residence, restoration work in the north-eastern corner of the fortified wall of the Citadel.
- 2002: conservation work in Governor's Residence.

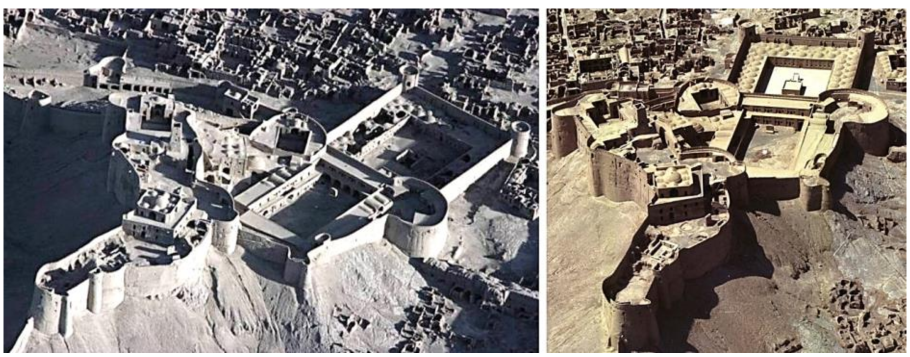


Figure 4.164- The Governor's District between years 1973 and 2000 (Source: archive of ICHHTO).

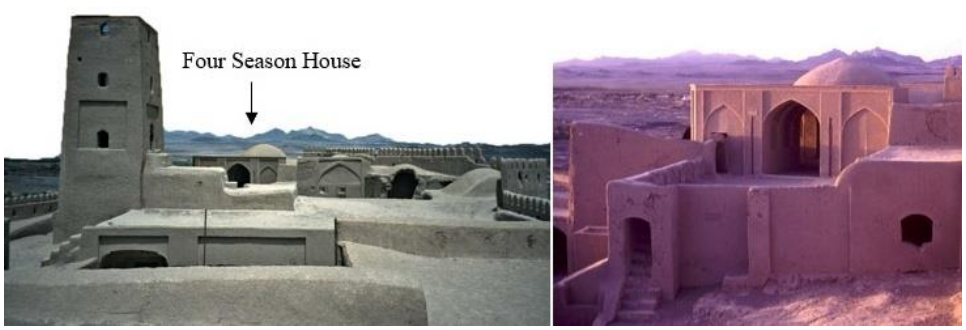


Figure 4.165- (Left) view from upper floor of the Governor's Residence to the north (Photo by Stefan, 1996. Source: https://www.flickr.com/); and (Right) view from Four Season House (Photo by Fabienne Louyot, 2003. Source: archive of Bam3DCG).

Figure 4.166- Governor's House during restoration (Source: personal archive of Prof. Tayari, 2002).

▪ **Physical Condition after Earthquake:** The 2003 earthquake caused the collapse of various sections of the Governor's Residence and the upper parts of the defensive walls. Notwithstanding, much of the lost fabric was from modern restorations. There are deep cracks and detachment on the remained walls.

Figure 4.167- Aerial pictures from Governor's Quarter taken in subsequence years (Source: Digital Global and Google Earth).

▪ **Proposed Intervention Plan:** In this area, the restoration plans are on the way according to the documents from the surveys before the earthquake. Because of the slow pace of work in this area, the remains of the structures are erasing off very fast by the erosion. The reason can be due to the location of the properties in the highest spot of the Citadel; access and carrying materials up to this point is to some extent difficult. At the moment, debris have been removed and some scaffolding has been installed; the usable parts are stored and some prevention and protection projects are being carried out. Since the Governor's Residence is on the highest spots and the wind is so strong in this area, the preservation of remains from erosion caused by wind and rain is a major task. In addition to all mentioned measures, because of the risk of mud slipping in surrounding of Governor’s Residence, its lower part in northern side of Barrack is consolidated by means of a heavy steel support system.[367]

Figure 4.168. The southern wall of Governor’s Residence consolidated by steel support system, as can be seen, from 2012 to 2015 the volume of this steel scaffolding by the progress of restoration works is decreasing (Photos by Joao Leitao, 2012. Source: https://www.flickr.com); and Rouhi, 2015).

[367] According to the Report on the joint UNESCO - ICOMOS Reactive Monitoring Mission to Arg-e Bam and its Cultural Landscape, IRAN (16 - 22 Oct. 2011) in art 3.1.1 (a) there was a claim about the existence of designed steel structure, “In what concerns emergency stabilization, the previous and present teams of management at Bam have addressed a truthful effort throughout the all site. However, the mission team shares concern with the heavy steel structure at the Governor’s Seat, which was not previously approved by the World Heritage Committee. The mission team was informed that since one year, it is used as scaffolding for wall stratigraphy registration. However in 2007, a simple structure was already in place to provide safety and for documentation registration (see Figure 6 at Vatandoust, Mokhtari and Nejati, 2008, p. 316).”

Figure 4.169- The present state of the Governor's Residence of Bam Citadel (Photo by Rouhi, 2015).

- Property No. 17: Yakhdan or **Icehouse**

▪ **Location-Geographic Co-ordinates:** This property is a part of Bam Citadel, but it is located out of the Zonation Map that was proposed by the Archeological group. Based on Geographical Coordinates from Google Earth, it is located in (Latitude: 29° 7'0.49"N– Longitude: 58°22'20.03"E).

▪ **Period of Construction:** The Bam Citadel's Yakhdan can date back to the Safavid period (1501-1736 AD) and it was in used until the late Qajar period (1785-1925 AD).

▪ **Property Description:** The Yakhdan is located outside of Bam Citadel's enclouser wall, in the north-east of the Citadel. The Yakhdan consisted of a relatively large domed roof and a long wall to provide shadow for freezing of water during winter. During winters, the ices were brought from the nearby mountains, so they were stored in the large tank under the large domed roof for the summer times. In this property, as shown in Figures 4.173 (2) and 4.173 (3), some 'palm trunks' were found embedded in the walls, which exactly shows that the traditional masons of Bam Citadel had intelligently used natural elements for strengthening of walls.

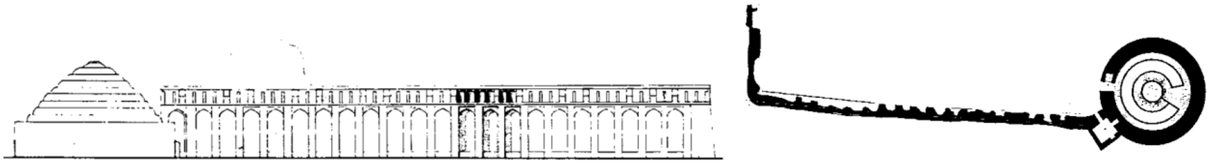


Figure 4.170- Plan and section of the Yakhdan of Bam Citadel (Source: Annual Report of Arg-e Bam Research Foundation, 2008).

▪ **Property Values:** From the ancient time, Persian architectures had mastered the technique of storing ice in the heat of summer in the desert. By seeing some type of buildings like Yakhdan of Bam Citadel in Iranian desert environment, we can well understand how people in the past applied some structural strategies to cope with the harsh weather condition. Sometimes before the earthquake, this property had been restored and transformed into an amphitheater / auditorium where many recent meetings have been held during 1995 and 1999.

▪ **Conservation History:**

- 1993: conservation work at Yakhdan
- 1994: survey and mapping of the Yakhdan; to set up plans for the restoration of the Yakhdan; restoration of the Yakhdan outside the Arg.
- 1995: uncovering the original ground of the Yakhdan, and removal of its debris; plastering the ground of the Yakhdan with cement; restoration of part of the south-eastern enclosure of the Yakhdan.
- 1998: completion of the pavement round the Yakhdan.

Table 4.22- Architectural information of the Ice House or Yakhdan of Bam Citadel (Designed by Author).

Main Original Materials and Construction Techniques: Adobe-mud brick construction technique	
Architectural Elements	Niches, Under walled arches, Adobe design on the façade and Huge stair type dome.
Types of Roof	Dome
Surface Coating Material	Mud and Sieved Straw and Mud and Straw Plaster.

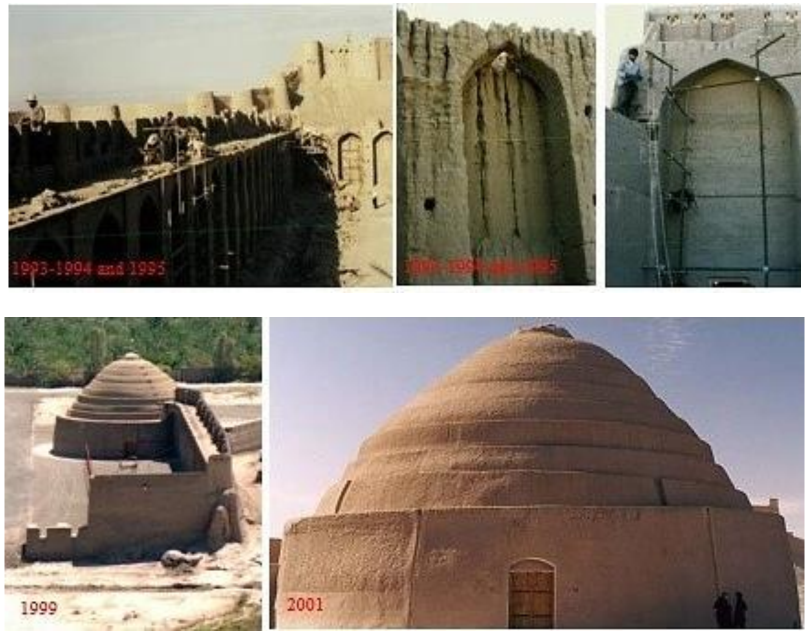


Figure 4.171- The Yakhdan of Bam Citadel from before the beginning of the restoration works, when it was abandoned, until its complete restoration (Photos by Ershad, 1961. Source: archive of ICHHTO; Personal archive of Prof. Tayari 1993-1994 and 1995; and Fernando mobu, 1999 and Jeremy Ingham, 2001. Source: https://www.flickr.com).

▪ **Physical Condition after Earthquake:** After the earthquake, this property missed the stabilization of the top of the ring of the dome and around its doorway.

Figure 4.172- Damage in different parts of the Yakhdan of Bam Citadel (Photos by Rouhi 2015).

▪ **Proposed Intervention Plan:** Until now, the vulnerable parts are stabilized by scaffolding, especially around the collapsed part of the domed roof, and minimum repair are being addressed. For now, there is no decision about reconstruction of the top of the dome.

Figure 4.173- The present state of the Yakhdan of Bam Citadel (Photo by Rouhi 2015).

Table 4.23- General information about the single properties analyzed (Designed by Author).

Property Name, Groups Participant and Project Schedule	Value	Damage Grade	Measures Taken Until Now: Initial Actions	Normal Conservation Work	Seismic Retrofitting		Notes
1) Main Entrance Gate This project is slowly in progress by the Iranian group of the RPBCH.			Debris Removal	Repairing	Traditional Technique		Since the property is like a ruin, due to continuous erosion a permanent monitoring system is needed.
			Protective Measures	Restoration	Innovative Technique		
			Preventive Measures	Reconstruction	Local Material	Modern Material	
2) Tower No. 2 This project is finished from 2010- 2011 by the group of the RPBCH.			Debris Removal	Repairing	Traditional Technique		Just a small part of the crenellations of this tower have been reconstructed with simultaneous use of local and modern materials. The reconstruction work in guard room, and crenellations of the Tower. No.2 and its side's walls is remained.
			Protective Measures	Restoration	Innovative Technique		
			Preventive Measures	Reconstruction	Local Material	Modern Material	
3) Tower No. 1 This project is finished from 2007-2011 by the Italian Ministry of Heritage and Cultural Activities and IGeS Ingegneria Geotecnica e Strutturale snc.			Debris Removal	Repairing	Traditional Technique		The rehabilitation of this property is almost completed, and the property is in ideal condition. The reconstruction work in guard room and crenellations of the Tower. No.1 is remained.
			Protective Measures	Restoration	Innovative Technique		
			Preventive Measures	Reconstruction	Local Material	Modern Material	
4) Bazaar The University of Isfahan, Mie University of Japan (2008-2010), and Iranian group of RPBCH (2006- in progress now) carry out this project in different areas.			Debris Removal	Repairing	Traditional Technique		The property is in satisfactory situation. The reconstruction of the roofs of the southern shops are remained. In this part, due to the importance of public safety, there is need to some protective measures like buttressing of damaged structure.
			Protective Measures	Restoration	Innovative Technique		
			Preventive Measures	Reconstruction	Local Material	Modern Material	
5) Tekiyeh This project is finished from 2005-2011 by the Iranian group of the RPBCH.			Debris Removal	Repairing	Traditional Technique		Although restoration works in this property have been carried out with high accuracy, the property is at risk of structural failures and damages during future seismic events; except of western part of the Tekiyeh, there is seen some large cracks at the body of the property which can be dangerous.
			Protective Measures	Restoration	Innovative Technique		
			Preventive Measures	Reconstruction	Local Material	Modern Material	
6) Friday Mosque In this project "The Well of 12 Emam" is just totally reconstructed with normal traditional methods from 2010-2011 by the Iranian group of the RPBCH.			Debris Removal	Repairing	Traditional Technique		Since the property is like a ruin, due to continuous erosion a permanent monitoring system is needed.
			Protective Measures	Restoration	Innovative Technique		
			Preventive Measures	Reconstruction	Local Material	Modern Material	
7) Mirza Na'eim School			Debris Removal	Repairing	Traditional Technique		Two issues of protective and preventive measures should be followed more carefully: the cracks at

The University of Politecnico di Milan by collaboration with the Padua, Parma and Florence Universities have participate in this project- Italian team finished their mission in two room of Mirza Na'eim School from 2006-2007.									Protective Measures	Restoration	Innovative Technique		room located in eastern part of the property threaten its stability.
									Preventive Measures	Reconstruction	Local Material	Modern Material	
8) Sistani House Dresden University of Germany- German finished the intended room of this property from 2007-2008; the Iranian group of RPBCH through the same intervention plan proposed by the university of Dresden is restoring other parts of the property.									Debris Removal	Repairing	Traditional Technique		This property is one of the best-preserved and reconstructed property, there is not any special problem.
									Protective Measures	Restoration	Innovative Technique		
									Preventive Measures	Reconstruction	Local Material	Modern Material	
9) Payambar Mosque The project is just finished from 2007-2011 by the Iranian group of the RPBCH.									Debris Removal	Repairing	Traditional Technique		This property is one of the best-preserved and reconstructed property, there is not any special problem.
									Protective Measures	Restoration	Innovative Technique		
									Preventive Measures	Reconstruction	Local Material	Modern Material	
10) West Sabat House The Iranian group of the RPBCH directs the Project.									Debris Removal	Repairing	Traditional Technique		Since the property is like a ruin, due to continuous erosion a permanent monitoring system is needed together with preventive measures.
									Protective Measures	Restoration	Innovative Technique		
									Preventive Measures	Reconstruction	Local Material	Modern Material	
11) Caravanserai The Iranian group of the RPBCH directs the Project.									Debris Removal	Repairing	Traditional Technique		In this property, any special work except of debris removal is not carried out. The erosion threaten the existence of the property. Some area have urgent need to preventive measures.
									Protective Measures	Restoration	Innovative Technique		
									Preventive Measures	Reconstruction	Local Material	Modern Material	
12) Second Gate The intervention plan of this project is prepared with CRAterre- ENSAG (France).									Debris Removal	Repairing	Traditional Technique		In this property, some minor restoration works have been carried out, but any special work is not started yet. Since the property is like a ruin, due to continuous erosion a permanent monitoring system is needed.
									Protective Measures	Restoration	Innovative Technique		
									Preventive Measures	Reconstruction	Local Material	Modern Material	
13) Stable The project is started from 2010 by the cooperation of Soil Engineering Services (Iran) and the Iranian group of the RPBCH, and now it is slowly in progress.									Debris Removal	Repairing	Traditional Technique		Since a large part of this property is like a ruin, due to continuous erosion a permanent monitoring system is needed.
									Protective Measures	Restoration	Innovative Technique		
									Preventive Measures	Reconstruction	Local Material	Modern Material	
14) Barrack The project is finished from 2006-2010.									Debris Removal	Repairing	Traditional Technique		This property is one of the best-preserved and reconstructed property. There is not any special

	Protective Measures	Restoration	Innovative Technique		problem, except of cracks and gaps that are seen in different part of the property, this cracks may cause to structural failures and damages during future seismic events
	Preventive Measures	Reconstruction	Local Material	Modern Material	
15) Commander's House The Iranian group of the RPBCH directs the Project.	Debris Removal	Repairing	Traditional Technique		The erosion threaten the existence of the property, a permanent monitoring system is needed.
	Protective Measures	Restoration	Innovative Technique		
	Preventive Measures	Reconstruction	Local Material	Modern Material	
16) Governor's Residence The Iranian group of the RPBCH directs the Project.	Debris Removal	Repairing	Traditional Technique		The erosion threaten the existence of the property, a permanent monitoring system is needed.
	Protective Measures	Restoration	Innovative Technique		
	Preventive Measures	Reconstruction	Local Material	Modern Material	
17) Yakhdan The Iranian group of the RPBCH directs the Project.	Debris Removal	Repairing	Traditional Technique		A permanent monitoring system is needed together with preventive measures.
	Protective Measures	Restoration	Innovative Technique		
	Preventive Measures	Reconstruction	Local Material	Modern Material	

Definition of Categories:

- Initial Actions: in this category the means of debris removal is cleaning of the site from the debris remained after the earthquake; the protective measures means the installation of adequate scaffolding and insertion of the required props and buttress in order temporarily to shore up and stabilize the detached portions of adobe walls; the preventive measures refers to the such minor protective measures like thatch surface coating of the surface of the property to prevent its further degradation. The ruins of the adobe monuments in this category is almost being maintained for more conservation works; the monuments that not be confront with any special conservation works except of aforementioned measures related to this category are still at risk of structural failures and damages during future seismic events.

- Normal Conservation Work: The appearance of the adobe monuments in this category is traditionally being protected and maintained, but they will still be at risk of structural failures and damages during future seismic events. Traditionally these measures are executed to repair the weakened parts or to reconstructed the destructed parts. Actually, the aim of these measures were to enhance the stability of the monuments, but more at maintaining a given state.

- Seismic Retrofitting: In this category, we are confront with two types of seismic retrofitting measures; traditional and innovative retrofitting techniques, which the second one in term of materials used is divided into two parts; applying of local materials or modern materials. Depended on technique applied, the operations in this category may be irreversible and invasive to significant extent. The seismic reinforcement measures proposed in these monuments produces an alteration of the material and mechanical properties of a significant volume of the structure. In following each of these two techniques are exposed:

- Traditional Technique: in this technique, the operations are carried out applying traditional techniques such as enlargement, lightening, Buttresses and pilasters, structural repointing, adobe bricks' substitution, unloading of the vault's extrados infilling and their stiffening, etc.
- Innovative Technique: in this technique, which in turn is divided into two parts, some local materials such as palm fiber, palm meshes, palm ropes, woods, reeds, etc., or some modern materials such as fiberglass meshes, fiberglass rods, metallic traction elements, plastic or metallic ending plates, additive materials, etc. these materials was used for execution of some innovate reinforcement technique such as jacketing, continuous confinement, local tying, stitching, grouting injection, needling and anchorage, etc., of the adobe monuments.

- A Comparative Analysis (SWOT) of Technical Intervention Plans Carried Out in Sistani House and Payambar Mosque of Bam Citadel

The Payambar Mosque and Sistani House are two best-preserved monuments of Bam citadel, which suffered severe destruction by the 2003 Bam earthquake. After Bam earthquake, as a part of the national and international efforts for reconstruction of some of the key properties of Bam Citadel, the Iranian experts from RPBCH and Dresden Technical University of Germany, respectively have contributed comprehensive intervention plans for Payambar Mosque and Sistani House. The central idea of these two proposed plans were to find a sensitive balance between the demands of the two adobe world cultural heritage properties and the demands of modern retrofitting techniques in an area with high seismic activity. However, each group through using some new technical methods, which had similarity in manners and differences in employed materials, tried to meet the stability of these adobe monuments. Since by performing a SWOT analysis between the related projects or intervention plans with a common goal, looking at their strengths, weaknesses, opportunities and threats, we can compare the results, it would help us to know which procedure can be considered as an ideal method for similar projects in the future. Therefore, in this paper, to get a better insight about the effectiveness of those intervention plans implemented, a comparative analysis (SWOT) as an organization's strategic planning tool is considered for comparison scale. As intervention plans were executed, the Sistani-House by Dresden University of Germany and Payambar mosque by Iranian experts from (RPBCH) have been chosen as pilot projects for reconstruction. In these cases, two technical and diverse intervention plans have been implemented for seismic reinforcement of the properties, one by using locally available materials (palm fibers and meshes) and another by using modern materials (fiberglass meshes and rods). The aim of the reconstruction of these monuments was to achieve a maximum of fidelity to the original constructions, which not only had to be not limited to the appearance, but had to regard also the structural character, the "microstructure", and especially the traditional building procedure. In the present section, the prevailing trend is to investigate the capabilities of executed intervention plans by 'SWOT' analysis to explore which approaches can have more seismic strength, compatibility and cost efficiency.

Table 4.24- The SWOT analysis related to Sistani House of Bam Citadel (Designed by Author).

Type	The SWOT analysis related to Sistani House of Bam Citadel (Innovative Technique - Modern Materials)
Strength	▪ Compatibility with the environment ▪ Keeping the authenticity in advanced level ▪ Reconstruction of one of the main monuments in the citadel ▪ Adapting of a new imported technology for restoration of adobe buildings in Iran ▪ Familiarization with the efficiency of local materials in reinforcement of adobe-mud bricks ▪ Reliable seismic safety level ▪ Appropriate speed of reconstruction
Weakness	▪ High cost technology ▪ Depended and imported technology ▪ Extreme intervention

Opportunity	▪ Opening to the public for visiting ▪ Reutilizing the monuments as its previous usage " technical office of the Bam Citadel" for close management of the site ▪ Training the local worker for this new technology
Threats	▪ Uncompleted project in eastern side ▪ Lack of any protective consideration for non-restored parts which are in immediate danger of the erosion by wind and rain ▪ Next possible earthquake ▪ Lack of proper protection against of deterioration factors (wind, rain, etc.) ▪ Lack of permanent management and planning for the future ▪ Not sufficient management system for the monument which is as a part of World Heritage Property

Table 4.25- The SWOT analysis related to Payambar Mosque of Bam Citadel (Designed by Author).

Type	The SWOT analysis related to Payambar Mosque of Bam Citadel (Innovative Technique - Locally Available Materials)
Strength	▪ Compatibility with the environment ▪ Keeping the authenticity in advanced level ▪ Reconstruction of one of the main monuments in the citadel ▪ Using of locally available material and development of traditional technology for adobe buildings ▪ Combination of modern and traditional method for reconstruction of adobe buildings ▪ Familiarization with the efficiency of local materials in restoration process of traditional buildings ▪ Using of palm meshes and fibers as tensile elements ▪ Reliable seismic safety level ▪ Low cost technology
Weakness	▪ Extreme intervention ▪ Mismatch of some parts in appearance and size with original ones like wind towers ▪ Long duration of reconstruction; due to time needed for preparation of local materials and their employing in work
Opportunity	▪ Opening to the public for visiting ▪ Reutilizing the monuments as its previous usage " Mosque" for visitors ▪ Training the local worker for this new technology
Threats	▪ Exposing of palm meshes and fibers to termite attacks ▪ Uncompleted project in northern side ▪ Lack of any protective consideration for non-restored parts which are in immediate danger of the erosion by wind and rain ▪ Next possible earthquake ▪ Lack of proper protection against of deterioration factors (wind, rain, etc.) ▪ Lack of permanent management and planning for the future ▪ Not sufficient management system for the monument which is as a part of World Heritage Property

- Conclusion

In Payambar Mosque and Sistani House like other properties of Bam Citadel, most of the interventions before the earthquake were limited to superficial restoration. Since in the technical restoration and reconstruction of these two monuments before the earthquake, seismic effects as a possible threat had not been considered; as a result, both the historical remains of the monuments and particularly their renowned and reconstructed parts were incapable to provide necessary stability to endure the main seismic motion of the 2003 earthquake. This error, in its turn, by causing further destructions of the monuments showed that the traditional methods of adobe's restoration need strict attention, thorough analysis and scientific upgrading. In Payambar Mosque and Sistani House, the proposers of intervention plans based on a particular cautiousness and a comprehensive view from factors which have impact on seismic endurance of the monuments proposed their intervention plans. Because of 'SWOT' analysis conducted on each of these plans and with respect to the authenticity of the monuments, they were able to meet their seismic resistance. However, in decision to select one of these two methods for similar projects, other various factors like durability, cost efficiency and time required are implicated. In these cases, the Sistani House's intervention plan has more durability and has more time saving, while the intervention plan of Payambar Mosque has much more cost efficiency. Therefore, depending on the condition prevailing of the sites and projects, the importance of properties, options available and financial aspects, each of these plans can be considered as a model for future approaches (Rouhi et al., 2017c). Overall, in cases like Bam Citadel, due to shortage of funds and the large extent of reconstruction required, the model of Payambar Mosque can be considered as the best convenient technique for restoration and reconstruction of the remaining monuments.

CHAPTER 5
CONCLUSION

Adobe Architectural Heritage Conservation: Critical Issues and Approaches with Bam Site

5.1 Development of the Theories of Cultural Heritage Conservation in the World

Civilizations throughout the world have demonstrated human development over the century, raised historic monuments and sites, which in turn express the ideals, aspirations, customs and beliefs of people in material forms. Many of these historical potentials have survived to the present time and bear witness to the long span of human history. Here is our duty to follow an appropriate approach to protect these valuable legacies for future generations. Nowadays by the development of the structures of UNESCO and its related Advisory Bodies (IUCN[368], ICCROM[369] and ICOMOS[370]), each international Charter and Recommendations are mostly reconciled with the characteristics of ancient monuments and sites. Although many factors contribute towards decisions leading to the conservation and restoration of an ancient structure and its ultimate preservation as a 'monument', and since there are no global instructions for each situation, based on these general principles, their sensibility from monument and physical condition of the historic sites, restorers start to propose an intervention plan.

In the previous sections, we endeavored to become acquainted with the World Heritage Cultural Landscape, and also we investigated the significance and issues related to Bam and its Cultural Landscape. The aim of this part is to pursue briefly the history and development of leading national European theories with respect to ancient buildings, the cross maturation of these mindsets, and their contribution towards initial movements, and current fertility of international approach for the preservation of historic monuments and sites. The general development of the concept is accompanied by a critical selection of the most significant theories and their relationship with current practice in the relevant cultural heritage context. The study intend to

[368] In 1947 as an international conference organized on the protection of nature in Brunnen (Switzerland) it was decided for establishment of an international organization for nature conservation and sustainable use of natural resources. Afterwards in 1948 International Union for Conservation of Nature and Natural Resources (IUCN) started its work to species survival, environmental law, protected areas, social and economic policy, ecosystem management, and education and communication.

[369] In 1950 at Assembly of UNESCO in Florence (1950), a main decision on cultural heritage preservation was taken, upon which a proposal for establishment of an international convention for the financial assistance in the subject of the conservation of cultural heritage properties was prepared. Meanwhile, it was preferred to found an International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), which was officially adopted at the 9th Session of the UNESCO General Conference, held in New Delhi, in 1956, and following an agreement with the Italian government in 1959 started working at an office in Rome.

[370] In 1964, in International Charter on the Conservation and Restoration of Monuments and Sites (the Venice Charter) was decided to found a global non-government organisation for promoting the application of theory, methodology, and scientific techniques to the conservation of the architectural and archaeological heritage. One year later in 1965, International Council on Monuments and Sites (ICOMOS) officially started to work. The members of ICOMOS contribute professionally to improving the preservation of heritage, the standards and the techniques for each type of cultural heritage property: buildings, historic cities, cultural landscapes and archaeological sites.

give a general consciousness about the process of the development of traditional approach to the treatment of medieval structures, which first was particularly proposed as "restoration movement" in the 19th century (Sir George Gilbert Scott, Eugène Emmanuel Viollet-le-Duc, etc.), the "anti-restoration movement" or "conservation movement" emphasizing the material authenticity and documentary value of the monuments (John Ruskin, William Morris, Camillo Boito, etc.), and the "modern conservation theory" which was based on a critical historical restoration of the work of art in its aesthetic, historical and use values (Alois Riegl, Cesare Brandi, etc.), which all were reflected in the Venice Charter (1964) and later in the policies of UNESCO and other related organizations.

The leap of theories on the concept of conservation and restoration had been started in three particular periods as it began with early approaches in the Italian Renaissance, through the French Revolution at the end of the 18th century and later on international policy instructions after the Second World War. Several 19th and 20th century's theorists have properly contributed on contemporary global approaches with regard to world cultural heritage properties. Historically, the basis of intervention theories had been situated between two opposing orthodoxies; "restoration movement" and "anti-restoration movement". John Ruskin was a strong proponent of the former, while Viollet-le-Duc argued for the latter. These architects and theorists of 19th century have influenced the philosophy of conservation in the status quo, who gained renown through both their practical works and their theories (Rouhi, 2016d). Although the aims of these two approaches in part coincide, both being directed toward the protection of historic buildings and works of art, their methods and objectives are often opposed, resulting at times in bitter conflicts (Jokilehto, 1986).[371]

- Restoration Movement

From ancient times, dealing with ancient monuments has to be evolved in different directions, or approaches. For instance, during the Renaissance period, monuments from ancient times were transformed for new uses, and in later times during the French Revolution, the usage of these buildings were transformed for industrial functions or military uses. The most dominate traditional approach that has probably existed in every old society, which today more or less continues to be applied, was preserving ancient structures so long as they continued their previous usage or they continued their function by new usage. The driving force behind these examples of 'reuse' was functional and financial (Powell, 1999).[372] The reasons for this

[371] Jokilehto, J. (1986). A History of Architectural Conservation: The Contribution Of English, French, German And Italian Thought Towards An International Approach To The Conservation Of Cultural Property (D.Phil. Thesis, The University Of York, Institute of advanced Architectural Studies, England. Retrieved from https://vk.com/doc277688559_437435201?hash=204ac4f1d4c699116f&dl=39b65a8b182586a0cd

[372] Plevoets, B., & Cleempoel, K.V. (2012). Adaptive Reuse as a Strategy towards Conservation of Cultural Heritage: A Survey of 19th and 20th Century Theories, Ie International Conference 2012:

approach could be found in two cases; firstly, the stableness of these structures, and there was no reason for their destruction, and secondly, construction of new structures need a long time and large financial resources. At this juncture, a few monuments even gained a symbolic universal value to take advantage from restoration activities, like ones which as expressed by Alois Riegl (1858-1905 AD) to have “memorial values”. On the other hand, other monuments that demonstrated an image or a statue of a “god” or “significance of the person” or “spirit” had to be respected and protected in their material authenticity.[373] Consequently, through particularly common renovation and renewal, even through structural improvement, without much concern about the material substance, the restoration activities were conducted towards keeping intact the function of those monuments. In other cases, monuments whose symbolic values have not been approved in the society had to be doomed to destruction.

By entering Italian Renaissance and establishment of the pillars of “romantic restoration”, although destruction and abuse of ancient monuments and sites had been continued, this mindset between Italian intellectuals was gradually growing so that all historical objects in the Roman Empire, as nostalgic remains of the past, had to be carefully preserved. In fact, this mindset founded the political attitude of the Italian Renaissance towards preservation of the ancient monuments. In the meantime, ancient sculptures, triumphal arches, memorial columns and other monuments and works of art were preserved, protected, as well as restored and completed in order to give them new actuality, new function and new life as a part and reference of present society (Jokilehto, 1986). Then this approach was further developed between other European countries, where the maturating of historic consciousness was more felt after the events of the French Revolution. The desire for protecting and restoring national monuments became a widespread movement, more specially with relation to mediaeval structures, so the works had to be done with more precision by applying initial investigations on the history, architecture, material of the monuments, as works had been done by Sir George Gilbert Scott in England and Eugène Emmanuel Viollet-le-Duc in France.

In 1840, because of new debate held in England on the principles of conservation and restoration of historic buildings, the ideas of cultural heritage preservation was divided into two opposing groups, restorers and anti- restorers, who gradually contributed to the expansion and clarification of their points of view. In these two fundamental theories, restorers principally based on “stylistic restoration” emphasized the practical and functional aspects of the original architecture. Instead, anti-restorers, while concerned about falsification that might happen

Reinventing Architecture and Interiors: the past, the present and the future, Ravensbourne, England, 28-29 March 2012.

[373] On the contrary, these monuments sometimes because of their symbolic values were subject to destruction by the malicious acts of opposition ideologies.

during restoration process, have recommend that the only task remained is conservation of the authentic material of the original objects where the cultural heritage finally consisted.[374]

Sir George Gilbert Scott (1811-1878 AD)[375] was one of the most prolific architects which Great Britain has produced, over 800 buildings being designed or altered by him (Cole, 1980),[376] including the Martyrs' Memorial, Oxford (1840), Albert Memorial, London (1864), St Pancras Chambers, London (1865), Chester Cathedral (1876), Edinburgh Catherdal (1879). In restoration, Scott showed a unrivalled power of searching for evidences, and a remarkable fertility in following up a clue or conjecturing an original design from a few remaining fragments (The Dictionary of National Biography, 1897).[377] Scott with its successive papers and statements founded the bases of his notion of 'faithful restoration' or "conservative restoration".[378] For Scott the "faithful restoration" meant respect to the original design; neither the original material nor for the form achieved through history. He as the greatest architectural restorers of the 19th century, during his restoration works usually faced ancient monuments with extensive interventions. Certainly, he sometimes remodeled rather than restored, and more than once his critics were successful in convicting him of an excessive energy in renovation (The Dictionary of National Biography, 1897). In the last year of Scott's life, the growing opposition to the prevalent practice of architectural restoration with which his name was identified took definite form, and the Society for the Protection of Ancient Buildings was inaugurated (Ibid). As mentioned by Jokilehto (1986), "A certain ambiguity that has accompanied the philosophy and practice of restoration may well be due to this. In England, where the treatment of mediaeval churches gradually developed from arbitrary treatment into 'faithful restoration' as defined by Scott, and was based on an apparent respect for all the historic stratification, the building in reality, in too many cases, was substantially changed according to the fashion of the time. This was pointed out strikingly by Ruskin, who emphasized the quality of workmanship in particular historic periods, the impossibility to reproduce this and the values connected with it at any other time, and the necessity to conserve the authentic object in its material consistency. Even 'faithful restoration', if it meant reproduction of original features, as it usually did, it was

[374] Leading personalities, such as Prosper Mérimée, who emphasized full respect for all historic periods, at the same time were responsible for directing 'complete restorations', which could mean purification from historic additions, as well as construction of parts that never had existed (Jokilehto, 1986).
[375] Sir George Gilbert Scott, British architecture, born in 1811 at Gawcott, Buckinghamshire and died in 1878 at Westminster Abbey.
[376] Cole, D. (1980). The Work of Gilbert Scott. London: Architectural Press, p. 1.
[377] The Dictionary of National Biography. (1897). "Scott, Sir George Gilbert, R.A.". In: Sidney, L., & Leslie, S. (eds.). London: Smith, Elder & Co, pp. 19-23. Retrieved from http://onlinebooks.library.upenn.edu/webbin/metabook?id=dnb
[378] Scott was an enthusiastic though not an accomplished writer. He published, besides various pamphlets, 1. 'A Plea for the Faithful Restoration of Ancient Churches,' 1850. 2. 'Remarks on Secular and Domestic Architecture,' 1850. 3. 'Gleanings from Westminster Abbey,' 1862 (The Dictionary of National Biography, 1897).

‘a lie’, a falsification, not the real thing anymore. One can question how far Scott was really conscious of this conflict, although he did confess that all restorers were offenders!”

At the same time, another leading figure in development of the theory of restoration movement was Eugène Emmanuel Viollet-le-Duc (1814-1879),[379] who for his “interpretive restorations” has been firmly linked with the architectural theory of the 19th century and to today.[380] As pointed out by the Sir John Summerson (1963), “There have been two supremely eminent theorists in the history of European architecture – Leon Battista Alberti and Eugène Viollet-le-Duc”.[381] Viollet-le-Duc’s “restorations” of ancient buildings frequently combined historical fact with creative modification, and his ‘updating’ of the church of “Notre Dame”[382] in Paris influenced the architecture of the 19th century to such a degree that it led to a massive revivalism of Gothic architecture everywhere (Proto, 2009).[383] Throughout his career, Eugène Viollet-le-Duc published his influential “(Dictionnaire raisonné de l'architecture française du XIe au XVIe siècle” (1854), “Entretiens sur l'architecture et Dictionnaire du mobilier” (1858) and his last work “Histoire d'un dessinateur, comment on apprend à dessiner” (1879). These books as the broadest and most philosophical expression of Viollet-le-Duc’s point of view exactly shown his idea about the issue of restoration. One school of thought, exemplified by the writings and work of Eugene Emmanuel Viollet-le-Duc, held restoration as “a necessary reestablishment in a finished state [of that] which may in fact never have actually existed at any given time” (Matero, 1993). In 1854, Viollet-le-Duc in his concerns about the reuse of historic buildings, and the role of this aspect on restoration works states:

“[…] the best of all ways of preserving a building is to find a use for it, and then to satisfy so well the needs dictated by that use that there will never be any further need to make any further changes in the building.” […] “In such circumstances, the best thing to do is to try to put oneself in the place of the original architect and try to imagine what he would do if he returned to earth and was handed the same kind of program as have been given to us. Now, this sort of proceeding requires that the restorer be in possession of all the same resources as the original master – and that he proceeds as the original master did.”[384]

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[379] Eugène Emmanuel Viollet-le-Duc, French architect and theorist, born in 1814 at Paris, and died in 1879 at Lausanne.
[380] His direct or indirect influence was felt all over France and abroad; he was involved in restorations in Belgium, the Netherlands and Switzerland (Jokilehto, 1986).
[381] Summerson, J. (1963). “Viollet-le-Duc and the Rational Point of View.” Heavenly Mansions and Other Essays on Architecture. New York: Norton, pp. 135-158.
[382] Other main restoration projects of Viollet-le-Duc included Mont Saint-Michel, Carcassonne, Roquetaillade castle and Pierrefonds.
[383] Proto, F. (2009). A short history of western architecture from Vitruvius to rem koolhaas. In: Puglisi, L.P. (ed.), Architectural Design; 79(1): 14-15.
[384] Viollet-le-Duc, E. (1854). In “The Foundations of Architecture. Selections from the Dictionnaire raisonné”, (Translated by Kenneth, D. (1990). Whitehead from the original French). New York: George Braziller, pp. 222-223.

Viollet-le-Duc, in the eighth volume of his Dictionary, published in 1866, "Dictionnaire Raisonné de l'Architecture Française"[385] insisted that, "The term Restoration and the thing itself are both modern. To restore a building is not to preserve it, to repair, or to rebuild it; it is to reinstate it in a condition of completeness which may never have existed at any given time."[386] Also about the method of restoration, he added, "every building and every part of building should be restored in its own style, not only as regards appearance but structure".[387] In fact, Viollet-le-Duc's interventions were often far-reaching, as he added for instance completely new parts to the building 'in the style of the original'.[388] So that later, Viollet-le-Duc's ideas of restoration had strongly been criticized by his contemporaries and descendants, John Ruskin as the leader of anti-restoration movement in his famous "The Seven Lamps of Architecture" considered restoration as 'the most total destruction which a building can suffer'.[389] And elsewhere, Boito (1884) in his speech at the Turin Exhibition, known Viollet-le-Duc's approach as a real falsification that is completely rejected, he also mentioned that, "This approach is full of risks. It has no theory. It has no understanding, which would save it from free invention: and free invention is a lie, a falsification of the antique, a trap for posterity. The better the restoration has been carried out, the better more successfully the lie will triumph […]." (Jokilehto, 1986).

- Conservation Movement

Then by adding emphasis on the aesthetic values, the new approach was developed in Europe with aim at the conservation and re-evaluation of the authenticity of objects, preservation of the structures based on stratification of the time that they belonged to, and avoiding of the falsification. This new approach was further developed by Giovan Battista Bellori (1613-1696 AD), who emphasized the authenticity of paintings, and by Johann Joachim Winckelmann (1717-1768 AD), who insisted on a distinction between the original and the restored parts in order not to falsify the intrinsic artistic values of antique works of art (Jokilehto, 1986). Gradually, in the late of 19th century anti-restoration movement developed among European philosophers such as Victor Hugo, A.N. Didron and Ferdinand Von Quast. Thence, the penetrating mind of John Ruskin and the efforts of William Morris gave it a clear definition, emphasizing the question of historic time and authenticity in relation to the original object, and the impossibility to reproduce an object with the same significance in another historical-cultural context. Any reconstruction was refused, and additions were recommended in contemporary form (Ibid).

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[385] Jokilehto, J. (1999). History of Architectural Conservation (Conservation and Museology) (1st Edition). Oxford: Butterworth-Heinemann.
[386] Viollet-le-Duc, E. (1875). On Restoration. London: Sampson Low, p. 16.
[387] Ibid, p. 42.
[388] Vaccaro, A. (1996). 'Restoration and Anti-Restoration'. In: Price, N., Talley, M., & Vaccaro, A. (eds.), Historical and Philisophical Issues in the Conservation of Cultural Heritage. Los Angeles: The Getty Conservation Institute, pp. 308-313.
[389] Ruskin, J. (1849), The Seven Lamps of Architecture. Londen: Smith, Elder, p. 179.

John Ruskin (1819-1900 AD)[390] who in Tolstoy's words is known as "one of the most remarkable men not only of England and of our generation, but of all countries and times" because he is 'one of the those rare men who think with their hearts'.[391] Ruskin's belief in preservation of ancient buildings had a significant influence on later thinking about the distinction between conservation and restoration (Niglio, 2013).[392] Among numerous publications of Ruskin "The Seven Lamps of Architecture" (1849), and "Stones of Venice" (1851-53) were high influential and still remain in print today. In The "Seven Lamps of Architecture", (1849), in the "Lamp of Memory", Ruskin wrote:[393]

"Neither by the public, nor by those who have the care of public monuments, is the true meaning of the word restoration understood. It means the most total destruction which a building can suffer: a destruction out of which no remnants can be gathered: a destruction accompanied with false description of the thing destroyed. Do not let us deceive ourselves in this important matter; it is impossible, as impossible as to raise the dead, to restore anything that has ever been great or beautiful in architecture" [...] "Do not let us talk then of restoration. The thing is a Lie from beginning to end. You may make a model of a building as you may of a corpse, and your model may have the shell of the old walls within it as your cast might have the skeleton, with what advantage I neither see nor care: but the old building is destroyed, and that more totally and mercilessly than if it had sunk into a heap of dust, or melted into a mass of clay: more has been gleaned out of desolated Nineveh than ever will be our of rebuilt Milan". [394]

The second famous anti-restoration philosopher was William Morris (1834-1896 AD),[395] who was particularly concerned about the practice of attempting to return buildings to an idealized state from the distant past (i.e. Viollet-le-Duc's approach), which often involved the removal of elements added in their later development and which Morris saw as contributing to their interest as documents of the past (Aubrey, 2013).[396] Morris was heavily influenced by the writings of the art critic John Ruskin. In 1900 and 1901, he published translations of Ruskin's texts in German, and in 1904-5, came from the print his important Das Englische Haus, much

[390] John Ruskin, British art critic, art patron, draughtsman and watercolourist, born in 1819 at London and died in 1900 at Coniston, Lancashire.
[391] Tolstoy, L. (1937). An Introduction to Ruskin's Works' (1899). In Recollections and Essays by Leo Tolstoy, Maude, A. (trans.). London: Oxford University Press, p.188.
[392] Niglio, O. (2013). John Ruskin: The Conservation of the Cultural Heritage, Kyoto University, Graduate School of Human and Environmental Studies, LECTURE. Retrieved from repository.kulib.kyoto-u.ac.jp/dspace/bitstream/.../2013_05_23_Olimpia_Niglio.pdf
[393] The Lamps were conceived as the seven fundamental and cardinal laws to be observed and obeyed by any conscientious architect and builder. They were not intended as the only rules to follow, but in Ruskin's opinion they were the important ones (Jokilehto, 1986).
[394] Ruskin, J. (1849). The Seven Lamps of Architecture. London: Smith, Elder, pp. 179-180.
[395] William Morris, British textile designer, poet, novelist, translator, and socialist activist, born in 1811 at Walthamstow and died in 1878 at Hammersmith.
[396] Aubrey, D. (2013). Theories of Architectural Conservation. Retrieved from https://vialucispress.wordpress.com/?s=Theories+of+Architectural+Conservation&x=0&y=0

appreciated also by Lethaby and other English architects (Muthesius, 1981).[397] Morris on 10 March 1877, opposing to destructive restoration proposed by Tewkesbury Abbey penned a protest to the editor of the Athenaeum, which in turn shows well Morris's point of view about the issue of restoration, "My eye just now caught the word 'restoration' in the morning paper, and, on looking closer, I saw that this time it is nothing less than the Minster of Tewkesbury that is to be destroyed by Sir Gilbert Scott. Is it altogether too late to do something to save it - it and whatever else of beautiful or historical is still left us on the sites of the ancient buildings we were once so famous for? Would it not be of some use once for all, and with the least delay possible, to set on foot an association for the purpose of watching over and protecting these relics, which, scanty as they are now become, are still wonderful treasures, all the more priceless in this age of the world, when the newly- invented study of living history is the chief joy of so many of our lives?"[398] Then, on 22 March 1877, Morris along his movement against restoration founded "the Society for the Protection of Ancient Buildings" (SPAB). This Society had an important role to play in uniting the forces against conjectural restoration, and promoting maintenance and conservative treatment (Jokilehto, 1986).

In this period, "faithful restoration", "analogical reconstructions" and "stylistic restorations" had been an officially accepted approach in France and England. At the same time, the issue of conservation and restoration in Italy was to be at a sort of compromise. In this case, the Italian charter of conservation (1883), which was drafted by Camillo Boito (1836-1914 AD)[399], was promoted strict conservation on similar lines to those of Ruskin and Morris, although equally critical about France and English approaches. The influence of Boito's thinking on the international conservation practice was very strong, as far as his ideas have been the basis for the Athens Charter in 1931. According to the theory of Camillo Boito, the method of restoration should be depended on the individual circumstances of the monument. As critical comparison taken by Camillo Boito (1836-1914 AD) about two principal theories, which were represented by Viollet-le-Duc and Ruskin, "He now considered it risky, as Viollet-le-Duc had proposed, to put oneself in the place of the original architect. Instead, one should do everything possible and even the impossible to maintain the old artistic and picturesque aspect of the monument; any falsifications should be out of the question." [...] "At the same time, Boito was also critical of Ruskin's approach, which he grossly simplified and misinterpreted to mean that one should not touch the historic building, and, rather than 'restoring' it, should let it fall in ruins."[400] For the

[397] Jokilehto, J. (1986). A History of Architectural Conservation: The Contribution Of English, French, German And Italian Thought Towards An International Approach To The Conservation Of Cultural Property (D.Phil. Thesis, The University Of York, Institute of advanced Architectural Studies, England. Retrieved from https://vk.com/doc277688559_437435201?hash=204ac4f1d4c699116f&dl=39b65a8b182586a0cd

[398] Morris, W. (1877). Tewkesbury Minster, Letter to *Athenaeum*, 10 March 1877. Retervied from https://www.marxists.org/archive/morris/works/1877/tewkesby.htm

[399] Camillo Boito, Italian architect and engineer, born in 1836 at Rome and died in 1914 at Milan.

[400] Jokilehto, J. (1999). History of Architectural Conservation (Conservation and Museology) (1st Edition). Oxford: Butterworth-Heinemann, p. 202.

first time in 1883, Boito in the Third Congress of Engineers and Architects "Risoluzione del III Congresso degli ingegneri ed architetti", held in Rome, in his paper "Questioni pratiche di belle arti, Restauri, concorsi, legislazione, professione, insegnamento"[401] summarized his recommendation on preservation of ancient monuments in seven points,[402] then in 1893 Boito published a revised version of Charter in eight short recommendations. The theme proposed by him for the Congress was the question whether restorations should imitate the original architecture, or whether, on the contrary, additions and completions should be clearly indicated (Jokilehto, 1985).

Generally, the Boito's thinking about the isuse of cultural heritage preservation was in such a way that a monument needed to be consolidated rather than conserved, and conserved rather than restored in order to give it a longer life. Moreover, in Boito's idea any attempt at restoration would immediately mean falsification, as Boito (1884) stated, "No restorations; and throw down immediately, without remission, all those that have been done so far, recent or old" (Jokilehto, 1986). In the case of restoration, he also distinguished three methodological approaches which he called, "archaeological restoration" (restauro archeologico) for antique monuments, "pictorial restoration" (restauro pittorico) for medieval monuments and "architectural restoration" (restauro architettonico) for Renaissance and other monuments. Furthermore, about necessities for using of the additions, he described how modern interventions should be applied in such a way that they would be recognized as such to avoid misunderstandings about the historic and artistic values of the monuments.

- Critical Restoration Movement

At the end of the 19th century the Italian influence was reverberate in England, France, Germany, Austria, etc., where with a new cultural attitude, they flourished the modern treatment assent in conservation and restoration of historic monuments. In the 20th century, the development of the theories of restoration can be seen after the 'broadening touch' by Gustavo Giovannoni (1873-1947 AD), and what was defined as a modern synthesis of the two previous approaches, so called as "restauro critico" (critical restoration theory), which was firstly defined by Alois Riegl (Vienna), Cesare Brandi (Siena), Renato Bonelli (Rome), Giulio Carlo Argan (Turin) and Roberto Pane (Naples). In fact, it would be said that most of the current international standards drafted on the subject of cultural heritage preservation are somehow as the result of this advanced theory of restoration; the authenticity that was proposed in this theory formed the basic structure of the Venice Charter (1964).

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[401] Boito, C., Questioni pratiche di belle arti, Restauri, concorsi, legislazione, professione, insegnamento. Milano 1893, 28ff), "Risoluzione del III Congresso degli ingegneri ed architetti, Roma 1883.
[402] In 1883, the Boito's recommendations formed the first Italian Charter of conservation.

As Jokilehto (1986) stated about critical restoration theory, "The theory is based on a historical-critical evaluation of the object; it is a strictly conservative approach considering all significant historic phases, but it takes into account both historic and aesthetic aspects, and allows for a reintegration of a work of art under specific conditions, if this can be achieved without committing an artistic or historic fake. In the case of a conflict regarding works of art that have preserved their potential unity, and particularly when certain additions are less significant, artistic values are given priority." In particular, this theory further applies the concepts and ideas introduced by Prof. Giovanni who stated that, "it is meant by 'Restoration' any intervention seeking to preserve and pass on to the future, without erasing the traces, making it easier to understand in the passage of time, the historical, artistic and environmental traces: it is based on the respect for original material and authentic documents, restoration is also a non-verbal critical interpretations expressed in concrete ways."[403]

Alois Riegl (1858-1905 AD)[404] was perhaps the most influential art historian of the beginning of 20th century (Zerner, 1976), who was the author of the first systematic and modern theory of conservation. His methodology was diverse and appeared to adumbrate various directions adopted by art historians in the later 20th century, including formalism, structuralism, post structuralism and reception theory (Dictionary of Art Historians, 2016). Riegl in his theory rejected earlier theories of "restoration movement" and "anti-restoration movement", and insisted that each monument belonging to different periods could be evaluated on the basis of their common and absolute criteria, so to decide for the preservation of every monument, the values proper to the period must be defined. In 1903, Alois Riegl in his essay "Der Moderne Denkmalkultus: Sein Wesen und seine Entstehung" conflict between these opposing theories on conservation by considering different values for ancient structures, such as commemorative values, age-value, historical value, intentional commemorative value, present-day values, use-value, art-value, newness-value and relative art-value.[405] Concerning the different values, Riegl

[403] Giovanni Carbonara. (2005). In Che cos'è il restauro? Nove studiosi a confronto, (da un'idea di B. Paolo Torsello), Venezia, Marsilio. Translated from original text by Author: "S'intende per "restauro" qualsiasi intervento volto a conservare e a trasmettere al futuro, facilitandone la lettura e senza cancellarne le tracce del passaggio nel tempo, le opere d'interesse storico, artistico e ambientale; esso si fonda sul rispetto della sostanza antica e delle documentazioni autentiche costituite da tali opere, proponendosi, inoltre, come atto d'interpretazione critica non verbale ma espressa nel concreto operare."

[404] Alois Riegl, Austrian art historian, born in 1858 at Linz, and died in 1905 at Vienna.

[405] As original text of Alois Riegl (1903) following values were considered for a monument:

- Erinnerungswerte: commemorative values
- Alterswert: age-value
- Historische Wert: historical value
- Gewollte Erinnerunswert: intentional commemorative value
- Gegenwartswerte: present-day values
- Gebrauchswert: use-value
- Kunstwert: art-value
- Neuheitswert: newness-value
- Relative Kunstwert: relative art-value

maintained that, "The contradiction between newness-value and age-value is at the centre of the controversy which rages over the treatment of monuments."[406] Riegl in his theory to respect the age-value of the monuments, and their protection from premature destruction was generally advocated to minimum intervention and limit restoration, as far as the measures are strictly necessary for the preservation of the objects. According to the definitions of Riegl, "the historical value of monuments mattered less than medieval architecture or the lessons that one could draw from this. It is for this reason that his restoration works were so "radical" and that his famous definition of restauration allowed for the restoration of a building to its complete state, which may in fact have never existed." (Cardoso Rosas, 2005).

Since the 19th century, the Italian influence was echoed in other countries of the world particularly by Camillo Boito, Cesare Brandi, and later by Gustavo Giovannoni. The relevance of Italian contribution to the field of restoration and conservation is fully recognized by Cesare Brandi (1906-1988),[407] who initiated critical restoration theory (D'Aquino, 2015).[408] In 1938, Brandi was appointed as first director of the "Istituto Centrale del Restauro" (ICR),[409] as a director of a main conservation center, Brandi developed his theory of careful restoration and conservation of monuments and he could intervened extensively in controversies of restoration. In 1977, Brandi in his book entitled "Teoria del restauro" defines that, "Restoration constitutes the methodological moment of recognition of the work of art in its physical form and its dual aesthetic and historical polarity, in view of its transmission to the future." (Brandi, 1977, p. 6). He also added that, "Restoration must be aimed at re-establishing the potential unity of the work of art, as long as this can be done without committing an artistic or historical falsehood, and without cancelling the traces of the work's passage through time" (Ibid, p. 9).[410]

In his theory, Brandi has summarized the essential concepts of conservation in relation to works of art; he has emphasized the role of historical critical definition as a basis for any intervention and has underlined the importance of the conservation of authentic. Although conceived mainly in term of works of art, Brandi considers them essentially relevant to architecture as well. In this way, his theory form a sort of grammar, the use of which requires a mature historical consciousness (Jokilehto, 1986).

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[406] Aloïs Riegl, Moderne Denkmalkultus : sein Wesen und seine Entstehung, (Wien: K. K. Zentral-Kommission für Kunst- und Historische Denkmale : Braumüller, 1903). Translation first published as Aloïs Riegl, "The Modern Cult of Monuments: Its Character and Its Origin," In: Kurt W. Forster and Diane Ghirardo. (trans.), in Oppositions; 25 (Fall 1982): 21-51.
[407] Cesare Brandi, Italian art critic and historian, born in 1811 at Siena, and died in 1988 at Vignano.
[408] Cesare Brandi can be considered as the Father of Italian modern restoration.
[409] "Istituto Centrale del Restauro" (Central Institute for Restoration) now is working with the name of the "Istituto Superiore per la Conservazione ed il Restauro" in Rome.
[410] Argenton, A., & Basile, G. (2003). Restoration and the Psychology of Art: An Occasion to Test out Cesare Brandi's "theory of Restoration". In: Basile, G. (ed.), Restoration of Scrovegni Chapel. Surveys, project, results, Skira, Ginevra-Milano, 2003, pp. 544-558.

- Major International Charters and Recommendations

Until the 19th century, the notion of heritage was limited to antique and medieval buildings but due to the destructions of the two world wars, awareness grew about the value of buildings of other periods and typologies including vernacular architecture, industrial buildings and even complete historic cities (Choay, 2007).[411] Since the 19th century, the rapid development of technology has placed considerable strains on social and economic organization and brought serious threats on world cultural heritage properties. On the other hand, there has also been a marked increase in the destruction capacity of monuments by the armed conflicts. Thus, in the first step, on 29 July 1899, the Hague Conventions concerning the Laws and Customs of War on Land, and later on 18 October 1907, the Naval Bombardment in Time of War provided for the protection of historic monuments. In the mid-20th, with more consciousness of the European scholars about the importance of cultural heritage properties, and to prevent multiple and destructive approaches for their conservation, the importance for ratifying of an international Charter and Standards for assisting in providing means for the preservation, conservation and restoration of cultural heritage properties was felt more than before.

UNESCO's international Charters on the subjects of cultural heritage conservation and restoration are documents, principles, norms and guidelines engendered by the General Conference, and principally intended to appoint standards and recommendations for interventions on historic monuments and sites. In this case, state parties were invited to take whatever legislative or other steps may be necessary to be declared in such Charters. In general terms, the primary Charters aimed to respect the authenticity of cultural heritage, prevent complete reconstruction, falsification, arbitrary and hasty treatments, and encourage scientific restoration and design novel interventions for promoting new technologies and materials. Gradually, the critical restoration movement that emerged in Europe replicated condition for an international alliance for codification of Venice International Restoration Charter. Certainly, Venice Charter is eloquent testimony of the international concern about the importance of the preservation of cultural heritage against multiple approaches and existing threats. For the first time in modern sense, the Charter as an international document considered monuments and ruins remaining from past as the cultural heritage and consolidated them worthy of protection and safeguarding, and get the government special authority for their conservation and restoration. In the following section, some of the most important treaties are noted because of their importance in the modern conception of cultural heritage.

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[411] Plevoets, B., & Cleempoel, K.V. (2012). Adaptive Reuse as a Strategy towards Conservation of Cultural Heritage: A Survey of 19th and 20th Century Theories, Ie International Conference 2012: Reinventing Architecture and Interiors: the past, the present and the future, Ravensbourne, England, 28-29 March 2012.

▪ **The SPAB Manifesto: The Principals of the "Society for the Protection of Ancient Buildings" as Set Forth upon its Foundation (1877)**

The manifesto of the SPAB can be named as the first document, which considered the importance of the cultural heritage conservation's problems in the 19th century; even today SPAB with its insistence on "Repair" NO "Restoration" remained as the philosophical basis for the society's directions. As written by William Morris and other pioneer members of the SPAB (1877):

[...]"For our part we assure them fearlessly, that of all the Restorations yet undertaken, the worst have meant the reckless stripping a building of some of its most interesting material features; whilst the best have their exact analogy in the Restoration of an old picture, where the partly-perished work of the ancient crafts master has been made neat and smooth by the tricky hand of some unoriginal and thoughtless hack of today. If, for the rest, it be asked us to specify what kind of amount of art, style, or other interest in a building makes it worth protecting, we answer, anything which can be looked on as artistic, picturesque, historical, antique, or substantial: any work, in short, over which educated, artistic people would think it worth while to argue at all." [...] "It is for all these buildings, therefore, of all times and styles, that we plead, and call upon those who have to deal with them, to put Protection in the place of Restoration, to stave off decay by daily care." [...] "Thus, and thus only, shall we escape the reproach of our learning being turned into a snare to us; thus, and thus only can we protect our ancient buildings, and hand them down instructive and venerable to those that come after us."[412]

▪ **The Athens Charter for the Restoration of Historic Monuments "Carta Di Atene" (1931)**

The Conclusions of the Athens Conference, organized by the International Museum Office (IMO) in Athens (1931), culminated by rendering of the first Charter of restoration "Carta del Restauro". Italian restoration theory was the main source of ideas expressed in Athens Charter; it seem that the principle set forth in "Carta del Restauro" reflected Camillo Boito's conservation theory and practice. The Conference proposed some general principles and doctrines in order to draft an international code of practices for the protection of monuments together with recommendations for conservation, restoration and consolidation of the context in which the monument sited. Among the recommendations presented in this Charter, we can refer to abandon restorations in toto and to avoid the attendant dangers, respect to the historic and artistic work of the past during restoration, respect to historic or artistic characters of monuments by considering of the occupation of buildings and so forth. In this Congress, the following seven main resolutions were made and called "Carta del Restauro" (Athens Charter for the Restoration of Historic Monuments, 1931):

[412] The SPAB Manifesto (1877). Retrieved from http://www.spab.org.uk/what-is-spab/the-manifesto/

1. International organizations for Restoration on operational and advisory levels are to be established.
2. Proposed Restoration projects are to be subjected to knowledgeable criticism to prevent mistakes which will cause loss of character and historical values to the structures.
3. Problem of preservation of historic sites are to be solved by legislation at national level for all countries.
4. Excavated sites which are not subject to immediate restoration should be reburied for protection.
5. Modern techniques and materials may be used in restoration work.
6. Historical sites are to be given strict custodial protection.
7. Attention should be given to the protection of areas surrounding historic sites.

▪ The Italian Restoration Charter: Norme per il restauro dei monumenti "Carta Italiana del Restauro" (1932)

In January 1932 the Carta Italiana del restauro "Italian Charter of Restoration" as resumption of the conclusions of the Athens Charter and, at the same time, in conformance with new principles proposed by Gustavo Giovannoni (1873-1947 AD)[413] was published. In this Charter, the adaption of a common methodology for intervention on the ancient monuments that meant the application of an official standard "Scientific Restoration" was supported. In this way, Giovannoni as the extender of the theory of "Scientific Restoration" consolidated the basis for the modern Italian approach for the cultural heritage conservation, who suggested using of any kind of modern technologies during the restoration procedures. In 1936, Giovannoni wrote an article on 'restoration' in the Enciclopedia Italiana, and started with a statement:

"*The intention to restore the monuments, both in order to con solidate them repairing the injuries of time, and to bring them back to a new living function, is a completely modern concept, parallel to the attitude of philosophy and culture which con ceives in the constructive and artistic testimonies of the past, whatever period they belong to, a subject of respect and of care*." (Jokilehto, 1986).[414]

▪ The Venice Charter: International Charter for the Conservation and Restoration of Monuments and Sites "Carta di Venezia" (1964)

[413] Gustavo Giovannoni, Italian engineer, architecture, city planner and architectural historian, born in 1873 at Rome, and died in 1947 at Rome.
[414] Giovannoni, G., 'Restauro', Enciclopedia Italiana, XXIX, 127ff.: "Il proposito di restaurare i monumenti, sia per consolidarli riparando alle ingiurie del tempo, sia per riportarli a nuova funzione di vita, è concetto tutto moderno, parallelo a quell'atteggiamento del pensiero e della cultura, che vede nelle testimonianze costruttive e artistiche del passato, a qualunque periodo esse appartengano, argomenti di rispetto e di cura."

The Athens Charter (1931) following the Second International Congress of Architects and Technicians of Historic Monuments, which met in Venice from May 25th to 31st 1964, was further superseded. Italian scholars such as Roberto Pane, Pietro Gazzola and Cesare Brandi, as pioneers of the theory "restauro critico" (critical restoration), have great contribution in drafting of Venice Charter. Internationally, this Charter codifies accepted standards of conservation and restoration practice relating to historic monuments and sites. Meanwhile, the meeting also recommended for establishment of an International Centre for the Study of the Preservation and the Restoration of Cultural Property, upon which International Council on Monuments and Sites (ICOMOS), was officially formed in 1965. Until nowadays, the Venice Charter is recognized to be the most influential international conservation document, where it specified the principles of conservation based on the concept of authenticity and integrity and the importance of preserving the historical and physical context of a monuments or sites. The Charter underlined the distinction between conservation and restoration where they were recommended that the conservation of monuments should have been strictly related to a permanent maintenance, and when, the restoration should be considered as an exceptional process that the traditional techniques prove inadequate.

For the first time in Venice Charter, the concepts of "authenticity and integrity" of the cultural heritage properties were shortly presented, where about authenticity it is stated that, "*Imbued with a message from the past, the historic monuments of generations of people remain to the present day as living witnesses of their age-old traditions*." *[...] "The common responsibility to safeguard them for future generations is recognized. It is our duty to hand them on in the full richness of their authenticity."* In addition, about integrity it is expressed that, *"The sites of monuments must be the object of special care in order to safeguard their integrity and ensure that they are cleared and presented in a seemly manner"* (Venice Charter, 1964).

▪ The Italian Charter of Restoration "Carta Italiana del Restauro" (1972)

In April 1972, in the attempt to reach uniform criteria for the management of Italian Antiquities and Fine Arts, the new guidelines for the conservation of artistic monuments with efforts of Pietro Romanelli, Alfredo Barbacci e Cesare Brandi was drafted in four Addendum along with instructions as follows (Italian Restoration Chart of Restoration, 1972):[415]

Addendum A *"the preservation and the restoration of antiquities" along with instructions for the Preservation and the Restoration of Antiquities*
Addendum B *"the execution of architectural restorations" along with instructions for the Execution of Architectural Restorations*

[415] The document was deeply inspired by the volume "Restoration Theory" written by Cesare Brandi in 1963, the book contained lessons and papers written by Brandi during his work at the Central Institute for Restoration, funded by himself in Rome in 1939 (De Antoni, 2012).

Addendum C *"the execution of restorations on painting and sculpture" along with instructions for the Execution of Pictorial and Sculptural Restorations*
Addendum D *"the protection of historical urban areas" along with instructions for the protection of the "Historical Areas".*

As Article 4 of Italian Charter of Restoration, it is underlined that there is a distinction between the preservation of artworks and their restoration, as written, *"It is meant by "preservation" any conservative provision that does not involve any direct action on the material of the artwork. It is meant by "restoration" any action on the material of artwork in order to maintain its material integrity and facilitate the reading and the transmission to the future in their entirety. This applies to artworks and other objects defined in the previous articles*."[416] And later in other Articles, regarding the preservation and restoration procedures, there were some instructions for government agencies and responsible institutions in the matter of conservation of the historical-artistic and cultural heritage, practical methods, techniques and materials employed. The document also stressed on the issue of authenticity with this word as read:

"The fundamental requirement of the restoration is to respect and preserve the authenticity of the component elements. This principal must guide and condition the operating choices. For example, in the case of out plumb masonry, even if practical necessities suggest the demolition and the reconstruction, the possibility of straitening the wall without replacing the original masonries must first be considered and tried. The substitution of damaged stones will happen only in the most extreme conditions."[417]

▪ **The Declaration of Amsterdam (1975)**

From 21th- 25th October 1975, during the "Congress on the European Architectural Heritage", the Declaration of Amsterdam was drafted. The document emphasized the importance of planning, education, legal and administrative measures in protecting the European cultural heritage properties. The Congress likewise affirmed that Europe's cultural heritage is an integral part of the cultural heritage of the whole world. Meanwhile, it supported the integration of the conservation activities from the single monument into the urban context and regional planning process. In this event, the term "integrated conservation" was introduced, indicating

[416] S'intende per salvaguardia qualsiasi provvedimento conservativo che non implichi l'intervento diretto sull'opera: s'intende per restauro qualsiasi intervento volto a mantenere in efficienza, a facilitare la lettura e a trasmettere integralmente al futuro le opere e gli oggetti definiti agli articoli precedenti (CIRCOL. N. 117 DEL 6 APRILE 1972. " Carta del restauro 1972 ").
[417] Esigenza fondamentale del restauro è quella di rispettare e salvaguardare l'autenticità degli elementi costitutivi. Questo principio deve sempre guidare e condizionare le scelte operative. Per esempio, nel caso di murature fuori piombo, anche se perentorie necessità ne suggeriscano la demolizione e la ricostruzione, va preliminarmente esaminata e tentata la possibilità di raddrizzamento senza sostituire le murature originarie. Così la sostituzione delle pietre corrose potrà avvenire soltanto per comprovate gravissime esigenze (CIRCOL. N. 117 DEL 6 APRILE 1972. "Carta del restauro 1972").

that historical knowledge, conservation, cultural behavior, and social benefits are interrelated. In this document, such a rational updated concept of "Monument" as an international asset was gradually propagating. It recalls that integrated conservation needed a wide cooperation with the populations from the international community. Moreover, it also emphasized better training programs and facilities; promoting methods, techniques and skills for restoration and rehabilitation; new legislative and administrative measures; and international exchange of knowledge, experience and trainees (Declaration of Amsterdam, 1975).

▪ **The Nara Document on Authenticity (1994)**

In the last 30 years, the issue of authenticity has become a very important theme in the conservation of cultural heritage properties. Although the Nara Document on Authenticity followed the principles of the Venice Charter, it tried to give a comprehensive definition about the notion of "authenticity", which today is internationally adapted. The Nara Document on Authenticity opened a new vision of Cultural Diversity and Heritage Diversity as it relates to the conservation; as mentioned in this document, "*The understanding of authenticity plays a fundamental role in all scientific studies of the cultural heritage, in conservation and restoration planning, as well as within the inscription procedures used for the World Heritage Convention and other cultural heritage inventories*" (The Nara Document on Authenticity, Art.10, 1994). The document underscores that, "*All cultures and societies are rooted in the particular forms and means of tangible and intangible expression which constitute their heritage, and these should be respected*" (The Nara Document on Authenticity, Art. 7, 1994). It was also mentioned that since there is no fixed criteria to base judgments of values and authenticity of cultural heritage, "*[...] the respect due to all cultures requires that heritage properties must be considered and judged within the cultural contexts to which they belong*"(The Nara Document on Authenticity, Art. 11, 1994).

▪ **The Burra Charter: The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (1999)**

The Burra Charter provides guidance for the conservation and management of places of cultural significance (cultural heritage places), and is based on the knowledge and experience of Australia ICOMOS members (Burra Charter, 1999).[418] The Charter is particularly important for its definition of all subjects related cultural heritage significance and the guidelines proposed to manage and to conserve all types of places of cultural significance including natural, indigenous and historic places with cultural values. The Burra Charter can be named as Gold Standard of Conservation philosophy. In relation to that, the Art. 1.2 defines Cultural Significance as *"aesthetic, historic, scientific, social or spiritual value for past, present or*

[418] The Australia ICOMOS Burra Charter (1999), developed under the aegis of the International Council on Monuments and Sites (ICOMOS) in succession to the earlier (1964) Venice Charter.

future generations. Cultural significance is embodied in the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects. Places may have a range of values for different individuals or groups. [The term cultural significance is synonymous with heritage significance and cultural heritage value. Cultural significance may change as a result of the continuing history of the place. Understanding of cultural significance may change as a result of new information.].” The Charter also gives a clear and fundamental guidance to the scholars. Meanwhile, it represents very clear definitions to the issues related to cultural heritage protection, and in particular contains the evaluation of the cultural significance of the monuments as well as their material and current or future usage and management. In following section, some other definitions of the Burra Charter are presented:

-Conservation means all the processes of looking after a *place* so as to retain its *cultural significance*.
-Maintenance means the continuous protective care of the *fabric* and *setting* of a *place*, and is to be distinguished from repair. Repair involves restoration or reconstruction. [*The distinctions referred to, for example in relation to roof gutters, are: maintenance Ñ regular inspection and cleaning of gutters; repair involving restoration Ñ returning of dislodged gutters; repair involving reconstruction Ñ replacing decayed gutters*.]
-Preservation means maintaining the *fabric* of a *place* in its existing state and retarding deterioration. [*It is recognised that all places and their components change over time at varying rates*.]
-Restoration means returning the existing *fabric* of a *place* to a known earlier state by removing accretions or by reassembling existing components without the introduction of new material.
-Reconstruction means returning a *place* to a known earlier state and is distinguished from *restoration* by the introduction of new material into the *fabric*. [*New material may include recycled material salvaged from other places. This should not be to the detriment of any place of cultural significance*.]
-Adaptation means modifying a *place* to suit the existing use or a proposed use.
-Use means the functions of a place, as well as the activities and practices that may occur at the place.
-Compatible use means a use which respects the *cultural significance* of a *place.* Such a use involves no, or minimal, impact on cultural significance.

▪ The Charter of Cracow (2000)

Although in Venice in 1964, it was decided to set up ICOMOS, officially it was established in the following year, so it held its first International Conference on Conservation “Cracow 2000”. It was the Charter of Cracow 2000; this Charter was deeply tied to the Venice Charter, which for the first time dealt with the reconstructive restoration of damages caused by armed conflict or natural disaster. The Charter distinguished that the conservative interventions on the architectural, urban and landscape heritage, as well as artifacts are categorized in different types such as environmental control, maintenance, repair, restoration, renovation and rehabilitation. In relation to those, the Art (1 to 4) paragraph "Aims and Methods" of the Cracow's Charter is presented below (The Charter of Cracow, 2000):

Art.1. *The architectural, urban and landscape heritage, as well as artefacts, are the result of an identification with various associated moments in history and social-cultural context. The conservation of this heritage is our aim. Conservation can be realized by different types of interventions such as environmental control, maintenance, repair, restoration, renovation and rehabilitation. Any intervention implies decisions, selections and responsibilities related to the complete heritage, also to those parts that may not have a specific meaning today, but might have one in the future.*
Art.2. *Maintenance and repairs are a fundamental part of the process of heritage conservation. These actions have to be organized with systematic research, inspection, control, monitoring and testing. Possible decay has to be foreseen and reported on, and appropriate preventive measures have to be taken.*
Art.3.*The conservation of built heritage is implemented by the project of restoration, including the strategy to conserve in the long run. This restoration project should be based on a range of appropriate technical options and prepared in a cognitive process of gathering knowledge and understanding of the building or site. This process may include traditional and subsequent new materials, structural investigations, graphical and dimensional analysis and the identification of historical, artistic and socio-cultural significance. All pertinent disciplines have to participate in the restoration project and the co-ordination should be carried out by a person qualified and well trained in conservation and restoration.*
Art.4. *The reconstruction of entire parts "in the style of the building" should be avoided. Reconstruction of very small parts having architectural significance can be acceptable as an exception on condition that it is based on precise and indisputable documentation. If necessary, for a proper use of the building, completion of more extensive spatial and functional parts should reflect contemporary architecture. Reconstruction of an entire building, destroyed by armed conflict or natural disaster, is only acceptable if there are exceptional social or cultural motives that are related to the identity of the entire community.*

In Cracow's Charter after highlighting the aforementioned concepts, in Art. 6 it is emphasized that, *"The purpose of conservation of historic buildings and monuments, whether in the urban or rural context, is to maintain their authenticity and integrity, including internal spaces, furnishings and decoration according to their original appearance. Such conservation requires an appropriate "project of restoration" that defines the methods and aim. In many cases, it also requires an appropriate use, compatible with the existing space and significance. Work on historic buildings must pay full attention to all the periods that are present"* (The Charter of Cracow, Art. 6, 2000). One of the most important Articles of this Charter is related to Art. 10

where it says that, *"Conservation/preservation techniques should be strictly tied to interdisciplinary scientific research on materials and technologies used for the construction, repair and/or restoration of the building heritage. The chosen intervention should respect the original function and ensure compatibility with existing materials, structures and architectural values. Any new materials and technologies should be rigorously tested, compared and understood before application. Although the in situ application of new techniques may be relevant to the continued well-being of original fabric, they should be continually monitored in the light of the achieved results, taking into account their behavior over time and the possibility of eventual reversibility. Particular attention is required to improve our knowledge of traditional materials and techniques, and their appropriate continuation in the context of modern society, being in themelves important components of cultural heritage."* (The Charter of Cracow, Art. 10, 2000).

- **The ICOMOS-ISCARSAH Charter- Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage (2003)**

The International Scientific Committee on the Analysis and Restoration of Structures of Architectural Heritage (ISCARSAH) as a forum and network of ICOMOS officially was established in 1966, which is nowadays internationally involved in engineering and technical aspects of cultural heritage's conservation and restoration. After the first meeting of the ISCARSAH, which was held in Rome in 1997, twice a year, members of ISCARSAH from all around the world have met each other. In October of 2003, in 14thGeneral Assembly in Victoria Falls, Zimbabwe, the ICOMOS- ISCARSAH Charter- Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage was ratified. Due to the importance of the ICOMOS- ISCARSAH Charter, its full text is presented below:

PRINCIPLES

PURPOSE OF THE DOCUMENT

Structures of architectural heritage, by their very nature and history (material and assembly), present a number of challenges in diagnosis and restoration that limit the application of modern legal codes and building standards. Recommendations are desirable and necessary to both ensure rational methods of analysis and repair methods appropriate to the cultural context.

These Recommendations are intended to be useful to all those involved in conservation and restoration problem, but cannot in anyway replace specific knowledge acquired from cultural and scientific texts.

The Recommendations presented in the complete document are in two sections: Principles, where the basic concepts of conservation are presented; Guidelines, where the rules and methodology that a designer should follow are discussed. Only the Principles have the status of an approved/ratified ICOMOS document.

The guidelines are available in English in a separate document.

PRINCIPLES

1 General criteria

1.1 Conservation, reinforcement and restoration of architectural heritage requires a multidisciplinary approach.

1.2 Value and authenticity of architectural heritage cannot be based on fixed criteria because the respect due to all cultures also requires that its physical heritage be considered within the cultural context to which it belongs.

1.3 The value of architectural heritage is not only in its appearance, but also in the integrity of all its components as a unique product of the specific building technology of its time. In particular the removal of the inner structures maintaining only the façades does not fit the conservation criteria.

1.4 When any change of use or function is proposed, all the conservation requirements and safety conditions have to be carefully taken into account.

1.5 Restoration of the structure in Architecture Heritage is not an end in itself but a means to an end, which is the building as a whole.

1.6 The peculiarity of heritage structures, with their complex history, requires the organisation of studies and proposals in precise steps that are similar to those used in medicine. Anamnesis, diagnosis, therapy and controls, corresponding respectively to the searches for significant data and information, individuation of the causes of damage and decay, choice of the remedial measures and control of the efficiency of the interventions. In order to achieve cost effectiveness and minimal impact on architectural heritage using funds available in a rational way; it is usually necessary that the study repeats these steps in an iterative process.

1.7 No action should be undertaken without having ascertained the achievable benefit and harm to the architectural heritage, except in cases where urgent safeguard measures are necessary to avoid the imminent collapse of the structures (e.g. after seismic damages); those urgent measures, however, should when possible avoid modifying the fabric in an irreversible way.

2 Researches and diagnosis

2.1 Usually a multidisciplinary team, to be determined in relation to the type and the scale of the problem, should work together from the first steps of a study - as in the initial survey of the site and the preparation of the investigation programme.

2.2 Data and information should first be processed approximately, to establish a more comprehensive plan of activities in proportion to the real problem of the structures.

2.3 A full understanding of the structural and material characteristics is required in conservation practice. Information is essential on the structure in its original and earlier states, on the techniques that were used in the construction, on the alterations and their effects, on the phenomena that have occurred, and, finally, on its present state.

2.4 In archaeological sites specific problem may be posed because structures have to be stabilised during excavation when knowledge is not yet complete. The structural responses to a "rediscovered" building may be completely different from those to an "exposed" building. Urgent site-structural-solutions, required to stabilise the structure as it is being excavated, should not compromise the complete building's concept form and use.
2.5 Diagnosis is based on historical, qualitative and quantitative approaches; the qualitative approach being mainly based on direct observation of the structural damage and material decay as well as historical and archaeological research, and the quantitative approach mainly on material and structural tests, monitoring and structural analysis.
2.6 Before making a decision on structural intervention it is indispensable to determine first the causes of damage and decay, and then to evaluate the safety level of the structure.
2.7 The safety evaluation, which is the last step in the diagnosis, where the need for treatment measures is determined, should reconcile qualitative with quantitative analysis: direct observation, historical research, structural analysis and, if it is the case, experiments and tests.
2.8 Often the application of the same safety levels as in the design of new buildings requires excessive, if not impossible, measures. In these cases specific analyses and appropriate considerations may justify different approaches to safety.
2.9 All aspects related to the acquired information, the diagnosis including the safety evaluation, and the decision to intervene should be described in an "EXPLANATORY REPORT".

3 Remedial measures and controls
3.1 Therapy should address root causes rather than symptom.
3.2 The best therapy is preventive maintenance
3.3 Safety evaluation and an understanding of the significance of the structure should be the basis for conservation and reinforcement measures.
3.4 No actions should be undertaken without demonstrating that they are indispensable.
3.5 Each intervention should be in proportion to the safety objectives set, thus keeping intervention to the minimum to guarantee safety and durability with the least harm to heritage values.
3.6 The design of intervention should be based on a clear understanding of the kinds of actions that were the cause of the damage and decay as well as those that are taken into account for the analysis of the structure after intervention; because the design will be dependent upon them.
3.7 The choice between "traditional" and "innovative" techniques should be weighed up on a case-by-case basis and preference given to those that are least invasive and most compatible with heritage values, bearing in mind safety and durability requirements.
3.8 At times the difficulty of evaluating the real safety levels and the possible benefits of interventions may suggest "an observational method", i.e. an incremental approach, starting from a minimum level of intervention, with the possible subsequent adoption of a series of supplementary or corrective measures.

3.9 Where possible, any measures adopted should be "reversible" so that they can be removed and replaced with more suitable measures when new knowledge is acquired. Where they are not completely reversible, interventions should not limit further interventions.
3.10 The characteristics of materials used in restoration work (in particular new materials) and their compatibility with existing materials should be fully established. This must include long-term impacts, so that undesirable side-effects are avoided.
3.11 The distinguishing qualities of the structure and its environment, in their original or earlier states, should not be destroyed.
3.12 Each intervention should, as far as possible, respect the concept, techniques and historical value of the original or earlier states of the structure and leaves evidence that can be recognised in the future.
3.13 Intervention should be the result of an overall integrated plan that gives due weight to the different aspects of architecture, structure, installations and functionality.
3.14 The removal or alteration of any historic material or distinctive architectural features should be avoided whenever possible.
3.15 Deteriorated structures whenever possible should be repaired rather than replaced.
3.16 Imperfections and alterations, when they have become part of the history of the structure, should be maintained so far so they do not compromise the safety requirements.
3.17 Dismantling and reassembly should only be undertaken as an optional measure required by the very nature of the materials and structure when conservation by other means impossible, or harmful.
3.18 Provisional safeguard system used during the intervention should show their purpose and function without creating any harm to heritage values.
3.19 Any proposal for intervention must be accompanied by a programme of control to be carried out, as far as possible, while the work is in progress.
3.20 Measures that are impossible to control during execution should not be allowed.
3.21 Checks and monitoring during and after the intervention should be carried out to ascertain the efficacy of the results.
3.22 All the activities of checking and monitoring should be documented and kept as part of the history of the structure.

5.2 The Basic Principles for Seismic Retrofitting of Adobe-Mud Brick Cultural Heritage

"Lesson must be learned continually and we must always be aware that we live Between Two Earthquakes."
(Feilden, 1987).[419]

Despite the development of engineering science especially in application of modern engineered structural elements and materials, a significant proportion of the world population are living in adobe-mud brick structures. After the decade of 1950, and mainly in the last years, the interest of earth architecture reemerged concerning the actual environmental issues in the world (Eires et al., 2013). As Morton (2008) stated, "There are many good reasons to use earth masonry or maintain the existing constructions. The main ones are environmental sustainability, occupant health, building quality and cultural continuity."[420] Contrary to common misconceptions that state earthen architectures have no place in modern structural design, and they are obsoleted due to some seismic weakness, it has been proven that in many cases, "it was not the use of earthen materials as such that led to the collapse of such buildings during earthquakes, but rather incorrect structural designs and bad craftsmanship" (Minke, 2006).[421] However, future trends and innovations are intended to advance the standard of living in adobe and other types of earthen constructions both in term of design and structure. In this case, modern adobe houses have no need for characteristic outward appearance; they can be modern or traditional, complex or simple, exclusive or humble. There are some modern buildings whose principal construction material is constituted of clay, and their combination with other construction materials has created a wonderful architectural space.[422]

Today, the adobe construction technique, due to its environmental sustainability, local availability of materials everywhere, simplicity in construction technique and cost-effectiveness will continue to be built everywhere in the world even in areas with high seismic risk. However, it is important to provide adequate upgrading to these vulnerable types of structures, both modern and historic adobe structures. In this case, unlike modern adobe structures, the seismic improvement in the historic adobe structures should ensure "life-safety

[419] Feilden, S.B. (1987). Between Two Earthquakes: Cultural Property in Seismic Zones, A joint publication of ICCROM and the Getty Conservation Institute: Southern California Graphics, p. 11.
[420] Morton, T. (2008). Earth Masonry- Design and construction guidelines. London: HIS BRE Press, p. 1.
[421] Minke, G. (2006). Building with Earth: Design and Technology of a Sustainable Architecture. Basel; Boston; Berlin: Birkhäuser, p. 204.
[422] As example of these contemporary adobe-style houses can be named, the Center of Gravity Foundation Hall at Jemez Springs, New Mexico, USA; Youth Centre at Spandau, Berlin, Germany; Kindergarten, Sorsum, Germany; Residence, La Paz, Bolivia etc.

protection"[423] and at the same time should preserve the "structural authenticity". In spite of this, after considering different socioeconomic reasons and the availability of other alternate solutions, it is expected that these types of structures will continue to be built for the decades to come, especially in developing countries (Islam &Iwashita, 2004). As Correia & Fernandes (2006) have stated, "Still, it would be an illusion to treat such matter as indicative of overall success. While in some regions it is now more feasible to improve policies regarding this heritage, the majority of the world has yet to implement significant measures promoting earthen architecture and its conservation."

Virtually all historic adobe sites have culturally significant archaeological deposits that could further the knowledge of life in the past and thus require professional evaluation to determine their integrity and extent (Tolles et al., 2002).[424] The historic fabric of earthen architectural heritage represents the history and culture of people in a specific geographic location, so that the raw building materials had altered and assembled to form buildings which have displayed the modification and manipulation of natural materials by human labors. Therefore, the preservation of world earthen architecture not only is the preservation of earthen buildings, but also is the protection of traditions and human genius applied to erect the constructions for specific requirements. At the moment, 14.25 percent of the sites from the UNESCO World Heritage List are earthen sites, and many are threatened; 150 out of 1052 sites registered in World Heritage List. As well as, 32.72 percent of the sites of the World Heritage List in Danger - partially or entirely are of earthen construction, 18 out of 55 sites registered in World Heritage List, which need either emergency intervention or a comprehensive management plan. Nevertheless, the preservation of these places of culture, and preventing their gradual and definitive loss entails entry into force for the urgent intervention measures.

Seismic retrofitting refers to the process of strengthening older buildings in order to make them earthquake resistant. According to conventional earthquake resistant design philosophy, the buildings must not suffer any considerable damage during small or frequent seismic motions, but they should just sustain only repairable damage during moderate earthquakes, and should not be disintegrated during major earthquakes. In the case of adobe's seismic retrofitting, it must be accepted that significant cracks and detachments may occur even during small and moderate earthquakes. However, the aim of seismic retrofitting measure is to limit the damages to a reparable level during moderate earthquake and to reduce the level of collapse during severe earthquakes or deferment of total destruction.[425]

[423] Most losses of life and wealth in developing countries during earthquakes are due to the collapse of adobe houses (Islam & Iwashita, 2004).
[424] Tolles, E.L., Kimbro, E.E., & Ginell, W.S. (2002). Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures, the Getty Conservation Institute (GCI), Los Angeles, p. 23.
[425] According to Feilden (1987), "The principles of repair should be to restore and improve the building's capacity to resist an earthquake, enabling it to absorb seismic energy without serious damage" (p. 48).

Historic adobe structures because of their age, considerable affectability of their materials from causes of deteriorations, constitution of brittle and fragile materials, no appropriate foundations, long and tall walls without adequate supports, heavy roofs and lack of proper linkage at the connections of walls-walls and walls-roofs are very vulnerable during the seismic events. Regarding the mentioned defects, the technical solutions for seismic retrofitting of historic adobe structures should increase the persistency of the structure during an earthquake. In the world, there are some unmodified adobe structures, which have withstood severe repeated earthquakes without total collapse. In these cases, the temporary stability of these surviving historically valuable adobe structures should not be the reason to ignore their seismic upgrading against the next possible earthquakes. Over time, these structures are confronted with more declines, thus a high attention must be taking into account for their seismic retrofitting.

All earthen constructions and more especially adobe architecture, in spite of their antiquity and their jeopardy and ubiquitously worldwide heritage, just recently have become scientifically accepted as an area of conservative investigation. From the late 20th century until now, the interests for improving the seismic weakness of adobe-mud brick structures have provoked a number of international research and academic study groups to extend their research activities in this field of study. Principally, at first, studies about earthen structures were aligned with United Nations relief groups in Europe, and then this issue was followed more seriously by the expert groups in North America.[426] At the international level, there are some research centers, committees, institutes such as CRAterre-ENSAG, ICOMOS-ISCEAH, UNESCO-WHEAP, ICCROM and Getty Conservation Institute (GCI), which jointly cooperate in international projects such as GAIA, WHE, GSAP and Terra, which within a multidisciplinary team of researchers, professionals, lecturers and trainers work on the dissemination of knowledge and know-how on earthen construction techniques all over the world.[427]

In recent decades, the field of earthen architecture conservation has grown significantly. This progression is reflected in a series of still continuing and very active international conferences devoted to the study and preservation of earthen architectural heritage, the 1st held in Yazd, Iran - November 25-30, 1972 - Conseil International des Monuments et des Sites et ICOMOS-Iran, and the latest as the Terra 2016 - July 11-14, 2016 held in Lyon, France. From the beginning of these conferences up to date, the number of participants in each of them has increased along with their geographic and professional diversity. In these conferences, different issues related to earthen structures such as chemistry, soil science, seismology, hydrology, structural

[426] More than thirty years ago, the University of New Mexico has scheduled courses in earthen structures and has advanced adobe studies for U.S. applications. In the meantime, since 1978, towards the formation of better earth building codes - learn how to build with adobe, the smaller organizations such as Southwest Solara Adobe (SWSA) has conducted classes every year around the Southwest and in Latin America.

[427] In APPENDIX. XII, the scope of duties of each of these organizations along with their ongoing joint projects is briefly exposed.

engineering, archaeology, sociology, and sustainability are discussed by scholars united by their interest in earthen architecture and conservation; academics, scientists, architects and conservation practitioners.

As the result of researches conducted for seismic retrofitting of adobe building, the options available for their reinforcement recently have been developed. Nowadays, the new construction techniques are intended to product stronger adobe buildings in the future, including: (i) internal and external reinforcement (e.g. synthetic wire meshes and rods, tying, anchorage etc.); (ii) structural design (e.g. buttresses and pilasters, robust layout, solid foundation, tapered wall (wide at base and thin at top), ring beam, etc.); (iii) stabilization of adobe mixture and mortar using chemical stabilizer and natural fibers; and (iv) diagnostic investigation (e.g. realization of hidden cracks, weaknesses, declines, etc.). Contrary to the modern adobe buildings, dealing with historical and cultural adobe architectural heritage encounters some restrictions on the level of the interventions, through which the authenticity of the monument should not be disputed. Due to the dependence of the restoration on the preservation of the aesthetic and historical values of adobe monuments, techniques, materials and design procedures in use for their structural reinforcement encounter many limitations, which is a real challenge for the engineers and architects.

However, seismic retrofitting measures in historically or culturally adobe architectural heritage should be based on a series of criteria conducted to manifest the efficiency of the interventions together with their compliance with recommended restoration criteria, the criteria that are imposed in international documents such as the Venice Charter (1964), and in a more specific way, in the ICOMOS/ISCARSAH (2003). Although the criteria proposed in these documents cannot be known as absolute requirements, but those basic principles developed will assist in conceiving and designing both efficient and respectful interventions. Fundamentally, the seismic retrofitting in historic structures absorbs some basic principles, which regardless of the location of the monuments and sites, and their constituent materials, they can guide the design of interventions contemplated for structures with high historical value. In the following section, some of these initial points are presented:

- **Comprehensive Study**

Whatever approach is adopted, all treatments should embrace the conservation goal of maximum retention of historic fabric to preserve authenticity and should be preceded by a systematic, multidisciplinary investigation of the building (Tolles et al., 2002).[428] The restoration of architectural monuments is particularly complicated. An appreciation of some external and certain unknown factors demands a profound knowledge of history, a true

[428] Tolles, E.L., Kimbro, E.E., & Ginell, W.S. (2002). Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures, the Getty Conservation Institute (GCI), Los Angeles, p. 28.

understanding of the present and an ability to anticipate the future (Gazzola, 1972).[429] In seismic retrofitting of adobe cultural heritage, the first and fundamental principle is to know the structure as a whole. The consideration of this can specify other basic principles, such as minimum intervention necessary, alternatives' compatibility and reversibility, and it also has a significant role in elimination of a conjectural response to intervention works. In fact, when either the physical state of damage or the effectiveness of solutions is unknown, the results of the interventions will be unpredictable. Generally, as recommended in ICOMOS/ ISCARSAH (2003), "knowledge of the structure requires information on its conception, on its constructional techniques, on the processes of decay and damage, on changes that have been made and finally on its present state."[430] This knowledge can usually be reached by the following steps (ICOMOS/ ISCARSAH, 2003):[431]

- definition, description and understanding of the building's historic and cultural significance;
- a description of the original building materials and construction techniques;
- historical research covering the entire life of the structure including both changes to its form and any previous structural interventions;
- description of the structure in its present state including identification of damage, decay and possible progressive phenomena, using appropriate types of test;
- description of the actions involved, structural behaviour and types of materials;

A 'pre-survey' of both the site and the building should guide these studies.

In professionally managed projects, the pre-survey knowledge can be preceded via a systematic and multidisciplinary investigation group including architectures, archeologists, historians, engineers, geographers, etc., through on-site and laboratory experimental investigations, structural analysis using appropriate methods and techniques.[432] In seismic areas, the information is also includes studies about past earthquakes, macrozonation, and the results of geotechnical site investigations. As an interdisciplinary study, the documentation and investigation of the experience between two earthquakes should be in such a way that it takes into account the pre and post-earthquake information of the monuments. In Iran, unfortunately, inadequate attention to this important principle has caused that empirical restorers who due to

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[429] Gazzola, P. (1972). Restoring monuments: historical background, Published in UNESCO (1972), pp. 15-30. Retrieved from unesdoc.unesco.org/images/0000/000011/001105eo.pdf

[430] ICOMOS/ ISCARSAH (2003). Recommendations for the Analysis, Conservation and Structural Restoration of Architectural Heritage. Retrieved from *www.esicomos.org/Nueva_carpeta/ISCARSAHSept2001.doc*

[431] Because these can all be carried out at different levels of detail it is important to establish a cost effective plan of activities proportional to the structure's complexity and which also takes into account the real benefit to be obtained from the knowledge gained. In some cases, it is convenient to undertake these studies in stages beginning with the simplest (ICOMOS/ ISCARSAH, 2003).

[432] Usually a multidisciplinary team, to be determined in relation to the type and the scale of the problem, should work together from the first steps of a study - as in the initial survey of the site and the preparation of the investigation programme (ICOMOS/ISCARSAH, 2003).

lack of proper training, professional jealousy and oversimplification have started intervening in the historic structures in a kind of aesthetic surgery, without any detailed knowledge about the structures and their weakness, as a consequence the results are to be deplorable e.g as what happened on restored Citadel Bam during 2003 Bam earthquake.

- **Respect to Original Materials and Authentic Documents**

As mentioned by Jokilehto & King (2000), "The issue of authenticity is not only an administrative verification of truth; it is above all the critical foundation for the conservation and restoration of this heritage."[433] The problem for the seismic retrofit of historic structures is to find the balance of interventions that reduces the risk for injury or property damage to an acceptable level without unduly destroying the historic fabric (Thomasen, 1993). In the meantime, historic adobe monuments not only are interesting because of their tangible values, but also because of their inherited intangible values.

As stated by Correia & Fernandes (2006), "it is essential to refer that in earthen architecture, there are more values that should be taken into account. Sometimes, some earth buildings walls have apparently no value. Their unique character and reason for restoration can be a social, religious or even political value, but also the unique construction technique that built it or the fact it can be one of the unique buildings made of earth. A reality still authentic in many places of the world, like it was 2000 years ago, so the maintenance of the knowledge and know-how is still an important value for earthen architecture: it is the guarantee of an identity and continuity of the cultural tradition."

The importance of retaining the historic fabric of an adobe structure varies with each specific building and depends on what type of treatment is appropriate for that building: stabilization, preservation, restoration, rehabilitation, or reconstruction (Tolles et al., 2002).[434] However, since our approaches in any of these types of treatments is diverse from one to another, the conservation should involves protection and restoration using "any methods that prove effective in keeping that property in as close to its original condition as possible for as long as possible" (Walston, 1978).

- **Minimal Intervention**

Interventions or alterations are minimized to preserve as much of the significant fabric of the building as possible, thereby safeguarding its authenticity while accomplishing whatever goal

[433] UNESCO. (2000). Synthetic Report of the Meeting on «Authenticity and Integrity in an African context», Great Zimbabwe National Monument, Zimbabwe, 26-29 May 2000. Retrieved from *whc.unesco.org/document/1080.*

[434] Tolles, E.L., Kimbro, E.E., & Ginell, W.S. (2002). Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures, the Getty Conservation Institute (GCI), Los Angeles, p. 9.

motivated the initial decision to make alterations (Tolles et al., 2002).[435] As mentioned by Correia & Fernandes (2006), "It is indispensable, when following the principle of minimum intervention to research and acquire a good knowledge concerning the object, material and its techniques, so adequate interventions are applied. This principle also helps to keep the unity, but especially the authenticity of the original object." Consequently, among all possible seismic retrofitting measures, the one that have minimal alteration should be preferred.

- **Compatibility and Durability**

As clearly recommended in ICOMOS Charter (2003), "The characteristics of materials used in restoration work (in particular new materials) and their compatibility with existing materials should be fully established. This must include long-term impacts, so that undesirable side-effects are avoided."[436] Regrettably, there are difficulties both in the efforts to conserve structures and/or the efforts to prevent the structure from decay, in part, because of the lack of information concerned with the compatibility of the materials and techniques (Correia & Fernandes, 2006). Since adobe architectural heritage are very sensitive structures, the use of identical, or similar but compatible materials in the repairing and retrofitting of deteriorated features to obtain similarity of performance has of great importance.[437] However, to try to restore the authenticity of the adobe cultural heritage to unity requires, a deeper focus on the compability of suggested materials must be implemented. Compatibility problem in adobe cultural heritage may be related to chemical, physical, mechanical, thermal and rheological phenomena, among other.[438] On the other hand, the aim of seismic retrofitting measures is that enlarge the seismic resistance of adobe heritage within a reasonable timeframe. Hence, the suggested techniques and materials must also be satisfactory durable, which can be compromised as the overall safety of the structure and the durability of the original parts.

- **Reversibility**

The use of processes which are reversible, or substantially reversible, when undertaking works to a protected structure is always preferable, as this allows for the future correction of

[435] Ibid, p. 7.

[436] ICOMOS Charter (2003). Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage. Retrieved from www.icomos.org/charters/structures_e.pdf.

[437] About the necessity of the compatibility of suggested materials in intervention plan of the historic adobe building, we can stimulate this principle with blood type (O) that can only receive the same blood group and any other bloods.

[438] Sometimes inattention to this basic principle can heightened the damages; as an engineering point of view "Whereas scientific restoration ensures that the original is not tampered with, and is confined to eliminating excrescences and their causes, natural and artificial, empirical restorers try by meticulous faking to give back an appearance of completeness. The new parts never merge altogether, not only because it is impossible for the restorer to identify himself completely with the creator of the original, but also because the new parts, after a short interval, begin to react independently. They are, in fact, subject to their own ageing process and, though initially accurately matched and integrated with the material and forms of the original, they gradually become detached, as time goes on, revealing their extraneous character." (Gazzola, 1972).

unforeseen problem, should the need arise, without lasting damage being caused to the architectural heritage (Environment Planning Guidelines No.9, 2011).[439] As Tolles et al. (2002) pointed out, “Reversibility allows for the use of improved technologies as they are developed and the removal of inappropriate alterations. This principle encourages alterations of an additive nature and discourages the removal of material or architectural features. In addition, the permanent storage of any removed material or feature is important, to provide the opportunity for future replacement.”[440]

- **Non-invasivity**

According to the ICOMOS Charter (2003), “No action should be undertaken without having ascertained the achievable benefit and harm to the architectural heritage, except in cases where urgent safeguard measures are necessary to avoid the imminent collapse of the structures (e.g. after seismic damages); those urgent measures, however, should when possible avoid modifying the fabric in an irreversible way.”[…] “The choice between “traditional” and “innovative” techniques should be weighed up on a case-by-case basis and preference given to those that are least invasive and most compatible with heritage values, bearing in mind safety and durability requirements.” Therefore, among possible alternatives, the least invasive one should be preferred to more invasive alternatives.

- **Distinguishability**

According to Article 12 and 13 of Venice Charter (1964), “Replacements of missing parts must integrate harmoniously with the whole, but at the same time must be distinguishable from the original so that restoration does not falsify the artistic or historic evidence.” […] “Additions cannot be allowed except in so far as they do not detract from the interesting parts of the building, its traditional setting, the balance of its composition and its relation with its surroundings”. In this way, concealment of retrofit measures (interventions) has been of paramount importance, and this principle has contributed to rejection of the time honored, visible fixes traditionally used (buttresses, tie-rods, wall or joist anchors, cables, etc.) (Tolles et al., 2002).[441]

Based on recent researches conducted, there is an inevitable question, i.e. which approaches concerning the seismic retrofitting of adobe cultural heritage is more efficient? In balance, this section aims to contribute for the development of methodologies to better monitoring, preservation, restoration, rehabilitation and reconstruction of culturally or historically important

[439] Environment Planning Guidelines. (2011). Architectural heritage protection: Guidelines for Planning Authorities, NO.9. Department of Arts, Heritage and the Gaeltacht, Ireland. Retrieved from http://www.buildingsofireland.ie/Resources/DOEHLGPublications/

[440] Tolles, E.L., Kimbro, E.E., & Ginell, W.S. (2002). Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures. Los Angeles: the Getty Conservation Institute (GCI), p. 7.

[441] Ibid, p.10.

adobe architectural heritage. Although earthquakes are recognized as the main cause of losses in adobe cultural heritage, the investigations in this filed are sporadic, and relatively few published technical papers have dealt with this type of historic buildings. At best, the current guidelines and standards along with striking range of styles, detail, clarity, and intent are characterized by the use of inadequate criteria and measures to guide the efforts. Given the existing shortages, the primary objective of the following section is to render the basic principles for scientific seismic retrofitting measures in historic adobe-mud brick structures. This information covers all available methods for analyzing the material characterization (e.g. laboratory tests on chemical, physical and durability properties), diagnostic investigation before, during and after interventions (e.g. NDT, MDT and DT in site investigation), and mechanical behaviour (e.g. small, medium and large-scale laboratory tests) of the historic adobe structures. Then after suggestion of those methods, an overview is taken on the efficiency of the internationally prevailing technical retrofitting proposals adapted and tested for seismic upgrading of adobe structures. Then after suggestion of those methods, an overview is taken on the efficiency of the internationally adapted and tested technical retrofitting proposals for seismic upgrading of adobe structures. The general ideas presented in this thesis can be widely applicable and that the general planning methodologies outlined in this section can be followed elsewhere for seismic retrofitting of historic adobe structures. In fact, the following section is devoted to providing the recommendations and suggestions in the form of gridlines for conservation, restoration and especially seismic retrofitting of culturally or historically adobe architectural heritage of Bam city between two earthquakes. Therefore, the result based on sites specifications can be developed for other cases in Iran and elsewhere around the world.

- Scientific Investigation in Historic Adobe-Mud Brick Structure during Different Stages of Interventions

As recommended in ICOMOS/ ISCARSAH (2003), “Diagnosis is based on historical, qualitative and quantitative approaches; the qualitative approach being mainly based on direct observation of the structural damage and material decay as well as historical and archaeological research, and the quantitative approach mainly on material and structural tests, monitoring and structural analysis.” Adobe architectural heritage are the structures that during their lifetime have suffered considerable losses of original fabric from quartet factors of deteriorations (human factors, biological factors, inherent factors and natural factors).[442] Typically, during conservation and restoration works, the structural elements of these monuments have been replaced wholesale rather than repaired, thereby reducing the authenticity. However, the respect to the authenticity of these valuable structures is depended to the amount of significant historical or cultural fabric that would be retained from their objects. Since seismic retrofitting measures in historic adobe structures are typically far from traditional methods, and incompatibility of alternatives can have negative impact on their values, therefore, before taking any action, it is

[442] Issued in the last part of Chapter 2.

essential that all the features or qualities that may compromised the characteristics of these structures have to be precisely investigated.

A careful collection of the information together with a precise verbalization of the documents acquired both from the monument and site on the spot is the basic pre-condition of any successful global intervention. However, to suggest the best alternatives and techniques, and to obtain a reasonable and reliable result during intervention works, it is necessary to know the task of the investigation as the basic stage during proposing the intervention plan. "At microscopic and macroscopic levels -and on physical and social planes - earthen architecture is vastly varied. Thus, a range of disciplines in study, research, and practice are associated with its conservation" (GCI, 2011).[443]

As it is the case for any other construction technique, the adequate conservation and rehabilitation of earthen architecture is obtained through proper diagnosis and subsequent understanding of applicable techniques of intervention (Lombillo et al., 2013). If an intervention work has not been initiated based on a scientific investigation of the structure, it might have harmful unexpected results. However, based on this definite reality and due to lack of comprehensive guidelines for the preservation of adobe cultural heritage, the necessity for scientific investigation to evaluate the state of conservation in built heritage in different stages (e.g. before, during and after interventions) is highly important. Generally, the scientific investigation are applied to improve the chemical, physical and durability of adobe materials, as well as to suggest the best solutions to increase the static and dynamic stability of the historic structures through correct detection of structural weaknesses and load bearing capacity of different structural elements. Although some of these methods may require high budget and skilled experts, their long-term benefits rationalized their applications.[444] Given the necessity to apply a pre-survey studies on historic structures, and since there are many similarities between seismic behavior of historic stone masonry buildings and adobe ones, some prevalent scientific investigation methods that are vastly used in historic stone masonry buildings could also be useful in historic adobe buildings. In the following sections, each of these required methods are presented.

An engineer, architect, or architectural conservator to deliver a comprehensive intervention plan and to obtain adequate information about the monument may offers a variety of tests (e.g. chemical, physical and mechanical and durability), diagnostic techniques (e.g. NDT, MDT and DT), numerical modeling tests (e.g. FEM and DEM) and scaled modeling tests (e.g. small,

[443] GCI (2011). Earthen Architecture Initiative Teaching: Guidelines for the teaching of earthen conservation. Los Angeles (C.A): The Getty Conservation Institute. Retrieved from https://www.getty.edu/conservation/publications.../ea_teaching_guidelines.pdf

[444] Cultural Heritages are major riches of any notion, which although their maintenance, repair and rehabilitation is very costly and time consuming, but the importance of their preservation justifies the time and money spent.

medium and large). Or they may offer geotechnical testing to identify the capability of the soil bearing pressure, and to control the presence of collapsible soils, if any evidence of settlement or foundation deficiencies is observed, or additional site works, such as over-excavation, re-compaction, and/or greater footing width, depth or reinforcement. In the following section, unlike the several available guidelines in lectures that mostly describe a single approach, the aim is to enumerate some applicable laboratory tests to survey the material characterization of adobe materials. Moreover, it suggests some effective non-destructive (NDT), minor-destructive (MDT) and destructive (DT) diagnostic techniques that can be applied for historic adobe structures. Furthermore, the numerical modeling available for non-linear analysis of adobe structures is proposed. Meanwhile, to better know the mechanical behavior of reinforced and non-reinforced adobe structures and to valorize the possibility of the application of new proposed intervention methods on historic adobe structures, a review has been conducted on available small, medium and especially large-scale adobe specimens and modeling tests which have been performed in international level. In addition, based on international recommendations and activities that have been performed in the field of the adobe's cultural heritage preservation, and based on what was experienced in Bam Citadel, as well as based on the author's extensive studies on this issue, the main traditional and innovative techniques for conservation, restoration and seismic retrofitting of adobe cultural heritage along with important points on their application are presented. At the end, following the information presented in previous sections, the pre-seismic decays and post-seismic decays in different location at historic adobe structures are separately categorized, and the possible retrofitting measures are suggested.

- **Field Studies and Laboratory Tests: Chemical, Physical and Durability Characterizations of the Adobe Materials**

At present, there are few engineering design codes available for the design of mud brick structures and those that do exist are based on little published experimental evidence (Hardwick& Little, 2010). Accordingly, due to the use of inadequate criteria and measures applied on their preservation, some of the interventions have had adverse effects, so further developing the damages. However, it is evident that technical solutions have to be developed to improve the seismic resistance of adobe structures (Islam & Iwashita, 2010). Therefore, to determine the quality of adobe materials and mixtures, there are some laboratory tests, which can evaluate the chemical, physical and durability characterizations of those ingredients. Nevertheless, during the conservation and restoration of damaged parts of historic adobe structures, the new suggested materials can be amended based on the results that are obtained from these laboratory experiments and field studies. In table 5.1, some main laboratory tests along with comments on their use are presented.

Table 5.1- Main laboratory tests mostly used for chemical, physical, durability properties of earthen materials (Designed by Author).

T	Technique	Comments

Chemical Properties	**Soluble Salts Content**	Adobe materials are strongly threaten by the salt attack. Driven by prevailing soil alkalinity and evaporation from aridity, crystalizing salts can exert significant forces, literally undermining and destroying adobe structures in the process (Liefeld et al., 2014).
	Carbonates Content	A high carbon content can increase biological activities (e.g. algae, lichens and possibly of bacteria) in the soil.
	PH Measurement	The behavior of clay particles when wet is largely controlled by the exchangeable cations of the clay and the PH of the clay-water system. For example, a low PH promotes flocculation of the clay particles from suspension, while a high PH can lead to the formation of a stable suspension or dispersion of clay particles.
	EDAX, XRF, XRD and SEM Analyses	Energy-dispersive X-ray spectroscopy (EDAX), X-ray fluorescence (XRF), X-ray diffraction (XRD) and scanning electron microscope (SEM) analyses are used for the elemental analysis or chemical characterization, and mineralogical analysis of the samples such as exfoliation, presence of vegetation, disaggregation, differential degradation, irreversible deformation, presence of openings, crust, etc.
Physical Properties	**Density**	The density of soil is defined by the ratio of dry mass to volume (including pores), In adobe brick with a density of less than 600 kg/m³, small insects such as wood lice can live in the straw and attack it (Minke, 2006, p. 18).
	Porosity	Porosity is a measure of the pores or empty space in a material, which may be formed due to soil texture, roots, worm, and insects, etc. Higher porosity is equal with lesser resistance to compaction.
	Capillary Absorption	Soil with high capillary absorption can be dangerous, since capillary entered in the structure can causing swelling and disintegration.
	Soil Colour	Soil color can provide information about organic matter in the soil, drainage, biotic activity, and fertility.
Durability Properties	**PSD**	A fine Particle Size Distribution (PSD) can affect the strength and load-bearing properties of materials.
	Atterberg's Limits	Atterberg limits, which is related to the shrinkage (SL), plastic (PL) and liquid limit (LL) of the soils are very important in construction water content drastically influences properties of fine-grained soils.
	Proctor's Test	This test is done to know the compaction characteristics of a soil with changes in its moisture content.
	Freeze-Thaw Stability Testing	Freeze-thaw cycle testing is a part of stability testing that allows to know the stability of soil through a series of extreme, rapid temperature changes.
	Wetting and Drying	Through repeated wetting and drying of hardened soil-cement specimens, the aim of this test method is to determine the soil-cement losses, water content changes, and volume changes (swell and shrinkage) produced.
	Abrasion Test	This test is to analyze abrasion resistance of the materials such as mud mortar and coating. Since the adobe surface coating are highly sensitive to abrasion, the should periodically be renewed.
	Erosion Test	The aim of this test is to evaluate the adobe material against of environmental factors such as rain. Sometime due to high erosion of the adobe surface, a weather-resistant coat of paint is recommended as protection.
	Shrink Swell Test	This test focuses on the knowing of swelling and shrinkage phenomenon in the surface layer of expansive soils.

▪ **Monitoring: NDT, MDT and DT on-Situ Experimental Survey Stage**

As recommended in ICOMOS/ ISCARSAH (2003), "Evaluation of the safety of the building should be based on both qualitative (as documentation, observation, etc.) and quantitative (as experimental, mathematical, etc.) methods that take into account the effect of the phenomena on structural behaviour." The knowledge acquired from scientific investigation is not only necessary for both financially and methodically correct intervention, but is also important to evaluate the static conditions of the monuments and their capability to withstand the age and natural catastrophic events. In this way, the utilization of NDT, MDT and DT on-situ experimental techniques, which have been improved or adapted to particular tasks to provide clues to hidden defects and structural weaknesses and which are originated from different building's periods, can play the same role of medical diagnosis in medicine science (such as Radiology, Endoscopy, MRI, etc.).[445] Efforts to improve the seismic performance of historic adobes are important not only before interventions, but also afterward; in this way, the modern diagnostic techniques can be applied for long-term monitoring or as quality-inspection tools after any conservative interventions. Meanwhile, it should be pointed that to perform on-site calibrations and testing of methodologies, preliminary information about chemical, physical and mechanical characterization of the materials together with environmental condition and deterioration mechanisms on the site is necessary.

As an important point mentioned by Korkmaz & Vatan (2008), "The investigation of the structure requires an interdisciplinary approach that goes beyond simple technical considerations because historical research may explain aspects of structural behaviour while structural behaviour may answer some historical questions. Therefore, it is important that an investigating team be formed that incorporates a range of skills appropriate to the characteristics of the building and which is directed by someone with adequate experience." On the other hand, the selection of the adequate investigation methodology depends on the accessibility of the possible objects, the physical and structural condition of the monuments, the dominate feature of the sites and many other factors, which correctly can be chosen by the well skilled and experienced experts.[446] In the meantime, the use of two or more diagnostic techniques would give a high level of reliability for the interpretation of the results, the demodulation of inhomogeneous irregularities (e.g. voids or delamination, cracks, presence of moisture and/or salt etc.), and the morphology of the structure investigated. In historic adobe structures, due to the importance of the keeping safe the original fabric, the priority should be upon the simplest available methods that are non-destructive. Only when those less destructive methodologies seem not to fulfill the demands, the more complex ones can be used.

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[445] Unfortunately, in Iran, the phase of on-site investigation of monumental buildings due to high cost of modern technologies, sanctions and lack of hardware and software requirements is traditionally utilized, so sometime their results are not always certitudes, even if they have benefited normally with sufficient utility when they are planned, processed and discussed in a multidisciplinary team of experts.

[446] The tests should always be carried out by skilled persons able to gauge their reliability correctly (ICOMOS/ ISCARSAH, 2003).

Different NDT and MDT methods offer different depths of penetration at different degrees of resolution. Until now, there is no technique available, which interpenetrates masonry structures of more than 150 cm thickness with an adequate resolution and which can be applied with a justifiable effort (On site for masonry Project, 2005). According to the mentioned defect, to apply the best monitoring system for historic adobe structures, there is the need to delve into this line of work in future researches. In table 5.2, it has been tried to follow those on-site diagnostic techniques that permanently are used for the structural investigation of historic stone masonry buildings, techniques that also would be useful for historic adobe buildings. For each technique, advantages and disadvantages are depicted, in conjunction with destructivity of the techniques, contact to surface, reliability of data, and the aims of application

Table 5.2- Different types of NDT, MDT and DT on-situ experimental survey stage and the aim of their application (Designed by Author).

Type	Technique	Contact to Surface			Reliability of Data			Application
		R 0	R 1	R 2	L	M	H	
NDT	**Active Thermography**							➢ Localisation of voids and other irregularities in the near surface region (up to 10 cm) ➢ Localisation of plaster delaminations ➢ Investigation of the masonry structure behind plaster ➢ Detection of moisture in the near surface region
	Geoelectrical Tomographies							➢ Characterisation of masonry structure behind plaster ➢ Detection of voids and of empty joints ➢ Map of different materials ➢ Detection of moisture ➢ Location of diffuse fracturing ➢ Monitoring diffusion of consolidation materials
	Impact-echo							➢ Determination of the thickness of walls and single leaves ➢ Detection of detachment of leaves ➢ Location of voids ➢ Location of deteriorated areas ➢ Quantification of cracks ➢ Correlation of sonic velocity to compressive strength (limited)
	Pulse Sonic							➢ Study of the masonry quality; ➢ Detection of both damaged portions and crack pattern; ➢ Detection of voids within a structural element; ➢ Detection of hidden elements; ➢ Detection of multiple leaves and quantification of their thickness;
	Radar (echo method)							➢ Detection and Localisation of the inhomogeneities (voids, metal or wood inclusion) ➢ Determination of the thickness of structures which are only accessible from one side ➢ Localisation of the detachments of walls with multiple leave structure (limited) ➢ Determination of the internal structure of complex elements (i.e. pillar) ➢ Determination of the moisture content and its distribution
	Ultrasonics							➢ Determination of the thickness of walls and single leaves ➢ Location of voids having sizes in the order of the wavelength of the ultrasonic waves (20 to 100 mm) depending on frequency of the emitted pulses ➢ Characterisation of cracks (limited) ➢ Correlation of ultrasonic velocity to compressive strength (limited)
	Hardness test							➢ Determing hardness of testing material
	Micro-Seismic Profiles							➢ Evaluation of the sonic velocities along profiles at the surface of a masonry structure.

	Micro-Seismic Profiles with Shear Waves							➢ Discrimination of different type of "anomalies" in a wall; ➢ Static verification of procedures and transformation the dynamic values of the elastic moduli to the static modelling.
	Micro-Seismic Tomographies							➢ The aim is to obtain a higher resolution in micro-seismic tomography.
	Shear-waves Micro Seismic Tomographies							➢ - ditto -
MDT	**Coring and sampling**							➢ Mortar – composition, type, compressive strength ➢ Stone/Brick unit – modulus of elasticity, compressive, tensile strength ➢ Masonry – compressive, splitting tensile strength
	Hole Drilling Method							➢ Estimation of the stress field in the surface of stone masonry elements.
	Optical and Digital Endoscopy/Boroscopy							➢ Determination of morphology of walls ➢ Location of voids ➢ Location of deteriorated areas ➢ Quantification of cracks
	PNT-G method							➢ In-situ surface strength of either pointing or fully bed mortar ➢ Absolute values of mortar strength provided a suitable calibration data-base is available.
	Single Flat Jack Test							➢ Determination of the state of stress acting in a masonry structure.
	Double Flat Jack Test							➢ Determination of the deformability characteristics of a masonry. ➢ Study of the stress-strain behaviour of the masonry. ➢ Estimation for the compressive strength of the masonry
	TSS Profiles							➢ The output of the method is a velocity profile along the depth of the hole.
DT	**In-situ compressive tests**							➢ Evaluation of compressive strength of built-in material. ➢ Determination of the stress-strain curve. ➢ Determination of modulus of elasticity.
	In-situ shear tests							➢ Evaluation of shear (in-plane tensile) strength of masonry. ➢ Evaluation of stiffness, shear modulus and ductility.
	In-situ diagonal tests							➢ Evaluation of shear (in-plane tensile) strength of masonry. ➢ Evaluation of stiffness and shear modulus.
	In-situ shear test with Flat Jack							➢ The scope of the test is to determine the cohesion and friction angle of the wall according to the Mohr-Coulomb criterion to get the shear strength associated with the shear sliding mechanism.
	In-situ shear test – Shove test							➢ The “shove” test is for determination of the in-plane sliding resistance along a mortar bed joint. ➢ Determination of coefficient of friction for brickwork masonry.

Note:

R0: Contact to surface not required; R1: Contact to surface required; R2: Contact to surface required with coupling agent

L: Low; M: Medium; H: High

▪ Numerical Modelling for Dynamic Analysis of Adobe Structures

Unreinforced Masonry buildings (URM) are characterized as structures with large variability of constituent materials. In this type of structure, internal and external agents (e.g. the quality of the materials, mortars, connections, standard of workmanships, age and deterioration mechanism) can highly affect the mechanical performance of the buildings. This consideration corroborates the hypothesis that an excessive precision in modeling can be not worthy, since it may hardly correspond to a better representation of reality (Sechi et al., 2014). But as the previous experiments shown, the numerical modeling can give an ideal pattern of global behavior of adobe buildings and of their reinforcement even in the non-linearity of the materials. Numerical modeling is nowadays a smart alternative to experimentation, since it is much less expensive and a very flexible means of studying several different solutions, however, it is totally effective when used as complementary to testing for both interpreting and understanding experimental results (Sechi et al., 2014). The result obtained from numerical modeling can show a meticulous evaluation regarding the frequent causes of structural pathologies and fragilities in adobe structure; moreover, they can provide valuable guidelines for the definition of the effectiveness of different methods for the seismic retrofitting. However, the good agreement with experimental results and the low computational cost that results from the use of simple constitutive hypotheses appear to be very encouraging for future applications (Illampas et al., 2011).

In recent years, the need to predict the load bearing capacity of adobe structure in static and dynamic conditions has led to the development of several numerical methods, which are characterized by their different levels of accuracy and complexity. The level of accuracy in the numerical models strongly depends on the knowledge of the material properties (e.g. constitutive laws, isotropic or orthotropic behaviour, etc.), the type of analyses conducted (e.g. linear, nonlinear), the model used (e.g. shell elements, brick elements), and the solution scheme adopted (e.g. implicit or explicit) (Varum et al., 2014). Since during an earthquake the structure is stressed with dynamic loads, in order to numerically analyze the seismic behaviour of masonry buildings, especially those brittle types of adobe structures, it is necessary to conduct non-linear analyses.[447] In this case, concerning non-homogeneous nature, and non-elastic behaviour of adobe materials under compressive and tensile loads, the description of their non-linear behaviour is more complex than other types of masonry buildings. This issue in the case of historic adobe structures, the structures that have missed their original quality due to their age, is much more complicated. Thus, as stated by Hendry (1998), “For a numerical model to adequately represent the behaviour of a real structure, both the constitutive model and the input material properties must be selected carefully by the modeler to take into account the variation

[447] Generally, the linear analysis cannot give information about the process and development of damages in adobe structures. On the other hand, the application of numerical modelling for non-linear analysis of adobe structures can give only qualitative information regarding the general dynamic response of adobe structure rather than accurate quantitative results.

of masonry properties[448] and the range of stress state types that exist in masonry structures."[449] Among different computational models, the selection of an appropriate numerical model is not a simple task, and depending on the accuracy and availability of the data, different methods will lead to different results.[450] As Lourenço (2002) pointed out, "The selection of the most appropriate method to use depends on, among other factors, the structure under analysis; the level of accuracy and simplicity desired; the knowledge of the input properties in the model and the experimental data available; the amount of financial resources; time requirements and the experience of the modeler." Among different existing numerical methods, the Finite Element Method (FEM) and Discrete Element Method (DEM) through different numerical strategies can properly processed the dynamic behaviour of adobe structures. However, their use in prediction analyses is still critical as they require high computational effort and expert engineering judgment in the interpretation of numerical results (Giamundo et al., 2014).

In the recent years, to validate the reality of the FEM and DEM outcomes, some researchers have compared the result of numerical modeling with those of the large-scale experimental tests. As a result, the performing affordable non-linear analyses in historic adobe structures still require high expertise. In following section, some of them are listed:

- Finite Elements Method (FEM)

According to the level of accuracy, the performance of FEM analysis on URM can be classified on three main approaches. These include detailed micro-modelling, simplified micro modeling and macro modelling (Lourenço, 1996). Ruíz (2011) in his Doctoral thesis entitled, "Numerical modelling of the seismic behaviour of adobe buildings" has defined each of these models as followings:

- Detailed-micro modelling: Bricks and mortar joints are represented by continuum elements, where the unit-mortar interface is represented by discontinuous elements (Ali & Page, 1987; Cao & Watanabe, 2004; Furukawa & Ohta 2009; Rots, 1991). Any analysis with this level of refinement is computationally intensive and it requires a good well documented representation of the material properties (elastic and inelastic) of the constituents.

- Simplified micro-modelling: The expanded units are represented by continuum elements, where the behaviour of the mortar joints and unit-mortar interface is lumped in discontinuous elements (Arya & Hegemier, 1978; Lotfi & Shing, 1994; Lourenco & Rots,

[448] In all cases, the nonlinear information of the adobe material is important to describe properly the material behaviour (Varum et al, 2014).

[449] Sarhosis, V. (2016). Optimisation procedure for material parameter identification for masonry constitutive models. Int. J. Masonry Research and Innovation; 1(1) 1: 48-58.

[450] For example, the FEM is suitable for analyzing of the global behaviour of masonry building in the elastic domain, but it is not suitable for analyzing of the local damages in parts such as arch, roofs, columns, etc.

1997; Page, 1978). This approach can be compared with the discrete element method, originally proposed by Cundall (1971) in the area of rock mechanics, where a special procedure is used for contact detection and contact force evaluation (Lotfi & Shing, 1994).

- Macro-modelling or continuum mechanics finite element: Bricks, mortar and unit-mortar interface are smeared out in the continuum and the masonry is treated as an isotropic material. This methodology is relatively less time consuming than the previous ones, but still complex because of the brittle material behaviour.

In overall terms, the detailed-micro modelling and simplified micro-modelling are computationally intensive for the analysis of large masonry structures, but they can be an important research tool in comparison with the costly and often time-consuming laboratory experiments (Lotfi & Shing 1994). In the meantime, the macro-modelling is faster than the previous ones and, in the case of adobe structures, does not significantly reduce the accuracy of the results (Varum et al., 2014). In this case, according to Lourenço (1996), the micro-models are probably the best tool available to understand the behaviour of masonry. In this FEM analysis method, all the failure mechanisms such as, cracking of the joints, sliding along the joints, cracking of the units, diagonal tensile cracking and masonry crushing can be considered.

- Discrete Elements Method (DEM)

In the Discrete Element Method (DEM), the particle may be rigid and the damage will concentrate only on the joints or elastic-plastic in order to consider the possible damage of the brick itself (Sarhosis, 2016). To simulate the adobe structures in DEM method, there is a need for some mechanical parameters such as density of adobe, bulk modulus, shear modulus, joint normal rigidity, joint shear rupture, joint tension rupture, joint dilation angle and joint friction angle, all of which are defined according to experimental tests.

Generally, there are four main classes of numerical codes, which conform to the definition of DEM technique, namely Distinct Element codes, Modal Method codes, Discontinuous Deformation Analysis codes and Momentum-Exchange Method codes. Among these codes, just in Momentum-Exchange Method codes, the bodies are rigid and for others, it might be rigid or deformable. In particular, a numerical code falls into the category of DEM whether it allows finite displacements and rotations of distinct bodies, including complete detachment or it recognizes new contacts automatically as the calculation progresses (Sarhosis, 2016). Unlike FEM method, the definition of the contact between blocks and the joints in the DEM method is not required, so the contact is defined by a set of point contacts with no attempt to obtain a continuous stress distribution through the contact surface. Meanwhile, in this method the masonry structure is represented by an assembly of blocks with special nonlinear behaviour at their boundaries (e.g. mortar joints), the walls are modeled in a micro-scale level (Sarhosis, 2016).

Table 5.3- Researches conducted to validate the reality of different numerical modelings applied for adobe structures (Designed by Author).

Specification	Report Results	Ref.
Experimental and DEM studies at a real scale and at a small scale in order to valid the ability of DEM for modeling adobe housing.	"It shows that the displacement are in the same range even if not exactly same due to choice of the numerical collapse time. Moreover, the numerical vertical loading curve gives a similar value of the collapse vertical force that has been applied to the wall sample (7.8kN for the experimental one and 8kN for the numerical one)."	(Daudon et al., 2014).
Dynamic finite element analysis of earth masonry Structures based on experimental material data	"A comparison among the numerical and experimental data shows that the FE model can provide sufficiently accurate estimates for stress and deformation, especially when applied to monotonic vertical axial loading scenarios. Of particular importance is the ability of the model to predict the material's actual ultimate strength." (…) "Regarding the validity of the numerical results obtained from the analysis of a complete model structure, these cannot be deemed as a sufficiently accurate representation of the actual response of earthen construction, despite the fact that they appear to be in context with the general behaviour of unreinforced masonry."	(Illampas et al., 2011).
Survey to find ideal numerical modelling of the seismic behaviour of adobe buildings.	"The numerical modelling of cracking and damage in concrete/masonry panels is based on discrete mechanics and continuum mechanics, and that plasticity-based models are suitable for micro and macro modelling of masonry."	(Ruíz, 2011).
Numerical modeling of the seismic response of adobe Houses protected with used car tire straps: a comparison between experimental and numerical modellings	"Several numerical analyses have been performed; the best results come from the pushover analysis, which can provide useful indications on how, and how much, the reinforcement acts." "The numerical results, however, point out as necessary further studies on the Adobe constitutive law, since a minimum variation of its characteristics can lead to large consequences in term of structural response."	(Sechi et al., 2014).
Finite element simulation of the structural response of adobe masonry buildings subjected to lateral loading: a comparison between experimental and numerical modellings	"The numerical investigation conducted enabled the identification of the factors, which critically affect the FE simulation of earthen structures."	(Illampas et al., 2014).
The use of continuum models for analyzing adobe structures: a comparison between experimental and numerical modellings	"The numerical results represented fairly well the real crack pattern, failure mechanism and displacement response, which validated the procedure following here for modelling the adobe module."	(Ruíz et al., 2012).

▪ **Small, Medium and Large-Scale Modeling**

To know the mechanical behaviour of adobe-mud brick structure in individual and collective units, there are some laboratory tests on scaled adobe-mud brick specimens: small-scale specimens with compressive strength (σr, Ey, v) and bending strength tests; and medium and large-scale specimens with compression / shear / bending tests, combined compression and shear tests, test walls construction and earthquake shaking table tests. The aim of these laboratory tests is enable restorers to propose adequate repair and/or strengthening solutions with enough study about the mechanical characterization of adobe bricks and the typical mechanism of damage of medium and large-scaled adobe models. This knowledge even has reference values for the design and construction of new adobe structures.

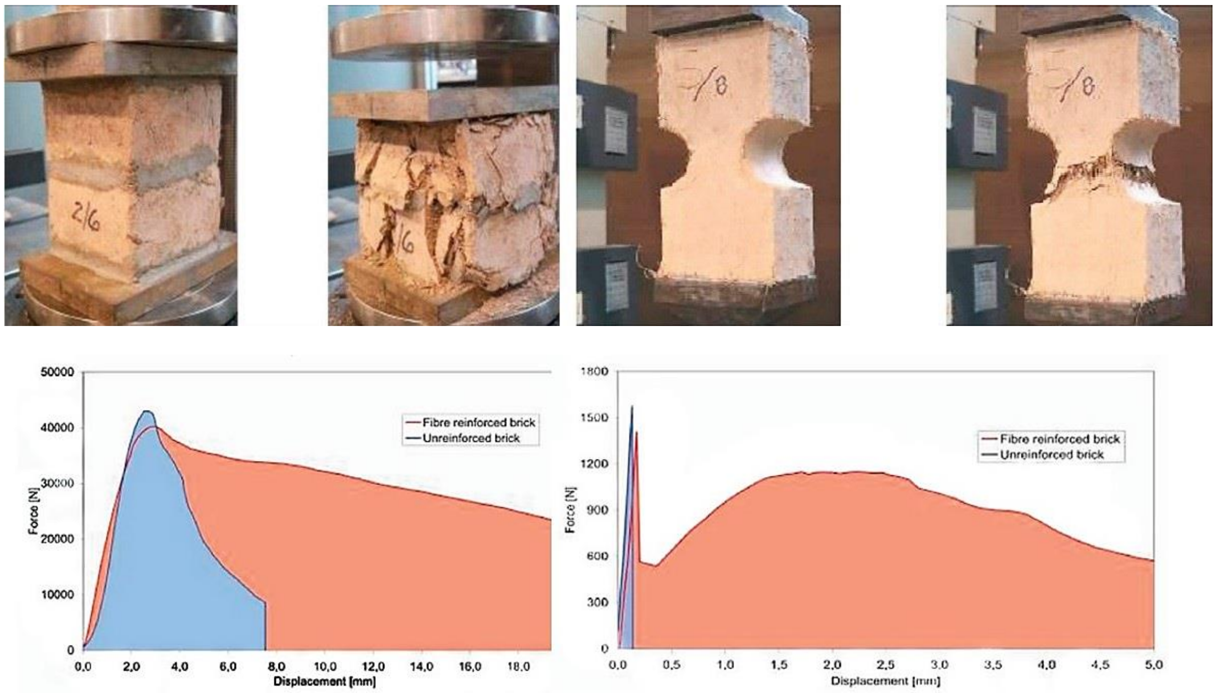

Figure 5.1- Compression and tension tests performed on reinforced and non-reinforced adobe units proofed that units reinforced with palm fiber has higher ductility than other non-reinforced (Source: Jäger & Fuchs, 2008).

As an important point, the seismic resistance of adobe building is not convenient enough; the interventions in residential adobe houses just can give time to evacuate, while in historic ones, they can only reduce the possibility of severe destruction. Nevertheless, in order to reduce the seismic risk at these vulnerable types of structures and to have better justification about their seismic behaviour, it is important to promote an adequate methodology to survey the efficiency of possible reinforcement measures. Therefore, the examination of dynamic performance of cracked adobe structures is completely imperative. In this issue, as mentioned by AAVV (2005), “the lack of expertise and research in the area has gained the attention of people who deal with heritage and the university researchers who share the same interest” (Correia & Fernandes, 2006). Although the experiences of these researches have been based on different philosophies and approaches, they could enrich our knowledge about the various aspects of seismic intervention in culturally important adobe structures at risk of earthquake losses. Occasionally, although there are different views towards seismic upgrading of adobe architectural heritage both in selection of ideal materials and techniques, and in the rate of authorized intervention, their contributions are nonetheless appreciated.

Through the world, there are some universities and laboratories, which have conducted projects to evaluate seismic behaviour of reinforced and non-reinforced adobe structures such as those performed in the Pontifical Catholic University of Peru, The Getty Conservation Institute in USA, Stanford University in USA, IZIIS-Ss. Cyril and Methodius University in Republic of Macedonia, Saitama University in Japan, University of Aveiro in Portugal and University of Sydney (UTS) in Australia. In following section, some of these experiments are elaborated:

- **Experimental Studies at the Pontifical Catholic University of Peru (PUCP)**

In 1972, several large-scale modeling tests have been conducted at the Pontifical Catholic University of Peru (PUCP) on different adobe structures reinforced with locally available materials.[451] A reinforced-concrete tilting platform was used to test full-scale adobe models, where the seismic force was represented by the lateral component of the weight of the models (Corazao & Blondet, 1973).[452] As the result of laboratory tests implemented on the non-reinforced adobe structure and reinforced adobe structure (consisting of vertical cane rods anchored to the foundation and horizontal crushed cane placed between mortar joints at every fourth courses), the deformation capacity and strength of the adobe structure was notably increased. As can be seen in Figure 5.2, the internal alternatives with prevention of the occurrence of cracks at the corners and connections could hold the integrity of the adobe walls.[453]

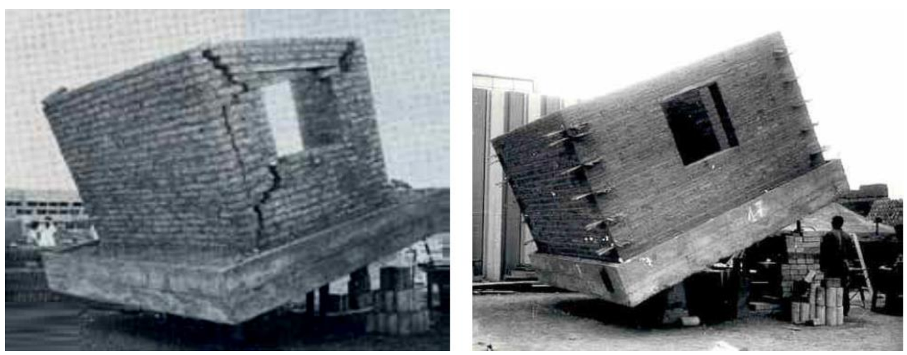

Figure 5.2- (Left) Seismic performance of the non-reinforced adobe structure; and (Right) the reinforced adobe structure (Source: Blondet et al., 2002).

Since 1992, once again at the PUCP some other large-scaled adobe models have been tested on the shake table test. In each of these models, some new intervention plans have been proposed for seismic reinforcement of adobe structures:

[451] This university has extensive experience and equipped laboratory on adobe research.

[452] Blondet, M., Neumann, J.V., & Tarque, N. (2006). The Peruvian Building Code for Earthen Buildings. Los Angeles: Getty Seismic adobe Project, pp. 45-51. https://www.getty.edu/conservation/publications_resources/pdf.../gsap_part2a.pdf

[453] Note: the use of interior cane rod and mesh has the following shortcomings: unless to post-earthquake reconstruction, this technique is inefficient for existing historic adobe structures; its application is hard and a high accuracy and time needed for placement of cane rods and meshes; availability of materials in any region.

Model 1) Adobe Reinforcement with Cane Rods, Cane Meshes and Solid Ring Beam
This type of reinforcement consists of placing an internal grid, with vertical and horizontal elements, able to bond efficiently with the structure, improving its seismic performance (Varum et al., 2014). In this model, it was pointed out that the cane reinforcement elements should be properly tied together and conveniently anchored to the adjoining structural elements. As the result of test shown, this reinforcement technique can prevent the separation of walls at corners, even during high cyclical lateral loads. The reinforcement proved to be very effective in preventing building collapse (Blondet et al., 2011). Although the reinforced model suffered significant damages, it did not collapse. In addition to a ring beam and cane reinforcement, the use of truss-like timber ties between the lintel and ring beam proved to be effective (Blondet et al., 2002). The results of the seismic behaviour of non-reinforced and reinforced adobe models are shown in Figure 5.4.[454]

Figure 5.3- Placement of wooden ring beam, vertical and horizontal cane reinforcement on adobe model (Source: Blondet et al., 2002).

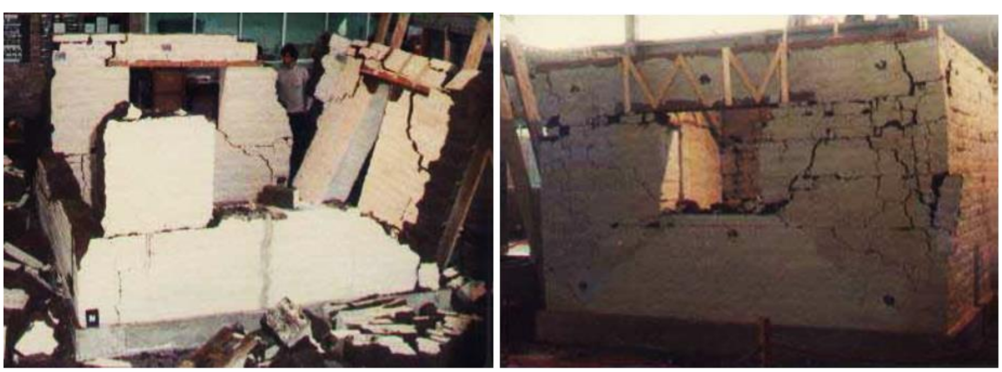

Figure 5.4- Reinforced and non-reinforced Adobe building models after shake table tests (Source: Blondet et al., 2002).

Model 2) Adobe Reinforcement with External Cane-Rope Mesh

[454] As cane is not available in all regions, Blondet et al. (2005) have suggested the use of internal mesh made of vertical PVC tubes and horizontal plastic mesh.

In this test, the adobe model was externally wrapped with vertical and horizontal canes fixed through holes made in adobe walls in every 30-40 cm. As can be seen in Figure 5.5, except of some cracks, the model was not suffered any collapse.

Figure 5.5- An adobe-building model with external vertical cane and horizontal rope reinforcement (Source: (Left) Blondet et al., 2011; and (Right) Varum et al., 2014).

Model 3) Adobe Reinforcement with Welded Wire Mesh

In this model, the welded meshes consisting of 1 mm diameter wires at 20 mm spacing were positioned horizontally and vertically, across the walls. Then all were nailed with metal bottle caps to the adobe walls, at the end, and the walls were covered with a 20 mm thick cement and sand mortar (Zegarra et al., 1997).[455]

Figure 5.6- Shake table testing of non-reinforced and reinforced U-shaped adobe walls (Source: Blondet et al., 2011).

[455] Blondet, M., Garcia, G.M., Brzev, S., & Rubiños, A. (2011). Earthquake-Resistant Construction of Adobe Buildings: A Tutorial (2nd Edition). Oakland: EERI/IAEE World Architecture Housing Encyclopedia. Retrieved from www.world-housing.net/wp-content/uploads/.../Adobe_Tutorial_English_Blondet.pdf

As the result of shake table test implemented on the two U-shape walls, while the non-reinforced model has almost collapsed, the reinforced model just faced some cracks in its body, Figure 5.7 (Right). The researchers found that it is possible for the walls to disintegrate into large blocks during severe ground shaking; however, the mesh prevents the walls from falling apart, and collapse can be avoided (Blondet et al., 2006). This seismic reinforcement scheme proved to be effective during the 2001 Arequipa, Peru earthquake (Mw = 8.4) and the 2007 Pisco, Peru earthquake (Mw = 8.0). Several adobe houses built with welded wire mesh had faced less damage than other non-reinforced adobe structures.

Model 4) Adobe Reinforcement with Polymer Mesh (Geomesh)
Like previous model, the polymer meshes were positioned horizontally and vertically, across the walls, and they were tied together through plastic or nylon strings placed during construction. As Blondet et al. (2011) Stated, "This reinforcing scheme demonstrated excellent seismic response during high intensity shake table tests (roughly equivalent to MM 7) on a full-scale adobe building model. The geomesh reinforcement increased the stiffness, strength and deformation capacity of the adobe walls. Total building collapse was prevented due to the confinement provided by the mesh."[456]

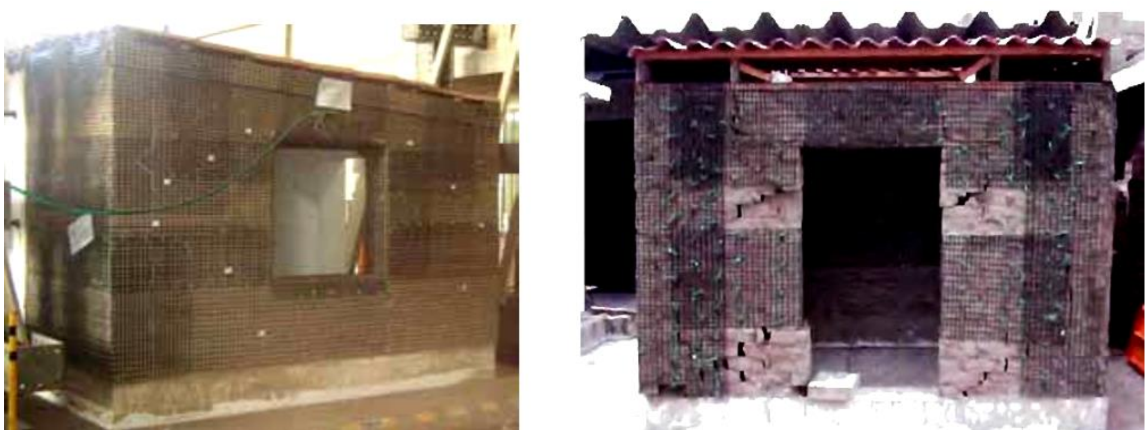

Figure 5.7- Geomesh attached to adobe walls, Reinforced adobe house with geomesh during a shake table test at the PUCP (Source: (Left) Blondet et al., 2011; and (Right) Dowling, 2006).

Model 5) Adobe Reinforcement with Car Tire Straps
In this system to improve the seismic resistance of adobe wall, the circumferentially cut straps from the treads of car tires was used as tension reinforcement element. As schematically shown in Figure 5.8, to wrap adobe model with car tire straps, vertical straps (every 1.2 m) under or through foundation together with horizontal straps (every 6 cm max) passed from holes made

[456] The details of adobe reinforcement with polymer mesh (geomesh) can be seen in the website of World Housing Encyclopedia written by Vargas-Neumann et al. (2007), entitled "Building hygienic and earthquake-resistant Adobe houses using Geomesh Reinforcement". After the 2007 Pisco earthquake, this reinforcement technique was developed with PUCP and CARE Peru.

on the walls. The purpose of the tests was to verify that the reinforcement system could meet the performance objective of preventing building collapse in moderate to severe earthquakes, and to obtain data to pre-engineer these strap-reinforced structures (Charleson, 2011).[457] Regularly spaced horizontal and vertical tensile elements have the potential to create a rational strut-and-tie bending force resisting mechanism, however, horizontal and vertical straps work together to improve in–plane shear strength (Charleson & French, 2008). As shown in Figure 5.9, results showed that the tire strap reinforcement system prevented building collapse, even during simulated ground shaking of high intensity (Charleson & Blondet, 2012).

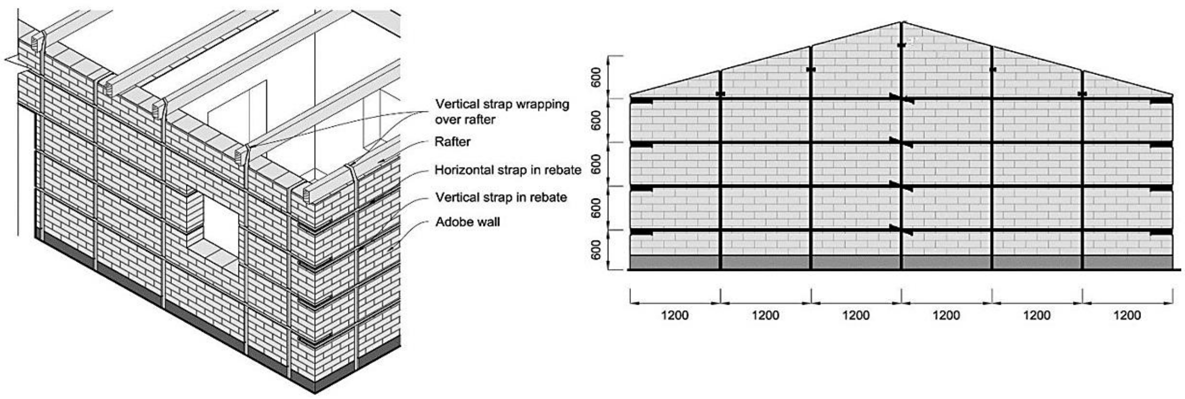

Figure 5.8- Schematic view of the instalation of Vertical and horizontal straps have been installed (Source: Charleson, 2011).

Figure 5.9- Adobe model reinforced with Car tire straps, before and after shake table test (Source: Charleson, 2011).

Model 6) Adobe Reinforcement with Integral masonry system (IM)

In the form of a joint project between UPM and PUCP, the seismic viability of the Integral Masonry System (IM) through a two-storey adobe model (3m×3m×3m) has been tested under

[457] Charleson, A. (2011). Seismic strengthening of earthen houses using straps cut from used car tires: a construction guide (1st Edition), EERI, Oakland, California. Retrieved from www.world-housing.net

the dynamic stresses imposed by the shake table test. As Adell et al. (2009) explained about this test, “The truss-reinforcement system consists of interlaced truss-reinforcement which crosses over each other in a three-dimensional manner. The voids are subsequently filled with brick, block, adobe, mud or recycled material in order to form the walls and boarding may be set on the trusses to form the floors.” […] “A polyethylene geomesh with 0.15 m openings was tied to the wall by the raffia strips on just two sides of the prototype. This was made with the aim of verifying the differences between the rendered and unrendered faces after testing on the displacement table.” As the test results showed, although under the largest displacement (130 mm), there cracks were seen at different parts of the model, especially along the lines of the reinforcement, they did not incur any damage that might affect the stability of the structure. Meanwhile, it was provoked that the polymeric mesh and rendering do not have any special effect on the seismic behaviour of the walls.

Figure 5.10 The process of adobe model’s construction by ISM system (Source: Adell et al., 2009).

Figure 5.11- Damages on adobe model reinforced with IM system after shake table test (Source: Adell et al., 2009).

Model 7) Evaluation of the Efficacy of Mud Injection to Repair Seismic Cracks on Adobe Structures

In 2012, to evaluate the possibility of mud injection to repair seismic cracks on adobe structures, a large-scaled adobe model in two phases was tested at PUCP. During the first phase of this laboratory test, to induce wall cracking representative of seismic damage, the undamaged model was subjected to a realistic simulated seismic shaking. After that, as explained by Blondet et al. (2012) "All major seismic cracks (wider than 1 mm) were opened using a drill and a hammer and pin as shown in Fig. 8, in order to facilitate mud penetration during the repair. The thicker cracks (more than 20mm after opening) were filled manually with mud. Then the thinner cracks were prepared for injection by sealing them with a layer of silicon over them and leaving small openings at 50 mm distance approximately. The mud-based grout was then injected through these openings until the cracks were fully filled." Then once again, the repaired model was subjected to the simulated seismic shakes. As the result of the test, the intervention carried out to repair the seismic damage could just retain 54% of the original lateral strength and 30% of the original lateral stiffness of the adobe model. Therefore, the main conclusion of this test was that although repair via mud injection is useful to recover the original stiffness and strength of the structure partially, this method must be combined with other reinforcing technologies to ensure that the repaired structure is stable against further seismic shaking (Blondet et al., 2012).

Figure 5.12- Grouting of cracks after finishing of the first phase (Source: Blondet et al., 2012).

Figure 5.13- The adobe model before phase 1, after phase 1 and 2 (Source: Blondet et al., 2012).

- **Experimental Studies at the University of Tokyo**

PP-Band Retrofitting Technique is one of the appropriate retrofitting techniques and different aspects of this method have already been studied in Meguro Laboratory, the Institute of Industrial Science (IIS), and The University of Tokyo (Meguro et al., 2011). As the advantage of PP-band reinforcement, this system is inexpensive, worldwide available, tolerates large deformations, durable, easy workmanship and has no need to special technology and knowledge. Furthermore, this material has no corrosion or insect failure effect and possesses excellent resistance to organic solvents and degreasing agent as well as electrolytic attack (Mendis et al., 2014).[458] Because of tests implemented, it was conducted that PP-band may potentially be used to prevent/delay brittle collapse of non-engineered structures under seismic loading (Sathiparan & Meguro, 2013). Figure 5.14 shows bending and diagonal shear tests on reinforced and non-reinforced models, and Figure 5.15 shows a full-scale adobe model reinforced with PP-bands before and after shake table test.

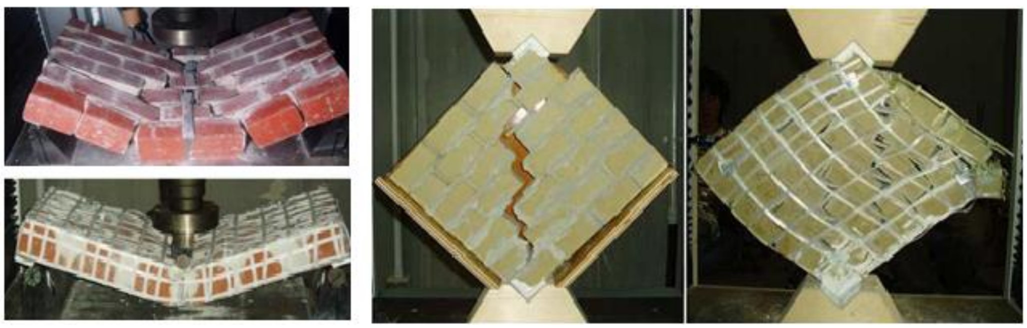

Figure 5.14- Failure patterns of brick masonry wallettes with and without retrofitting by PP-band mesh under bending and diagonal shear tests (Source: Sathiparan & Meguro, 2013).

Figure 5.15- The result of shake table test on reinforced and non-reinforced adobe models (Source: Sathiparan & Meguro, 2013).

- **Experimental Studies at Aveiro University**

Since 2005, concerning the mechanical properties and structural characterization of adobe structures and their constituting materials several scientific studies have been conducted at the Civil Engineering Department of Aveiro University of Portugal (e.g. Varum et al., 2005; Arêde et al., 2007; Silveira et al., 2007; Varum et al., 2008; Figueiredo et al., 2012). Thorough evaluation of the performance of non-reinforced and reinforced adobe structures, the aim of

[458] Note: PP-Band is sensitive to UV radiation. As research conducted at the University of Tokyo, it was conducted that 2mm mud /mortar cover is enough to prevent any passage of UV radiation.

these studies have to establish a basis of knowledge essential for the safety analysis of adobe structures. Given that the structural behaviour of adobe structures are deficient under horizontal loads, especially those loads are induced by the seismic motions, the Department of Civil Engineering of Aveiro University has recently been conducting several experimental tests on the seismic behavior of adobe structures located in the Aveiro district. In one of these tests, a Double-T adobe wall (height = 3.07 m, length =3.5 m and thickness = 0.29 m) was tested by applying of the uniform vertical loads at the top of the wall (20KN) and cyclic horizontal forces of increasing amplitude, the model was built by using of adobe bricks from a demolition site in the Aveiro region. The adobe blocks used had mean dimensions of 29×45×12 cm^3, a specific weight of approximately 16 KN/m^3, a mean compression resistance of 0.46 MPa and a mean tensile resistance of 0.15 MPa (Figueiredo et al., 2012).

However, the model was imposed with two series of tests. During the first series of the test, the non-reinforced model was subjected to cyclic and dynamic tests, as the result, wall was faced with cracks in its façade, which these cracks have significantly reduced its strength and stiffness. Then during second series of the test, the damages have been repaired by the grouting injection of lime gum into the cracks, after that the wall was reinforced with synthetic mesh-band. As explained by Figueiredo et al. (2012), “The mesh was fixed to the wall with angle beads and angle profiles in PVC using highly resistant nylon threads on all of the wall’s concave vertices. Plastic fixing plugs with a depth of 70 cm and cylindrical base of 4 cm in diameter were used, forming a 0.5 m square mesh. The wall was then plastered with lime mortar, similar to the original wall.” After repairing and retrofitting of the cracked adobe wall, the same test that was utilized for the non-reinforced model was also implemented on reinforced model. As the result showed, the grouting injection of cracks along with mesh-band wall reinforcement significantly improved the seismic resistance of the adobe wall.

Figure 5.16- Respectively from right to left U-shape model after first simulated cracking, after grouting, after reinforcing with mesh-band and final damage state (Source: Figueiredo et al., 2012).

- **Experimental Studies at University of Sydney (UTS)**

In 2006, Dowling as a part of its Doctoral dissertation “Seismic strengthening of Adobe-Mud brick Houses” has studied the seismic behaviour of U-shaped adobe wall units, under a modified version of the EI Salvador design spectrum. The dynamic simulation was undertaken on the state-of-art MTS uni-axial shake table located at the University of Technology, Sydney (UTS) (Dowling, 2006).[459] The main aim of the project was to find cost-efficient retrofitting methods for adobe structures in developing countries. In this project, different reinforcement solutions have been tested included: the use of pilasters/buttresses at wall corners, internal wire mesh reinforcement, internal/external bamboo rods, chicken wire, string and ring beam, details of models tested can be seen in Table 5.4. The models had been built with adobe blocks (150 mm ×150 mm ×50 mm) and 12-13 mm thick mortar joints. In these tests, the U-shape walls were considered as non-load bearing walls, the weight of adobe roof is not applied. In addition to those experimental tests carried out shake table, a model house was reinforced in a similar manner to 3f U-shaped adobe wall, (Figure 5.17), the testing sequence of this test is exposed in Table 5.4.

Table 5.4- The specifications of U-shape adobe walls tested in UTS (Source: Dowling, 2006).

Model	Horizontal reinforcement	Vertical reinforcement	Ring Beam
3A	None	None	None
3B	None	Corner Pilasters	None
3C	Chicken wire mesh (internal)	None	None
3D	Chicken wire mesh (external wrapping)	Chicken wire mesh (external wrapping)	Timber
3E	Chicken wire mesh (internal)	Bamboo(external)*	Timber
3G	Chicken wire mesh (internal)	Bamboo(internal)*	Timber
3I	Chicken wire mesh (internal) Bamboo (external)	Bamboo(external)*	Timber
3H	Chicken wire mesh (internal)	Bamboo(external)	Timber**
3F	Fencing wire (external)	Bamboo(external)	Timber**
3J	Chicken wire mesh (internal) Fencing wire (external)	Bamboo(external)	Timber**
3K	Chicken wire mesh (internal)	Timber poles (internal)*	Timber**

Notes: *Vertical reinforcement connected to concrete foundation of test frame - ** Timber Ring Beam Connected to Wall Restraint

Table 5.5- Summary of testing sequence and resultant damage grades for all U-shape adobe wall units (Source: Dowling, 2006).

	Simulation	Intensity Displacement	3A	3B	3C	3D	3E	3G	3I	3H	3F	3J	3K
Unscaled	**S1**	40%	0	0	0	0	0	0	0	0	0	0	-
	S2	100%	0	0	0	0	0	0	0	0	0	0	-
	S3	150-200%	0	0	0	0	0	2	0	0	0	0	-

459 Dowling, D. (2006). Seismic Strengthening of Adobe-Mudbrick Houses. (Ph.D Thesis, Faculty of Engineering University of Technology, Sydney, Australia). Retrieved from https://opus.lib.uts.edu.au/bitstream/10453/20234/2/02whole.pdf

Scaled	**S4**	20%	0	-	0	0	0	-	0	0	0	0	0
	S5	50%	0	0	0	0	0	-	0	0	0	0	0
	S6	75%	4	-	1	1	0	-	0	0	0	0	0
	S7	100%	-	4	4	3	1-2	-	0-1	1	1	0-1	1
	S8	125%	-	-	-	-	3-4	-	1-2	1-2	1	1	2
	S9-S10	75%(×2)	-	-	-	-	-	-	2-3	2-3	2	2	2-3
	S11-S12	100%(×2)	-	-	-	-	-	-	3	3	3	2-3	3-4

Figure 5.17- Specimen 4A after simulation of S8 (Source: Dowling, 2006).

Table 5.6- Testing sequence and observation for model of 4A (Source: Dowling, 2006).

Simulation	Intensity	Damage grade	Observation
S1	10%	0	No damage observed
S2	25	0	No damage observed
S3	50	0	No damage observed
S4	75	1	Rocking of E shear wall. Separation at base. Minor cracking from lintel above door (E wall).
S5	100	2-3	Major rocking of E shear wall. Major cracking in E shear wall. Minor cracking in all other wall panels.
S6	125	3	Sever rocking of E shear wall. Sever cracking in E shear wall. Moderate cracking in all other wall panels.
S7	100	3	Progressive additional damage in all wall panels. Severely damaged. Collapse prevented.
S8	Shakedown	4	Progressive additional damage in all wall panels. Severely damaged. Collapse prevented.

The successful testing of eleven U-shaped adobe wall units revealed the following general outcomes (Dowling, 2006):

- Major improvements in the seismic capacity of adobe-mud brick structures can be achieved using low-cost and low-tech means. Such improvements are viable and effective for both new-build constructions and for the retrofitted-strengthening of existing dwellings.
- U-shaped adobe wall panels (with appropriate ‘wing’ wall restraint) exhibit classic failure patterns when subjected to shake table testing using a suitable input time history. Damages were consistent with real structures subjected to real earthquakes.
- Test results confirm the importance of appropriate time scaling of input time history to induce damaging near-resonance conditions in a structure. Time scaling is also necessary to ensure dynamic similitude between specimens, such that accurate comparisons may between the performance of different specimens.
- Test results challenge the assumption that corner pilaster/buttresses will adequately restrain the out-of-plan overturning moment induced in a wall, which create vertical corner cracking due to tearing failure in the orthogonal wall.
- Test results indicate that there is some uncertainty relating to the structural performance of internal vertical reinforcement, with significant cracking occurring at a lower intensity than expected. It would appear that the presence of internal vertical reinforcement introduces significant discontinues in the structure. This aspect, coupled with the complexity of construction, raises questions about the viability of using this from of reinforcement.
- Test results indicate that significant improvement in the earthquake resistance of adobe mud brick structures can be obtained by using external vertical and-or horizontal bamboo reinforcement, external horizontal wire and/or internal horizontal chicken wire mesh reinforcement and a ring beam. These additions, when securely tied together, create ad integrated matrix which restrains movement and enhances the overall strength of the structure. The reinforcement system acted to delay the onset of initial cracking, and reduce the severity of cracking during repeated high intensity shaking. Most importantly, collapse of reinforced structures was prevented.

- **Experimental Studies of Getty Conservation Institute (GCI)**

In the last decade 20th century, the Getty Conservation Institute within the Getty Seismic Adobe Project (GSAP) carried out a vast investigation into different methods that could be employed for seismic reinforcement of historically or culturally important adobe structures. The research that was carried out during the GSAP was designed to provide knowledge about of the existing historic adobe structures, adobe’s seismic damage typologies both through field observations following the Northridge earthquake and the results from an extended dynamic research program, and to develop theory, tools and techniques for seismic upgrading of historic adobe structures.[460] As part of the GSAP sponsored by the Getty Conservation Institute, with emphasis on minimal intervention to the original fabric of historic adobes, nine small-scale (1:5) and two large-scale (1:2) model buildings with different reinforcement system were respectively tested on the shake table at Earthquake Center at Stanford University and at the Institute of Earthquake Engineering and Engineering Seismology (IZIIS).[461] The primary purposes for using large-scale models were to gather numerical data on the buildings' dynamic behavior and to compare the performance of the large-scale models with that of the small-scale models, in particular, to evaluate the influence of gravity loading on failure modes (Tolles et al., 2000). During the GSAP, the results of the research program clearly demonstrated that the basic theory of stability-based design can efficiently fulfills the demands for seismic retrofitting of historic adobe structures. Based on these laboratory tests implemented GSAP (2002) has developed an effective retrofit system "global design issues". The basic elements of global design are (Tolles et al., 2002):

- Upper-wall horizontal elements (mandatory): Three possible types of upper-wall elements are (1) partial plywood diaphragm, (2) concrete or wood bond beam, (3) external nylon or steel straps or cables combined with existing, flexible roof or floor framing. Upper-wall horizontal elements are most effective in providing anchorage to the roof or floor, providing out-of-plane strength and stiffness and establishing in-plane continuity.
- Vertical wall elements (optional except for thin-walled structures): This design is consisted of center-core rods anchored with an epoxy grout, which is exemplified by nylon straps, steel straps, or steel cables, should be attached to both interior and exterior wall surfaces. The use of vertical elements can greatly increase the "ductility" of the walls, as shown in combination with upper and lower wall elements.
- Lower-wall horizontal elements (optional): These elements can consist of straps or cable elements or even buttresses. Lower-wall horizontal elements can be used to improve the performance of adobe walls by preventing cracked wall sections from "kicking out" in plane, along the length of the wall.

[460] The first few models tested demonstrated the general effectiveness of the retrofit measures, and the remainder of the research effort was directed toward parametric studies, identification of failure modes, and analysis of how these types of retrofit measures may work (Tolles et al., 2000).

[461] To address the possible effects of scale, however, two additional 1:2 scale model buildings, model 10 and model 11—unretrofitted and retrofitted, respectively—were constructed and tested using procedures similar to those used on the 1:5 scale models. The principal objectives of these tests were as follows (Tolles et al., 2000):

1. To compare the performance of the 1:2 scale models with that of the 1:5 scale models in an attempt to understand the limitations of small-scale testing
2. To compare the dynamic performance of the retrofitted model with that of the unretrofitted control model
3. To acquire quantitative measurements and documentation of (a) the dynamic behavior of the models for general analysis, and (b) the loads in the retrofitting elements to allow for sizing of these elements in future design applications.

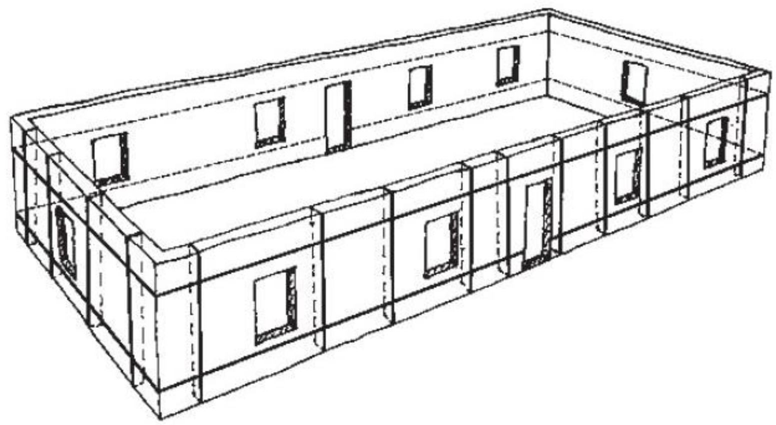

Figure 5.18- Diagram showing how vertical elements add resilience and redundancy to the structural system and restrict the displacement of cracked wall sections. These can be surface straps or internal center-core rods (Source: Tolles et al., 2002).

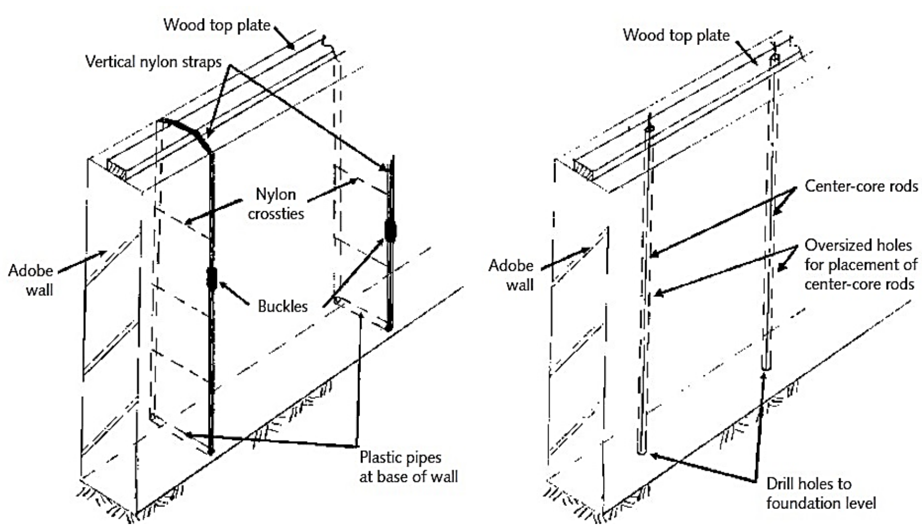

Figure 5.19- (Left) Diagram of vertical straps and crossties on adobe wall; and (Right) Diagram of center-core rods in adobe wall (Source: Tolles et al., 2002).

Table 5.7- The GSAP's Model Adobe House Testing: Specification and Results (Tolles et al., 2000).

Model No.	Scale and SL	Walls	Type of retrofit	Collapse level
1	1.5 (7.5)	NE	Upper horizontal strap	X
		SW	Upper and lower horizontal straps	No collapse
2	1.5 (7.5)	NE	Bond beam and center-core rods	No collapse
		SW	Bond beam, lower internal horizontal straps, and vertical straps	

3	1.5 (7.5)	ALL	Bond beam, lower internal horizontal straps, and vertical center-core rods	No collapse
4	1.5 (5)	NE	Upper horizontal strap	No collapse
		SW	Upper and lower horizontal straps	
5	1.5 (11)	ALL	None (control model)	VII
6	1.5 (11)	NE	Bond beam, lower horizontal straps, and vertical straps	VII
		SW	Bond beam, lower horizontal straps, and local ties at piers between the door and windows.	VII&IX
7	1.5 (5)	NE	Partial wood diaphragm—upper strap at attic-floor level, lower straps, and vertical straps.	No collapse
		SW	Partial wood diaphragm—upper strap at attic-floor level, lower straps, and vertical straps.	X
8	1.5 (7.5)	NE	Partial wood diaphragm—upper strap at attic-floor level, lower straps, and vertical straps.	No collapse
		SW	Partial wood diaphragm—upper strap at attic-floor level, lower straps, and vertical center-core rods; no lower strap on west wall	
9	1.5 (7.5)	ALL	None (control model)	VI
10	1.2 (7.5)	ALL	None (control model)	VIII
11	1.2(7.5)	NE	Partial wood diaphragm—upper strap at attic-floor level, lower straps, and vertical straps.	No collapse
		SW	Partial wood diaphragm—upper strap at attic-floor level, lower straps, and vertical center-core rods; no lower strap on west wall	

Figure 5.20- East wall in Model 10 test VIII (left), and Model 11 test VIII (right) (Tolles et al., 2000).

5.3 The Main Possible Traditional and Innovative Techniques for Preservation and Seismic Retrofitting of Adobe Cultural Heritage

We should be guided by experience, and focus much more on a real understanding of the design and on selecting appropriate materials, no matter if they are traditional or innovative (Claudio Modena, 2015).[462]

The importance of adopting a holistic approach to building preservation cannot be overemphasized (Tolles et al., 2002).[463] When an architectural monument no longer serves the purpose for which it was built, its conservation ceases to be a practical necessity and becomes a purely cultural task, the importance attributed to which will depend on the cultural maturity of succeeding generations and their sense of the urgency of preserving their cultural heritage (Gazzola, 1972). Improvement of the seismic resistance of historic buildings should be integrated into a regular maintenance program, based upon periodic inspections by specially trained architects and engineers (Feilden, 1987).[464] Therefore, earth techniques require regular maintenance, which is ignored nowadays, being even regarded as unacceptable in a modern context (Houben & Guillaud, 1994). Between two seismic phenomena, the conservation and restoration works very soon must come to an end. However, there is the need to a cyclical maintenance program that the necessity of its execution has the key role to the successful historic building survival. In historic adobe structure, this fact is of a great importance due to fast rate of adobe's deterioration. The damages caused by deterioration factors can have a negative impact on the stability of the historic adobe structures. As Feilden (1987) stated, "Observation shows that well-maintained buildings survive much better than those that are poorly maintained. Indeed, it has been estimated that some 50 percent of the damage that occurs in an earthquake may be attributed to lack of proper maintenance."[465] If during the preliminary condition assessment, it was identified that such deterioration reached a critical level, the need for a comprehensive program to rectify deficiencies was certainly essential, so at this time the safety and historic fabric retention remained as a high-priority goal. So far, a careful attention in the form of regular monitoring for replacing, repairing, rehabilitating, reinforcing and/or reproducing of the early stages of cracking, local discontinuities, sagging, or bulging must be taken into account. However, changes in the structure should frequently be noted, and their

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[462] GCI. (2015). Conservation Perspectives: The GCI Newsletter, Vol.30, No.1, Spring 2015. Los Angeles: The Getty Conservation Institutes. Retrieved from http://www.getty.edu/conservation/publications_resources/newsletters/30_1/discussion.html

[463] Tolles, E.L., Kimbro, E.E., & Ginell, W.S. (2002). Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures, the Getty Conservation Institute (GCI), Los Angeles (C.A), p. 13.

[464] Feilden, S.B. (1987). Between Two Earthquakes: Cultural Property in Seismic Zones, A joint publication of ICCROM and the Getty Conservation Institute: Southern California Graphics, p. 119.

[465] Ibid, p. 32.

causes should be halted before it becomes substantial. Sometimes due to lack of cyclical maintenance and suggestion of improper treatments, the damages have usually been unrecoverable and the only option is to protect the adobe structure as a ruin, because the fabric unity does not exist anymore, so any encroachment may cause the falsification of the original fabric. Consequently, in this vulnerable type of structure that has natural propensity to deterioration factors, the construction should regularly be preserved; meanwhile, in earthquake-prone areas, the seismic reinforcement measures should be considered, which nowadays constitute the most devastating phenomena both for historic and modern structures.

Generally, in a well-planned intervention strategy, the scientific, technical, managerial, social, legal and financial criteria should be considered, and effort for promotion of the study should also be taken into account. After consideration of the mentioned primary steps, decisions for possible intervention operations, through cooperation, synergy of interdisciplinary works and initiatives, institutional and professional networks, have to be carried out on the embodied value of the structure versus the protection of the structure. Meanwhile, the actions within a coherent and methodological intervention program, besides common repairing measures must prevent the causes of the defects and improve the seismic resistance of the structure, even if the structure is worth preserving. In addition, temporary operations, such as shoring and other short-term seismic strengthening measures, may be recommended to stabilize the building, while long-term planning and fund-raising for the project are accomplished (Harthorn, 1998).[466] Furthermore, the conservation of earth cultural heritage and the promotion of its values are essential for this heritage to be universally recognized as an area of study and professional practice (Balderrama, 2001).

Measures to be implemented should consider practical intervention to conserve or restore the buildings, and a combination of tradition and modernity in the restoration of earthen structures (Correia & Fernandes, 2006). As Tolles et al. (2002) stated, “If conventional seismic retrofitting practices are followed, extensive alterations of structures are usually required. These alterations can involve the installation of new structural systems and often substantial removal and replacement of existing building materials. However, historic structures so strengthened and fundamentally altered may lose much of their authenticity. They are virtually destroyed by the effort to protect against earthquake damage, before an earthquake even occurs.

Thus, the conflict is seen to be between retrofitting an adobe building to make it safe during seismic events, at the cost of destroying much of its historic fabric in the process, and keeping the historic fabric of the building intact, but risking structural failure and collapse during future

[466] Tolles, E.L., Kimbro, E.E., & Ginell, W.S. (2002). Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures, the Getty Conservation Institute (GCI), Los Angeles (C.A), p. 29.

seismic events."[467] However, between two earthquakes, during broad-scope maintenance programs, a careful attention should be given on possible methods of the seismic interventions, as a specialized type of structural reinforcement that put the highest respect to the original fabric of the structure. The key factors for seismic retrofitting of adobe cultural heritage are:[468]

- Improvement the Strength of the Adobe Bricks
- Improvement the Stability of the Adobe Walls
- Improvement the Stability of the Adobe Connection
- Improvement the Stability of the Adobe Roofs

- Improvement the Strength of the Adobe Bricks

In the last years, several universal studies have been devoted to achieve optimal stabilization strategy for adobe-mud brick blocks. In these researches, different aspect of adobe bricks ranging from physical-mechanical and mineralogical characterizations to possible reinforcement with natural fibres (e.g. jute, palm, straw, hump etc.) and chemical stabilizers (e.g. portland cement, hydrated lime and pozzolanas etc.) have been studied.[469] The aims of these studies were to enhance the strength and durability of adobe bricks as these additives or stabilizers not only can increase the stability of bricks against of loads applied, but also can protect them from deterioration agents. The durability is relatively conditioned by environmental deterioration factors, while strength is particularly related to resistance against static and dynamic loads. However, the studies about soil stabilization have shown that with incorporation of appropriate additive materials, it is possible to obtain much more durable and stronger adobe bricks.

Totally, there are some basic principles for application of efficient additives that are related to chemical, physical, mechanical, thermal and rheological compatibility of materials added, so any fault in selection of an appropriate additive can result in more damage of the adobe structure. As an example of this case, "once the adobe bricks are modeled in cement, its ability to breathe - its natural capacity to rid itself of the moisture that wicks up into its walls as a result of capillary action - is eliminated" (Cornerstones Community, 2006).[470] In addition to those mentioned principles, the stabilization of adobe bricks should also be inexpensive, locally available, and easy to construct. In the meantime, studies about the past conservation techniques make it possible to understand how many historic adobe structures have been preserved during

[467] Ibid, p. xii.
[468] The retrofitting techniques, then, should be chosen considering the basic criteria described in Section 5.2 in base to the extension of the damaged area, as well.
[469] Semistabilized adobe bricks is made the same way as traditional adobe, except the stabilizer is mixed into the adobe soil prior to packing it into a form.
[470] Cornerstones Community. (2006). Adobe Conservation: A Preservation Handbook. New Mexico: Cornerstones Community Partnerships, p. 10.

several centuries, resisting harsh weather conditions. Although in most of these stable historic structures, the adobe bricks have been produced with high quality of composition, they also benefited from natural additives. In Table 5.8, the characterization of some mineral, synthetic, vegetable and animal additives are shown.

Table 5.8- Mud additives (Source: Bahobail, 2012).

Type of additives	Materials introduced	Reduces the shrinkage and swelling	Strength and hardener	Water resistance	Compressive strength	Tensile strength	Erosion resistance	Sets quickly
Mineral Additives	**Sand**	*			*			
	Pozzolana		*		*		*	
	Ashes	*	*					
Synthetic Additives	**Portland cement**	*	*	*	*		*	*
	Hydraulic lime		*					
	Hydrated lime		*					
	Gypsum				*			*
	Magnesium oxide				*			
	Soap			*				
	Bitumen			*				
Vegetable Additives	**Fibers**		*			*		
	Vegetable Oils and Fats			*				
	Tannins			*				
	Gum Arabic				*			
	Palmo copal			*				
	Sap and latexes		*		*			
	Molasses		*					
Animal Additives	**Fibers**					*		
	Blood		*	*				
	Casein	*						
	Animal glues		*	*	*			
	Oils and fats			*				
	Urine	*					*	
	Excrements	*	*					

Furthermore, the deployment context of the adobe bricks production for use in conservation and restoration process is being done manually so that the use of new mechanical technique can effectively reduce the possible errors during the material composition and adobe molding. Nowadays, there are some mechanically innovative techniques through which by the use of motorized hydraulic brick press produces 5,000 to 20,000 bricks per day by machines that may reduce the fallacy of their materials composition and their molding under an appropriate uniform pressure, see Figure 5.21.

Figure 5.21- A mixer with a conveyer-belt system feeds a large-size commercial pressed-earth-block machine operation, made by AECT Compressed Earth Block machines (CEB/Adobe) company (Source: http://aectearthblock.com).

- Improvement the Stability of the Adobe Walls

One of the determining factors for the seismic improvement of historic adobe structures is to provide reinforcement for the walls; the adobe walls are the main seismic-resisting elements of an adobe structure. Seismic motions can cause adobe walls to crack at the openings, corners and connections, and because of the development of these cracks, the adobe walls will break up in large blocks. Therefore, the aim of the reinforcement is to keep these large pieces together. Depending on the physical state of the structures and availability of the local materials, the horizontal and vertical reinforcement can be applied by such ductile materials as bamboos, reeds, cables, canes, ropes woven by naturally available materials (e.g. vines, palm, etc.), timbers, synthetic and natural meshes, fiberglass rods and so forth. In addition, there are other materials such as chicken wire, barbed wire, or steel wire, in which due to the possibility of corrosion in these materials, their use as far as possible is prohibited in historic adobe structures. However, it should not be forgotten that the compatibility and durability of materials used in historic adobe structure is of a great importance.

Each vertical and horizontal reinforcement measures has its role in the stability of adobe walls. Vertical reinforcements by tying the walls together to the foundation and ring beam at the top restrains out-of-plane bending and in-plane shear. On the other hand, horizontal reinforcements by transmitting the out-of-plane forces in transverse walls to the supporting sides' walls restrains shear stresses and minimizes the development of vertical cracks. Meanwhile, to provide a stable matrix and to ensure mutual support for maintaining the integrity of the adobe walls, it is necessary that all of the horizontal and vertical reinforcement elements be exactly tied together and to the other structural elements.

- **Renewing of Adobe Surface Coatings**

Since adobe surface coatings are continuously exposed to environmental deterioration factors (e.g. rain, wind and temperature fluctuations), every effort should be taken to recoat the surface with the same material that originally covered the adobe surface. In this process, after the deteriorated parts are scraped off, the surface is cleaned and made slightly wet. Then by the same techniques, the renewed parts should be patched as closely as possible to the original ones. It is a common error to assume that instead of mud surface coating, harder and stronger materials like lime plaster and portland cement should be used for rendering the adobe surface. In this case, if serious deterioration has not been observed on the adobe surface, the use of these materials during restoration work will likely cause far greater damaging.[471] In addition, the deterioration caused by water, which is the result of the penetration of water and its capillary action between adobe coatings and walls can be aggravated in contact with lime or cement. Furthermore, during repairing and replacing of the surface coatings of curved roofs with a fresh layer of adobe mud over an existing surface, high care should be given to temporarily support of the roofs, because adobe materials are heavier when they are wet than after they are recoated. If they are not supported, the roofs may collapse or deflect. Furthermore, despite renewing adobe surface coatings, other measures such as better slopping of roofs, providing efficient drainage system and installing downpipe in critical part of the structure can prevent granular disintegration of the adobe surface coating.

Figure 5.22- The northern part of Mirza Naem School before and after adobe surface coating, before earthquake (Source: personal archive of Prof. Tayari, between 1993-1995 AD).

[471] As an example about the importance of the issue of the application of an appropriate material for adobe surface, "over time, the cement plaster detaches and falls dragging part of the wall" (Correia & Fernandes, 2006).

- **Structural Repointing: Repairing and Replacing of Adobe Mortars**

This method is a widely applied technique in all types of masonry structures, which only in compliance with specific criteria has efficient capability in enhancing the mechanical properties of the adobe walls. The operation of this method is related to the partial repair and replacement of the deteriorated mortar joints with better quality mortar in order to improve the mechanical characteristics of adobe walls. In fact, the structural repointing of adobe mortar can enhance the stability of adobe wall against both vertical and horizontal loads, more especially during the deformations applied by the seismic motions. During an earthquake, adobe mortar joints are greatly affected due to the confinement effect of the joints. As mentioned before, during an earthquake, the failures in adobe walls is usually caused by shear in plane forces or more frequently out of plane forces. The reason is that two leaves of walls are not connected well and/or there is lack of proper bond joints between mortars and bricks; as a result, the differential behaviour of these leaves cause an easy separation of the bricks from the mortars.

Note: Most importantly, before any action an on-site investigation should be carried out in order to investigate physical and chemical characterization of the materials, the morphology of the adobe walls and the thickness of the section. Then the section should be prepared, and then the joints should be repointed and refined. If it is necessary, the scape operation should also be executed during the deep repointing. The process of the removal and replacement of old mortars should not be destructive, as well as a high care should be taken for the compatibility and durability of the new mortars. For the former, it is essential to rake out the old mortar to a depth of two or three times the thickness of the adobe brick. And for the latter, in order to avoid inhomogeneous behaviour of adobe mortar, it is important that the mortars replaced be compatible with the original ones, and while it is stronger, it should not be excessively rigid. The use of incompatible materials such as portland cement mortar is not allowed, because these materials do not have the same thermal expansion rate as adobe bricks, so this feature may cause to crack, crumble, and eventually disintegrate the adobe walls. Meanwhile, it should not be forgotten that before replacing the new mortar joint, the adobe bricks should be made wet to increase the cohesive bond.

- **Substitution of Adobe bricks: Repairing and Replacing of Adobe Bricks**

Repointing, grouting, and replacing defective mortar are common remedies, but in extreme cases reconstruction may be the only available course (Feilden, 1987).[472] In this process, reasonable effort should be assigned to find the best quality of soil for adobe mixture, similar to the original fabric. During substitution of adobe bricks, it would be better not to consolidate the new adobe bricks with additives despite the high quality of soil; reinforced adobe bricks can behave in the same non-compatible manner with older and existing unstable adobe bricks. It is important to note that the reusing of the ground up adobe soil (deteriorated adobe bricks) is

[472] Feilden, S.B. (1987). Between Two Earthquakes: Cultural Property in Seismic Zones, A joint publication of ICCROM and the Getty Conservation Institute: Southern California Graphics, p. 53.

actually prohibited, because they frequently contain a high percentage of salt. Depending on the level of deterioration, the locally deteriorated and disintegrated adobe bricks are replaced with new ones and are patched in place. During replacing the old bricks, the deteriorated parts must be well scraped out, cleaned and if necessary covered and/or supported by suitable tools. In addition, in order to restore the integrity of the wall portion and to obtain a monolithic behaviour, adequate connections should be provided between adobe bricks. Furthermore, during the restoration work, the new bricks and intervention spaces should be lightly wet to increase the cohesive bond.

Figure 5.23- Substitution of Adobe bricks in the west tower of the second entrance gate of Bam Citadel (Source: personal archive of Miss. Jafarizadeh, 2010).

Note: Although repairing and replacing of adobe bricks have many advantages, substitution of adobe bricks can restore the original function of structural element and generally the global behaviour of the historic adobe structure. Depending on the size of substitution and materials used, they might be reversible and they fulfill the minimum intervention principle. Apart from these advantages, this method can have some disadvantages that must be taken into account: it is mostly invasive and irreversible technique, and non-well patching of adobe bricks may cause non-dependent behaviour of the structure.

Figure 5.24- The preparation of the wall section for patching with new wall in future reconstruction works (Source: (Left) archive of RPBCH, 2010; and (Right) Rouhi, 2015).

- **Bed-joint Reinforced Repointing**

As a common reinforcement technique in historic masonry structures, the bed-joint reinforced repointing is performed when the rate of deterioration in adobe wall reaches a critical level, especially close to the adobe foundation that needs more stability, where the operation of the repairing and replacing of the adobe bricks cannot restore the desirable stability. Meanwhile, this technique can be used between mortar joints for stitching of cracks in the adobe walls. The operation in this technique is that along with transverse direction on one or both sides of the wall, the reinforcement rods are inserted between mortar joints, and then all steps mentioned in structural repointing are followed. Generally, the bed-joint reinforced repointing can enhance the stability of adobe wall against both vertical and horizontal loads, more especially during the deformations applied by the seismic motions. This technique can reduce the tensile stresses in resistant elements, and increase the ductility and the ability to dissipate energy of the structure.

Figure 5.25- Bed-joint reinforced repointing with metal rods (Source: https://www.permagard.co.uk/advice/how-to-repair-cracks-in-walls).

Note: structural repointing and reinforced repointing have many advantages: they can restore or improve the stability of adobe walls through increasing the interconnectedness of adobe bricks; they are effective in prevention of water penetration through mortar joints; depending on the compatibility of mortar used, they can be recognized as a reversible technique; they can be used even in irregular adobe walls, etc. Apart from these advantages, the use of these techniques can have some disadvantages that must be taken into account: the incompatibility of mortar joint used can accelerate the decay of adobe units; the rods used in bed-joint reinforced repointing may lead to corrosion, unless they have corrosion resistance properties etc.

- **Grouting Injection of Small Cracks (3 mm< C >5 mm)**

During the last years, grout injection has revealed to be an economic and reliable solution for repairing and consolidating ancient masonry (Silvia et al., 2009).[473] A grout can be defined as a fluid mortar employed for the filling, homogeneization, imperviousness, consolidation and/or upgrading of the mechanical properties of system presenting pores, voids, cracks, loss of

[473] Several studies have shown that grouting injection as a reversible strenghtening technique by filling of the existing voids and cracks has significant role in reduction of the structures' internal weakness.

cohesion or of cohesionless system (Toumbakari, 2002).[474] Repairing cracks is essential in order to obtain an improved structural load bearing capability, especially if the historic adobe structure is built in seismic area. Accepting the inevitability of cracking and making timely repairs as part of cyclical maintenance must continue, or the level of intervention necessary to repair cracking rises proportionately (Tolles et al., 2002).[475] Sometimes, the repairing and replacing of deteriorated parts of historic adobe structure might be destructive; therefore, in this situation the grouting injection would be a more practical, preferable and less intrusive solution.

As said before, due to natural interaction of adobe materials with the surrounding environment, cracks are always visible in the body of these structures. However, during moderate to major seismic ground motions, the additional loads will cause the development of the previous cracks, so the necessity of ongoing maintenance to minimize such cracks constitutes as the key step in preservation of the historic adobe buildings. Despite that, crack repair also prevents further decay caused by other agents, like water infiltration and plant growth (Silvia et al., 2009). The research conducted by PUCP research team evaluated the efficiency of injecting mud-based grout inside adobe wall to restoring the original strength of the structure. The results have shown that grouting is an effective method for repairing cracks in adobe walls when crack widths are in the range of 3 mm to 5 mm (Blondet et al., 2011).[476] Generally, grouting of earthquake-generated cracks should achieve the following objectives (GCI, 2007):[477]

- Recover original wall integrity and strength by repairing the earthquake generated wall discontinuity;
- Reduce vulnerability to further damage. Grouting as a repair technique cannot be considered an intervention for retrofitting because of its limited ability to strengthen buildings. Applied grout can act as an energy absorber during a seismic event, inducing crack generation in the grout rather than the wall itself, as historic cracks reopen.

Based on limitations in the use of certain chemical additives in grouting injection of adobe walls, such as portland cement, hydrated lime and pozzolanas, i.e., additives that cause

[474] Toumbakari, E.E. (2002). Lime-Pozzolan-Cement Grouts and their Structural Effects on Composite Masonry Walls (PhD Thesis, Department of Civil Engineering - miscellaneous, K.U. Leuven, Belgium). Retrieved from https://lirias.kuleuven.be/handle/123456789/313779

[475] Tolles, E.L., Kimbro, E.E., & Ginell, W.S. (2002). Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures. Los Angeles: The Getty Conservation Institute (GCI), p. 6.

[476] Mud-based grout using soil sifted with a #10 (2 mm) sieve and moisture content ranging from 30% to 40% was carefully injected in the walls. Tests showed that the wall was restored to its original strength. The grout mix consisting of soil stabilized with gypsum (20% to 30% ratio) also proved to be effective, however the injection process was more complex (Blondet et al., 2011).

[477] GCI. (2007). Interdisciplinary Experts Meeting on Grouting Repairs for Large-scale Structural Cracks in Historic Earthen Buildings in Seismic Areas. Los Angeles (C.A): The Getty Conservation Institute (GCI). Retrieved from https://www.getty.edu/conservation/our.../field.../grout_experts_meeting_aug07.pdf

subsequent undesirable chemical reactions with adobe materials, during repairing process of historic adobe structures, careful attention should be given to the selection of appropriate grouts raw materials and compositions. However, while the materials injected should have compatibility with original fabric of the structure, they should also have adequate durability, mechanical and rheological properties.[478] Despite of the grout injection recognized advantages it is a non-reversible technique, which can induce durability and compatibility problem with the injected system, if non-suitable materials are chosen to compose the grout (Silvia et al., 2009). Thus, it is a big mistake that during the grout design the durability and compability of its raw materials be ignored.[479] In table 5.9, Toumbakari (2002) well depicted the requirement of grouts related to the mechanical behaviour and the durability of the injected structure.

Table 5.9- Requirements of grouts related to the mechanical behaviour and the durability of the injected structure (Source: Toumbakari, 2002).

Requirement		Description
Mechanical Behaviour	**Injectability**	▪ low yield value and viscosity. ▪ penetrability: in voids with diameter smaller than 0.3 mm. ▪ stability: no substantial density gradients along the height of the stored grout. ▪ low bleeding: lower than 5% after 120 min rest.
	Bonding with existing materials	▪ relatively low shrinkage (although autogeneous shrinkage is unavoidable). ▪ minimal heat of hydration. ▪ setting and hardening in dry as well as in wet environment.
	Sufficient mechanical properties within a defined span	▪ development of the required mechanical properties in 90 days. ▪ compressive and flexural strength dictated from the structural analysis.
Durability	**Compatible microstructure**	▪ compatible porosity and pore size distribution: they depend on the porosity of the existing materials as well as on the required strength of the new materials. ▪ type of the hydration products: similar (though not necessarily identical) to the existing.
	Bonding with the existing materials	▪ limitation of diffusion of SO2, chlorides etc. ▪ resistance against deterioration due to environmental factors.
	Properties of the raw materials	▪ minimal content in gypsum and soluble salts (especially in releasable alkali).

[478] The rheological property of grouts is related to their fluidity and penetrability or injectability features.
[479] That's why during a grout design for historical masonry consolidation, subsequently to the selection of the raw materials composing the grout, according the defined requirements, the grout is tested in a trial zone, in order to validate the design on site, only after the full approval, the gout is used for further consolidation (Silvia et al., 2009).

Using earth as a component or as all part of the grout almost solves the problem of compatibility and prevents possible additional durability problem (Warren, 1999). On the other hand, as Silvia et al. (2009) stated, “The interaction between a mud grout and the earth construction to be injected has also great importance in deciding on a grouting intervention. The shrinkage/swelling behavior of earthen materials may constitute a major drawback, since the bond between the repair and the original material may be compromised by the water introduced. During the injection, the original earthen materials interact with grout by absorbing its water. This can have two types of effects on the original materials. As a result of being absorbed, the water makes the earthen materials swell and at the same time makes the grout shrink, as soon as it dries. Cracks may occur in the interface, turning the grouting into a failed intervention. The grout water absorption may also result in a reduction of the original earthen materials strength. This can constitute a major problem if high amounts of grout are required to be injected, because the structural integrity may be compromised.” Therefore, during a grouting injection of cracks, various negative factors affecting should be evaluated.In August 13-16, 2007, along with “Interdisciplinary Experts Meeting on Grouting Repairs for Large-scale Structural Cracks in Historic Earthen Buildings in Seismic Areas”, Lima, Perú, a range of variables were proposed regarding clay-based grouts that must be considered in designing a testing protocol. These include (GCI, 2007):

- The chemical reactions between water and grout components (i.e., percentage and type of clay in mix), between the grouting materials and the crack/wall interface (fluidity characteristics; relationship between grout clay and host clay), and between grouting material and the environment (i.e. variability of mixing time).
- The effect of crack width on grout performance (fine and large cracks vs. thicker ones; crack tips)
- Advantages and disadvantages of adding other constituents (stabilizers, amendments, etc.) to basic grout material.
- There is a need to control micro-crack formation within grout. It is well known, for example, that adding plant fibers to mud slows the drying process in adobe. The inclusion of such additives could produce positive effects to reduce shrinkage, increase suspension of particles, reduce the water evaporation rate or increase tensile strength across cracks.
- Further testing is needed to better explain the bonding between particles in the substrate and the grout and whether added or extant materials such as dust will improve the adhesion between them.
- Further testing is needed to understand the effects of pre-wetting the substrate through the crack.
- In establishing the range of acceptable properties for soil/clay-based grouting materials, both the working and cured properties of the grout must be considered.
- Standardized test methods and parameters for results that have been developed for other grouting materials can serve as references, but these must be modified for clay-based grouts.

- The testing protocol should consider the difference between proprietary, premixed materials prepared in the lab under a controlled environment and materials made in the field.

Note: the grouting injection has many advantages: it can restore and improve the uniformity and homogeneity of the deteriorated adobe section; it is effective in prevention of water penetration through gaps; it can increase the strength of the adobe walls with restoring the continuity of multi leaf sections, etc. Apart from these advantages, the use of this technique can have some disadvantages that must be taken into account: it is an irreversible technique; it is not suitable for adobe walls with low percentage of voids; it may damage the infill of adobe walls; it may cause dwelling, shrinkage and segregation; it may not be precise without enough knowledge about the distribution of voids, their size and depth, the usage of an appropriate NDT and MDT diagnostic technique is necessary; it may not be effective if the structure is not covered well and when the technique is not combined with other seismic retrofitting measures.

- **Stitching of Large Cracks**

Stitching is one of the common techniques for fastening large cracks in masonry structures. This technique is an innovative-engineered technique to restore the structural continuity, tensile strength across the cracks, reestablish compression, and stabilize the structure by the locally junction of two independent wall sections (large cracks), which have the potential of detachment under the dynamic loads. Unlike grouting injection that has difficulty in insertion of metal tie in a drilled hole and its grouting, the stitching of large cracks has less hassles. In this technique, after removal of two or three adobe courses on both sides of a crack, stitching by means of the placement of the U-shape or flat metal, wood or plastic sockets supposedly fixed to the wall is performed. Then, the empty space is filled with new adobe bricks, and in other parts of cracks the operation of grouting injection is implemented to prevent the penetration of water within the adobe wall. Sometimes due to the existence of very large cracks in adobe walls, no option remains except for destruction of the wall and its reconstruction.

Figure 5.26- Stitching of large crack in Tabai House of Ardakan (Source: archive of ICHHTO, 2010).

Note: stitching of large cracks has many advantages: it can improve the connections of adjacent cracked walls; it can partially return the original strength and ductility of the adobe wall; it can control the development of the cracks, etc. Apart from these advantages, the use of this technique can have some disadvantages that must be taken into account: depending on the type of materials used, it might be irreversible and obstructive, and also harmful for the original fabric.

- **Jacketing of Adobe Walls with Mesh-Bands**

This system is usually used for the reinforcement of the historic masonry's roofs, walls and columns; mesh-bands are usually installed on the surface of adobe elements, but during post-earthquake reconstruction, they can also be used horizontally between adobe mortar joints. In fact, the idea behind this technique is to have a thicker section, to increase compressive, tensile and shear strength and ductility (Modena et al., 1997). In this technique, the mesh bands with frequent connectors on the one or both faces of the adobe walls are executed; double mesh can be applied in critical locations where the probability of cracks are high, such as at connections and at corners of openings. Moreover, the meshes are covered with traditional methods of surface coating. Nevertheless, the execution of this system is almost easy, so the only problem is the difficulty of installation and fixation of the meshes on the walls. In addition, if the jacketing of wall is poorly implemented, there is the possibility of local failure in adobe façade. Furthermore, the steel reinforcement nets should not been used as a mesh-band, especially in places where the risk of capillary action exists, because the steel corrosion can cause the adobe plaster to spall. Therefore, instead of steel mesh, natural meshes (e.g. palm fiber) and synthetic meshes (e.g. FRP, GFRP)[480] jacketed on the adobe walls would be adequately efficient. Moreover, less stiff mesh-bands appear to be more effective in terms of both ultimate strength and stiffness increase of the panels. That is due to the particular design criterion (weaker material has a larger adhesion area), and also due to the fact that stiffer material is more vulnerable to de-bonding, especially when the number of plies increases (Valluzzi et al., 2002). However, the use of less stiff mesh bands would have better result.

Note: The application of mesh-bands can have numerous technical and practical advantages in their favor: they can effectively increase the strength and ductility of structural elements and in general the global behavior of the adobe structure; flexibility and somewhat easy application; high strength and stiffness-to-weight ratio; fatigue and corrosion resistance, handling and the on-site workability; they can be reversible depending on the material used to cover meshes, etc.

[480] In addition to common natural and synthetic mesh-bands, there is also some other composite mesh systems such as SRP (Steel reinforced polymer), SRG (Steel Reinforced Grout) and FRCM (Fiber Reinforced Cementitious Matrix), which are more and more applied in the structural-reinforcement-field techniques, whether in reinforced concrete structures or in historic masonry structures. But the application of these composite systems in the natural aggressive environment, generally characterised by the presence of moisture and salt, thermal cycles, frost-defrost actions still need more experimental and numerical studies.

Apart from these advantages, the usage of this system may have some disadvantages that must be taken into account: some of meshes may have heat and radiation sensitivity; the application of incompatible meshes may accelerate the decay of adobe units; the high stiffness and non-flexibility of the meshes may lead to eccentricity under dynamic loading; they may be obtrusive depending on the materials used to cover meshes.

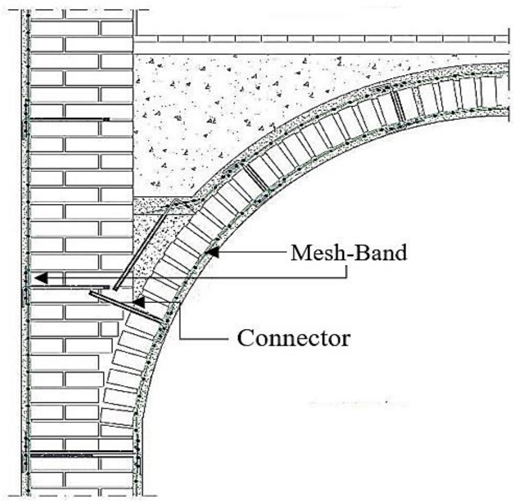

Figure 5.27- (Left) the installation of mesh band on adobe wall and roof (Designed by Author); and (Right) the deterioration of steel mesh-band in adobe wall (NIKER, D3.2, 2010).

- **Confinement for Towers, Columns and Pillars**

In addition to composite materials that typically can improve the stability of columnar elements, the confinement is another basic technique to tie up horizontal displacement or flexural failure in elements that are under vertical load pressures, especially during an earthquake when the structure must resist against dynamic loads. This technique is the most common method in stone masonry buildings, when due to overloaded compression, complications such as cracks, spalling, crushing and bulging might be observed on columns and pillars. In this system, the vertical elements are tied with metal rings, advanced polymer strips or tensile bands. To implement confinement in critical sections of adobe structures, the selection of the materials becomes significantly important so that they should not corrode or interact with adobe resulting in deterioration, and the system should not exert high pressure on the structure.

Note: the application of confinement technique has many advantages: it is effective in increasing the load-bearing capacity, stability and stiffness of the structural element; it is effective in prevention of local crushing of the external leaves in mutli-leaf columns; it is a reversible technique, etc. Apart from these advantages, the use of this technique can have some disadvantages that must be taken into account: in exposing to environmental agents, the usage of incompatible materials can be obstructive and may lead to deterioration problems.

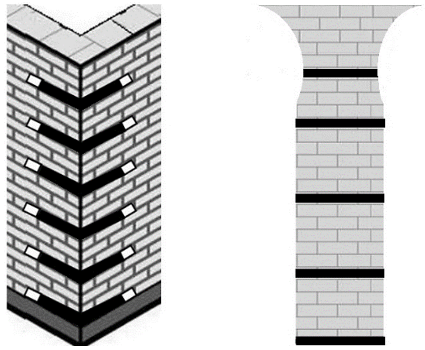

Figure 5.28- Samples of possible confinement for adobe's columnar elements (Designed by Author).

- **Needling and Anchoring**

Needling and anchoring as a deep internally light or non-post-tensioned intervention is implemented to prevent the probability of cracks and to improve the stability and shear behaviour of the adobe walls with large thickness (e.g. adobe fortification). In this partially irreversible intervention, the anti-corrosion metal rods are inserted into holes (diameters ranging from 4.0 to 8.0 mm) drilled in body of adobe walls, and then they are externally bolted on end steel, wood or plastic plates. In order to minimize localized stress damage, before bolting of the metal rods, the holes should be grouted with compatible materials. Depending on the condition of the walls, restorers may suggest different number of metal rods and different designs for their placement (e.g. vertically, horizontally and transversally). An example of this method is carried out by Italian groups in Tower No. 1 and Sistani house of Bam Citadel.

Figure 5.29- The anchorage of Tower No. 1 of Bam Citadel by the Italian group (Source: Porta & Santoro, 2010).

Note: the needling and anchoring of adobe walls has many advantages: its insertion along both length and width can increase the stability of adobe walls; it can improve the global behavior and integrity of the adobe walls, etc. Apart from these advantages, the use of this technique can have some disadvantages that must be taken into account: the non-corrosion resistance of rods inserted may cause deterioration problems; it is mostly an irreversible technique; over time, it may lose its effectiveness; its operation during drilling, insertion and grouting may be invasive.

- **Enlargement**

Enlargement as a traditional restoration operation is applied to increase the mechanical capacity of the masonry walls (shear and compressive load bearing). In this technique, the new attached wall with the same traditional techniques and materials is connected or interlocked in one or both sides of the wall. The quality of connection between new and old walls, and the differences in their stiffness can cause the separation and partial or total collapse of the adobe leaves.

- **Buttresses and Pilasters**

The buttresses and pilasters are a counter support or footage wall, which in a homogeneous unit with the rest of the structure are originally built as part of the entire original construction. In seismic areas, the main role of these structural supports is to increase the deformation stability of the structure with relieving the stresses in certain places, to increase the stiffness and integrity of the structure, to prevent outward and inward overturning of the walls, and to increase the interlocking of the adobe bricks at the corners. Sometimes, the buttresses are built with flying arches. This design, in addition to being known as a decorative form, can also prevent the overturning of adobe walls, see Figure 5.31. Despite the advantage of buttresses and pilasters as a later strengthening device, any mistake in their design, placement and attachment may threaten the stability of the structures, as it can be seen in the caravanserai of Bam Citadel. IAEE (1986) in his "Guidelines for Wall Construction with Buttresses and Pilasters" proposed some geometrical specifications for design of buttresses and pilasters, see Figure 5.30.

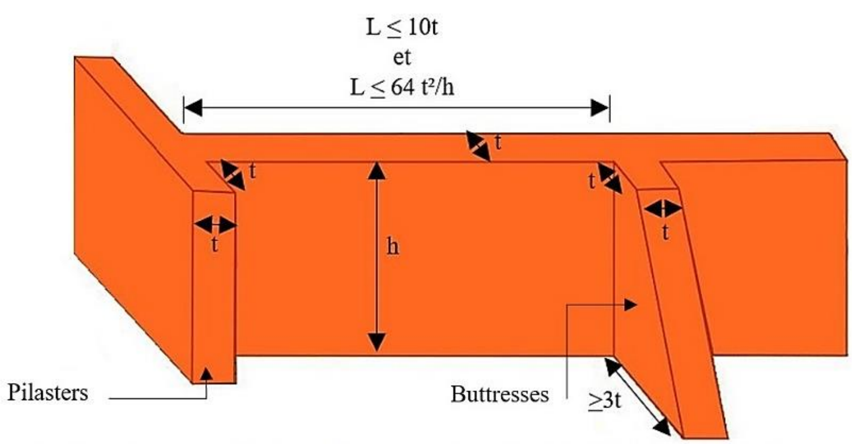

Figure 5.30 Geometrical specifications for construction of adobe's buttresses and pilasters (Source: inspired from IAEE, 1986).

- **Sabats and Flying Arches**

In protecting the present-day cultural heritage, in order to reduce losses, a critical re-evaluation of traditional seismic technologies can indeed result in a more effective prevention, a more appropriate relief action and less harmful rehabilitation (Harrouni et al., 2017). Sabats and flying arches are one of these traditional techniques. In Bam Citadel, where the city is organized in an irregular network of narrow streets, there were some flying architectural elements, which in addition to providing shade for the passengers, had also the role of an empty joint of separation. From an engineering point, these elements can have a significant role in bracing the adobe walls between themselves, so they can increase the dynamic deformation of adobe walls during an earthquake. Therefore, in future reconstruction process of Bam Citadel, it would be worth to have a high degree of attention to engineering qualities of these traditional architectural elements.

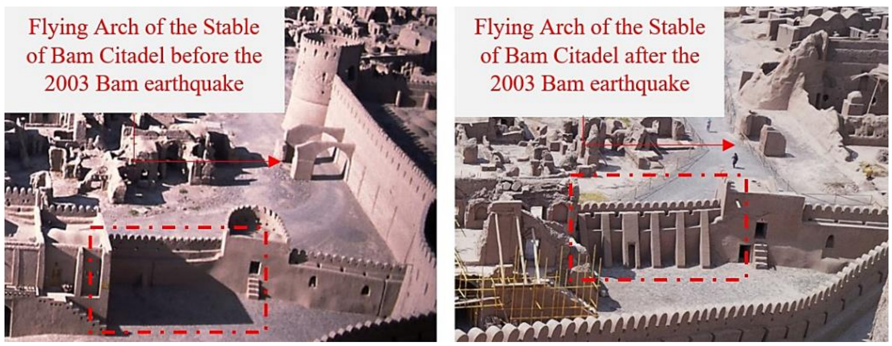

Figure 5.31- Construction of buttresses in west wall of second defensive wall of Bam Citadel after the 2003 Bam Citadel (Source: (Left) Photo by Steven, 2001. Source: archive of Bam3DCG); and (Right) Rouhi, 2015).

- Improvement the Stability of the Adobe Connection

In any masonry structures, the best seismic retrofitting design will be achieved when it ensures box action of the masonry structure during an earthquake, which means that the structural elements with good quality of connections should behave as a box of limited deformability in their plan. In this subject, examination of earthquake damage shows that bonding of walls together at the corners is vital, together with tying of floors and roofs to walls (Feilden, 1987),[481] so an appropriate connection between floors-walls, between roof-walls and between perpendicular walls have a decisive role in minimizing the localized stress damage and global seismic behaviour of the structure. Recent seismic events in Bam City widely documented the damages, the observation of the seismic damages has shown that (chapter 3 of this thesis) the seismic behaviour of adobe structure is strongly dependent on how the walls are interconnected with other structural elements such as foundation, floor, roof and perpendicular walls. It is generally recognized that a satisfactory seismic behaviour is attained only if out-of-plane collapse is prevented and in-plane strength and deformation capacity of walls can be fully exploited (NIKER, D3.2, 2010).[482] Thus, it can be concluded that the pronounced vulnerability

[481] Feilden, S.B. (1987). Between Two Earthquakes: Cultural Property in Seismic Zones, A joint publication of ICCROM and the Getty Conservation Institute: Southern California Graphics, p. 52.
[482] NIKER, D3.2 (2010). Critical review of retrofitting and reinforcement techniques related to possible failure, POLIMI. Retrieved from http://www.niker.eu/assets/Files/Download/D3.2

of structural connections, even if the structure are built with high quality of the materials, will quite often be defective, so it can negatively affect the limit box action of the adobe buildings subjected to seismic motions. Despite the local improvement of the connection with intervention measures described for the "Improvement the Stability of the Adobe Walls", there are some other global extensive interventions that can efficiently improve the stability of the adobe connections.

- **Ring Beam**

From an engineering perspective, although the application of a number of relatively simple seismic retrofitting measures can efficiently enhance the stability of adobe walls during an earthquake, but inattention to the connections can be destructive. However, support provided by a continuous roof system at the tops of the adobe walls can add additional stability to the walls, especially when the roof system is anchored to the walls. A ring beam, as a seismic band or belt, is one of the most essential earthquake-resistant provisions for adobe's load-bearing walls. In this system to prevent individual behavior of the ring beam during an earthquake, all the joints must be anchored and tied with walls and roof, and firmly tied with galvanized steel wire. This system can be made of a diagram of wood, fiberglass rods, bamboo etc., and its internal volume can be filled with materials such as concrete or adobe bricks. Even in connection of roof-floor, these materials can be used as a single element without any diagram. This seismic retrofitting measure due to its invasive and destructive procedure, rather to post-earthquake reconstruction operations is not recommended for withstand historic adobe structures.

Note: As Tolles et al. (2002) stated, "The design of bond beams is often based on elastic design criteria, which usually results in a very stiff beam. After cracks in the adobe walls develop during an earthquake, the stiffness of the bond beam may exceed the stiffness of the walls by two or three orders of magnitude. Adobe walls have pulled out from underneath bond beams during earthquakes due to the difference in stiffness between the bond beam and the cracked wall sections and the lack of a positive connection between the bond beam and the adobe walls." [483]

- **External Reinforcement: Tying and Anchoring of Adobe Walls Externally**

A widely used seismic retrofitting measure in traditional stone masonry structures is the application of the metal ties in external part of the structures. This pre-stressed system with tying of walls at corners improves the integrity of the structure, and can reduce the possibility of large cracking at connections and out-of-plan behavior of walls. To apply this engineering system in historic adobe structures, there are some limitations; however, some consideration

[483] Tolles, E.L., Kimbro, E.E., & Ginell, W.S. (2002). Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures. Los Angeles: The Getty Conservation Institute (GCI), p. 42.

such as compatibility of material used, the level of pre-stressing and respecting the authenticity of the structure should be taken into account. If the proposed reinforcement satisfies all three mentioned criteria, it can be considered as an effective restraint system with low cost, easy installation, easy maintenance and repair requirements. The level of tightening and the dimension of the anchoring system are totally related to both tensile capacity of stretcher and the quality of adobe material, and excessive tightening can cause damage to the adobe walls at anchoring level. As Feilden (1987) stated, “Experiments have shown that adobe or mud brick with diagonal pre-stressed cables anchored at top and bottom has much greater resistance to dynamic forces. In existing adobe buildings, reinforcement in the form of diagonal galvanized steel wires might be added under the layer of mud plaster that is normally renewed and anchored with small elements of reinforced concrete at the top and bottom.” [484]

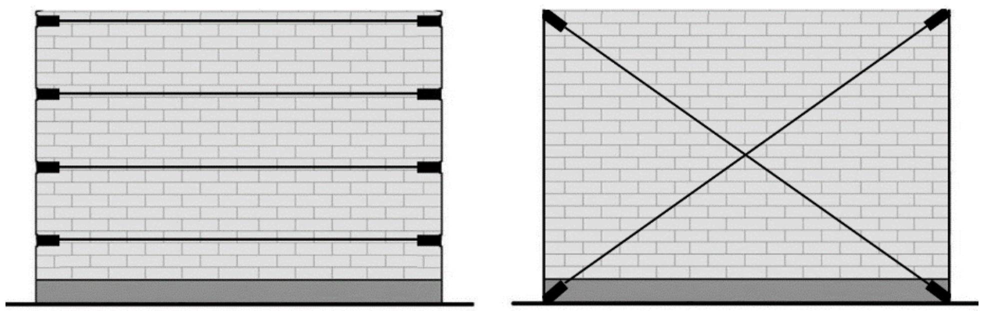

Figure 5.32- Samples of possible methods for the adobe walls external reinforcement (Designed by Author).

- Improvement the Stability of the Adobe Roofs

During an earthquake, the non-seismic resistance of adobe roofs can endanger the stability of whole structure, even if all other structural elements being well reinforced. Despite of usual causes of deteriorations in adobe structures which their remedies are common between adobe walls and roofs, such as Local Dismantling and Reconstruction, Grout injection of the cracks, Structural Repointing, Bed Joint Reinforced Repointing etc., there is some other causes of damages that their seismic improvement need to special intervention design. These causes of damages are related to the relative displacement or rotation of the supporting load-bearing walls, lack of an appropriate connection walls and roof, uneven distribution of the load over the roofs, heavy weight of roofs.

- **Jacketing with Synthetic Mesh-Bands**

The main object of this system is to increase the integrity of roof surface, to prevent partial collapse and to enhance the integrated behavior of adobe roofs against deformation caused by

[484] Feilden, S.B. (1987). Between Two Earthquakes: Cultural Property in Seismic Zones, A joint publication of ICCROM and the Getty Conservation Institute: Southern California Graphics, p. 129.

seismic motions. In this technique, the mesh bands with frequent connectors on the one or both faces of the adobe roof are fixed, and then all surface is covered with traditional surface coating. Since during an earthquake there is a high probability of failures in load bearing walls and sides' piers of adobe roofs, it is necessary that the mesh-bands also cover the mentioned sections.

- **Unloading of the Vault's Extrados Infilling and their Stiffening**

During the 2003 Bam earthquake, one of the main reasons for severity of damages on vault roofs was due to the heavy weight of infilled roofs. The removal of this soil and stiffening of vaults not only can reduce the high load pressure to vaults and its sides' piers, but also can prevent the destructive equilibrate action of infilling during an earthquake. In this process, first infillings are slightly removed and then the vaults are stiffed with some special design (e.g. arch like stiffening, honeycomb shape or any other forms) in their place. A sample of this approach can be seen during the restoration of the vaults of the Barrack of Bam Citadel.

- **Internal Reinforcement: Tying and Anchoring of Adobe Walls-Roof Internally**

The insertion of lightweight tensile reinforcement, with some degree of pre-stressing to bond elements together, gives the masonry of historic buildings greater earthquake resistance without altering the structural system (Feilden, 1987). A common seismic retrofitting measure in large masonry arches, vaults and domes is the insertion of tie rods in upper spans of piers between two arches and their anchoring on metal, wooden or plastic plates. This system increases the deformability of the roofs and reduces the possible failure at conjunction between walls and roofs. Tolles (2006), as part of the GSAP, has designed an intervention technique for the connection of adobe walls with its sides' flat walls, see Figure 5.33. In figure 5.34, two other internal reinforcement of wall-roof connection applied in Monuments of Bam Citadel are shown.

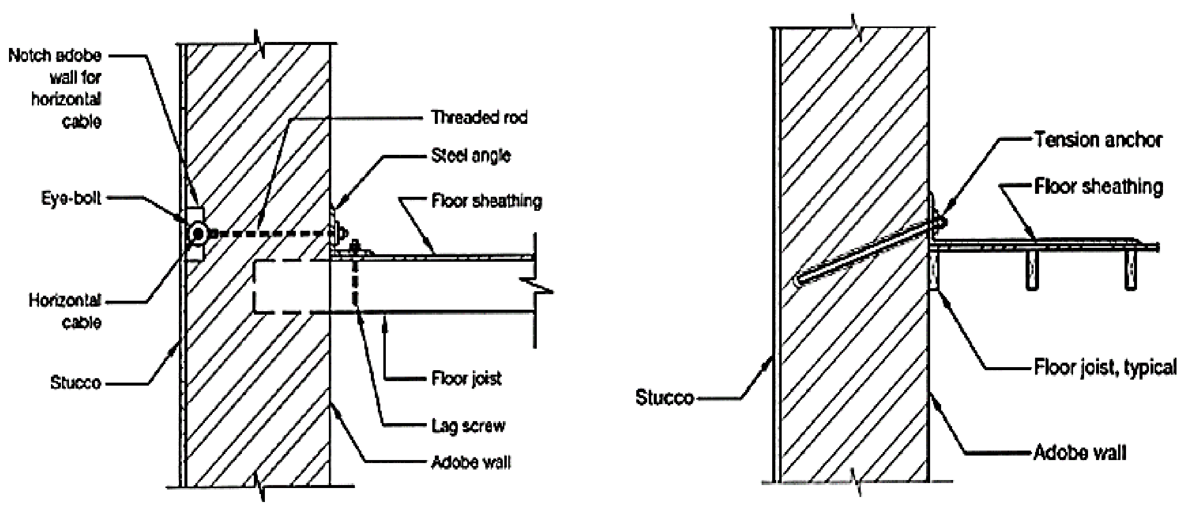

Figure 5.33- Wall-floor connection for earthen walls (Source: Tolles, 2006).

Figure 5.34- Internal reinforcement of wall-roof with tying and anchoring of tie-rods in Sistani House of Bam Citadel (Photo Rouhi, 2015).

Figure 5.35- Tying of wall-roof with use of palm fibres in Bam Citadel (Source: archive of RPBCH, 2010).

Notes: both techniques of tying and anchoring of adobe walls externally and tying and anchoring of adobe walls-roof internally have many advantages: they are effective in compensating the weakness of adobe structural elements in tension; they generally need minor alteration; they can limit the possible detachment of the adobe connections and can ensure the stability and integrity of the structural elements. Apart from these advantages, the use of these techniques can have some disadvantages that must be taken into account: if tying elements are not selected properly, they may lead to corrosion problems; they may be obtrusive and change the appearance; they are mostly irreversible techniques.

- Further Remarks

As a general overview have been cast on the main traditional and innovative techniques for seismic reinforcement of historic adobe structures, and techniques that have shown their effectiveness in shake table tests, and based on limitation existed in application of each of these techniques, it well indicates that making decision for the selection of an appropriate seismic upgrading measure is not a simple task. However, depending on the physical condition of the historic adobe structure, if the materials in retrofitting projects are durable, readily available, and compatible with the original fabric of the structure, and also if the interventions are minimally invasive and reversible, each of these techniques can be followed as the method of operation. Therefore, efforts must be made to standardize the realization and utilization of these terms across disciplines.

Practices inadmissible in literary texts and considered a falsification of the original by historians are still widely accepted in the case of visual art and even considered praiseworthy because of a widespread belief that the formal values of a work cannot be understood unless the work is complete (Gazzola, 1972). However, exclusive concern with visual qualities has led to the preservation of architectural details at the expense of the whole in some instances—a phenomenon at variance with current conservation principles and practice (Tolles et al., 2002). To avoid this repeating mistake, an intervention design should be a flexible instrument that responds to various circumstances and multidisciplinary approaches.

As elaborated and proposed in this research, the possible seismic retrofitting measures for historic adobe structures have recently been developed with aims that increase the ductile behaviour of the structure. It has to be noted that 'good' ductile performance means that large deformations and very severe damage occur, not only in the newly added materials and/or components, but also in the original materials/components to which they are structurally connected (NIKER, D3.2, 2010). During the Getty Seismic Adobe Project (GSAP), the efficiency of two fundamental design approaches for seismic retrofitting of historic adobe buildings was studied: stability-based approach and strength-based approach. As the results of investigation have shown, the stability-based approach to retrofitting historic adobe buildings can be the most effective method of providing for life safety and of limiting the amount of damage during moderate to severe earthquakes (Tolles et al., 2002). [485]

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[485] As defined by Tolles et al. (2002):
1) Strength-based design relies on improving the strength of the adobe material and wall connections and changing the overall structural configuration. This could consist of the addition of shear walls or diaphragms. It assumes the elastic behavior of the building and focuses on traditional means for delaying cracking.
2) Stability-based design is concerned with the overall performance of the building and with assuring structural stability during the post-elastic, post-yielding phase. Stability-based design features can reduce the potential for severe structural damage and collapse after yielding has occurred.

As can be seen in Figure 5.36, the aim of strength-based design is to resist the forces generated by the elastic response of the building, while the aim of stability-based design is to address the post-elastic response of the building during a design-level earthquake (allow buildings to move and crack in an earthquake, thereby dissipating energy). In my view, the exclusive determination of a design approach for intervention in historic adobe structure is not a correct solution. The reason is that the constituent materials of adobe structures are brittle, and these structures due to their age over time have sustained lots of overt and covert structural weakness, so there is no clear relationship between the level at which initial yielding occurs and the level at which the structure collapse. However, since intervention in historic structure should be based on high respect to inherent values of the structure, their seismic retrofitting cannot solely be achieved on the basis of either strength-based design or stability-based design, the approaches which solely may imperil the authenticity of the structure. Thus, the approach should be in a centrist process of those two seismic design approaches. Therefore, while contributing to redistribution of seismic loads, it improves the elastic behaviour of the adobe structures, and enhances the stability of the structure after initiation of damage. However, if the seismic retrofitting measures have not properly been designed, they can correspond to loss of authenticity of the historic structure, and even loss of any residual life after disaster, and vice versa, the properly designed intervention can upgrade the disaster resistance of existing unsafe historic monuments, or damaged monuments while being repaired. In table 15, based on the location of damages in different parts of the adobe structures with their possible causes and indicators, major possible reinforcement actions are presented.

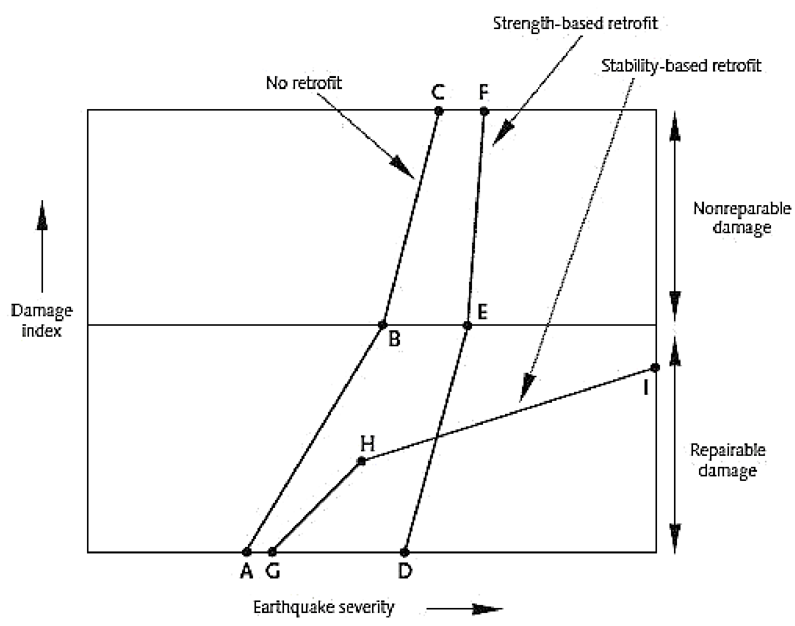

Figure 5.36- Plot of damage-progression index versus earthquake severity for unretrofitted structures (ABC) and for stability-based (GHI) and strength-based (DEF) retrofitted structures (Source: Tolles et al., 2002).

Table 5.10- Damages at different parts of historic adobe structures with possible causes, indicators and possible reinforcement actions (Designed by Author).

Location	Pre-seismic Decay		Seismic Damage		Possible Retrofitting Measures
	Damage Type	Damage Causes	Damage Type	Damage Cause	
Foundations	-Deterioration -Crushing -Settlement	-Natural and biological agents -Overloading -Changes in the water table -Inadequate design -Unsymmetrical load distribution - Poor water drainage	-Cracking (Horizontal, vertical and diagonal) -Rotation -Overturning	-Local soil condition -High earthquake's acceleration -Insufficient strength of foundation	-Repointing/Reinf. Repointing -Buttresses -Adobe bricks' substitution -Underpinning -Enlargement -Over-excavation -Re-compaction -Greater footing width or depth
Mortar Joints	-Deterioration -Sanding -Loss in adhesion -Push out	-Natural and biological agents -Inappropriate quality -Inappropriate thickness	-Separation in connections between bricks and mortar joints	-High dynamic load applied to mortar joints	-Structural repointing -Bed-joint reinforced repointing -Horizontal reinforcement with meshes
Walls' Intersection	-Small or large cracking at corners -Deterioration	-Settlement -Natural agents (water penetration) -Overloading	-Separation or dislocations	-Flexure and tension due to out-of-plane movements -Inappropriate connection	-Buttresses and pilasters -Ring beam -Jacketing with Mesh-bands -External reinforcement
Wall-Section	-Separation of leaves -Exfoliation -Swelling -Loosening of infill -Efflorescence -Partial collapse -Generic cracking	-Natural and biological agents (e.g. water penetration, presence of vegetation, animals) -Overloading -Poor water drainage	-Large cracking* -Partial collapse of external leaf -Total collapse -Damage to infill walls, cavities or structural gaps	-The concentration of loads -Lack of enough deformability -Eccentric loading -Lacked of internal reinforcement	-Jacketing with Mesh-bands -Repointing and reinforced repointing -External reinforcement -Needling and anchoring -Grouting injection -Stitching of cracks -Renovation of surface coating
Columns and Piers	-Small cracking -Deterioration at base -Bulging -Tilting	-Overloading -Differential settlement -Natural and biological agents	-Rotation -Displacement -Crushing -Large cracking at base -Detachment from sides walls	-Change in load transfer mechanism -Eccentric loading -Inadequate connection	-Buttresses and pilasters -Repointing/Reinf. Repointing -Enlargement -Confinement -Adobe bricks' substitution -Jacketing with Mesh-bands -Horizontal reinforcement with meshes -Vertical reinforcement with rods

Wall- Plane	-Small cracking* -Leaning -Partial collapse -Settlement -Displacement	-Overloading -Natural and biological agents -Differential settlement	-Overturning -Partial or total collapse -Large cracking* and detachment	-Change in load transfer mechanism -lack of enough deformability -Eccentric loading -Lacked of internal reinforcement	-Grouting injection -Needling and anchoring -Buttresses -External reinforcement -Stitching of cracks -Substitution -Jacketing with Mesh-bands -Horizontal reinforcement with meshes -Vertical reinforcement with rods -Repointing/Reinf. Repointing -Adobe bricks' substitution -Enlargement -Ring beam
Opening	-Deterioration -Small cracking	-Natural agents (water penetration) -Overloading	-Cracking at corners -Partial detachment	-Concentration of seismic loads at corners -Large openings	-Reduction of the size of openings -Jacketing with double Mesh-bands at corners
Roof system (arches, vaults, domes)	-Deterioration -Small cracking at spandrels -Distortion of shape -Partial collapse	-Natural and biological agents -Overloading -Differential settlement	-Large cracking at spandrels -Partial or total collapse -Detachment	-Inadequate lateral support -Inadequate connection -Change in load transfer mechanism -Equilibrate action of infilling	-Unloading of the vaults' extrados infilling and their stiffening -Ring beam -Internal and External tying -Buttresses -Adobe bricks' substitution -Jacketing with Mesh-bands
Towers	-Separation of leaves -Exfoliation -Swelling -Loosening of infill -Efflorescence -Partial collapse -Generic cracking -Crushing -Leaning	-Natural and biological agents (e.g. water penetration, presence of vegetation, animals) -Overloading -Differential settlement	-Large cracking at base -Mid-high damage -Partial or total collapse -Out-of-plane flexural damage -Upper portion collapse	-Long height -Inadequate lateral support -Lacked of internal reinforcement	-Grouting injection -Confinement -Needling and anchoring -External reinforcement -Jacketing with Mesh-bands -Horizontal reinforcement with meshes -Vertical reinforcement with rods -Strenghtening of supports

Note: * horizontal, vertical or diagonal cracks

5.4 Synthesis Notes and Conclusions

Considering the wide themes developed in this thesis, there is the need to draft some synthetic notes about the state of adobe's preservation in Iran, and particularly about the future of Bam and its cultural landscape. These synthetic notes within a theoretical and technological point of view can summarize the results of the work in an organic framework, and can explain the main problematic key issues to reduce seismic risks in historic adobe architectural heritage in Bam, and those that are scattered throughout Iranian territory.

It is indispensable to spend many words to underline the importance of the preservation of the adobe cultural heritage all over the world, where based on their specific weather condition and limit access to construction materials, this type of construction technique with special architectural typologies from ancient time have had been recognized as the dominant pattern. In the meantime, Iran owns without any doubt the most important and best-architected quantity of adobe monuments in the world; the few remained historic adobe structures in around historically important Iranian cities well-represent a tangible imagination of their common cultural and historical identities. However, the preservation of this heritage is not only a solemn duty, but it is an extraordinary opportunity. In this way, the monumental conservation and restoration of the country's cultural heritage, mostly built with adobe materials, needs a deep knowledge of their real constitution, and also needs to understand the significance of their conservation.

In Iran, adobe architectural heritage is rich and complex. As a ubiquitous form of construction, adobe architecture appears in many constructions, from monuments until dwellings in historic fabric of cities. In this sense, from ancient times, adobe materials have extensively been used for the construction of mansions, urban houses, citadels, fortifications, defensive walls, towers, etc. They were also widely used in religious buildings, like fire temples and mosques. However, several of these types of monuments are included in the UNESCO World Heritage list such as Tchogha Zanbil (1275-1240 BC), Takht-e Soleyman (3rd to 7th centuries), Shahr-i Sokhta (founded around 3200 BC) and Bam Citadel (6th to 4th centuries BC). In addition to those mentioned international cultural heritage, Iranian Cultural Heritage Organization (ICHO) protects hundreds of adobe monuments throughout the country, especially in provinces located in the central part of Iran, such as Kerman, Esfahan, Fars, Semnan, etc. As a worrisome situation, since Iran is a seismic hazard prone country in the world, most of its historically or culturally adobe monuments are located in active seismic zones, which can threaten their existence. Therefore, it is significantly important to provide additional structural reinforcement to prevent sudden collapse of these valuable types of structures during an earthquake. Every historic adobe building in Iran is one of the steadily detracting number of country's cultural heritage that are significantly vulnerable to urban development and natural hazards. Most often, these two main factors are cited as being responsible for the demolition of the remaining historic adobe structures. Therefore, the protection of the country's few remaining historic adobe structures from the aforementioned causes of destruction is imperatively essential. In the following section, the basic problems of cultural heritage preservation in Iran are discussed, problems that need more attention.

Generally, the Iranian cultural heritage can be categorized into three categories: identified-registered, identified-non-registered and non-identified. Here, due to lack of sufficient attention from the institutions in charge of cultural heritage, which are responsible for identification, registration and preservation of the country's historic monuments and sites, the identified-non-registered and non-identified sites lie in a similar situation, thus they are threatened by many negative factors. This problem is even true about registered national monuments, which is related to the protection of the border of the monuments; in many cases, designation of this border is under the responsibility of the local authorities. However, it is solely a challenging task to convince local government to protect not only a particular monument but also its environment or landscape which is actually threatened by new urban development. In most of these cases, the new urban development undermines most of a city's plans; the officials have certainly neglected the character of city's valuable monuments and the importance of their preservation. Moreover, rapid urban growth and the rise in Real Estate values have resulted in the condemnation of historic monuments and sites, which are not determined to be valuable enough to benefit the protection from the state support, so the historic texture of ancient cities first fall into ruins and soon after disappear altogether. In such cases, unfortunately, the identified-non-registered and non-identified national heritage are being trespassed. In fact, the reason for this negligence in Iran is that the identification and the inventory of historic sites as a national heritage would take many years. Furthermore, the problem is that any effort regarding historic monuments and sites is based on the assumption that they have been identified, or, in other words, the identification and registration merge as the first essential step for all subsequent measures eventually taken upon them. In this regard, any action related to dictation of duties to the involved organs, new instructions and recommendations for the registration and preservation of this type of cultural heritage is desperately essential.

During the recent decades, some Iranian adobe monuments, due to their great importance, have been subjected to conservation works, while over time, the smaller ones have suffered a gradual decline because of lack of sufficient attention. In Iran, there are many adobe architectural heritage that because of lack of adequate attention are simply abandoned, both those that during centuries have faced reparable damages and those that have suffered considerable structural damages. In addition, due to inadequate scientific intervention, there is a large number of examples, which indicate the extent of the irreplaceable destruction of heritage by natural disasters. Actually, these threats continue largely unabated today. Based on surveys conducted about the causes of damages induced on adobe monuments of Bam city, most of these structures have not sufficiently been reinforced to withstand seismic events. Although nowadays the technologies to rehabilitate historic buildings are rapidly developing in Iran, in this context, a critical re-evaluation of traditional techniques is developing, especially concerning the restoration of monuments, but the loss of certain technical expertise is rarely compensated by up-to-date know-how. Due to lack of artistic training and architectural education, and because of the permanently deficient situation of modern investigation and intervention methods, the operations are not adequate to satisfy the demands of restoration projects; however, the country's historic monuments are later subjected to profound alterations and much criticism. Therefore, the necessities for establishment of Adobe Research Center in Iran can properly associate in development of scientific intervention.[486] However, as the main task, these national heritage should be seismically retrofitted fairly recently, although they have been well maintained. On the other hand, although a significant set of Iranian heritage are threatened by earthquakes, scientific research on those conservation is at its infancy. This is mostly due to practitioners' lack of knowledge of the material and of proper scientific diagnosis. As a result, current interventions, on occasions, are being inappropriate. Until the late 20th century, in Iran, less structural retrofitting was preferred during conservation and restoration works, more archaeologically based upon the monument's remaining vestiges, with the aim of ameliorating the monuments "original feature", but not its exact pristine form; so more re-surfacing and re-appealing forms of restoration works came closer to eclecticism. Indeed, not all restoration projects followed this principle, but as a model, this principal of operation was widely adopted and admired for the most of the projects. In Bam city, as example of this approach can be seen in Ameri house, severely damaged by the 2003 Bam earthquake, which based on the author's personal interview with Miss. Jafarizadeh, the head of Ameri House's restoration project before earthquake, during restoration works not only there was no seismic retrofitting considerations, but also a lot of manipulation has taken place in architecture.

Today in Iran, the traditional technique of adobe-mud brick construction technique is mostly forgotten due to restrictions on their use. Here, this type of construction technique pertaining to damages induced upon historic adobe buildings in past Iranian earthquakes is prohibited. In fact, this approach devalues the culture of adobe construction technique so far that the traditional building style is being disappeared in some historic cities of Iran. As said before, Iran is recognized as a country with a great number of adobe structures in the world, and adobe architecture constitutes an important part of cities' historic urban landscape. In the meantime, although adobe construction technique is a part of Iranian traditional architectural style which has a history of over 8000 years, now the culture of the country that produced the architecture

[486] In this way, during ninth International Conference on the Study and Conservation of Earthen Architecture (Terra 2003), Yazd, Iran, the proposal of establishing an international research center for adobe structures in Iran was welcomed by High-ranking officials from ICCROM and ICOMOS. Even, in this process, the historical airport of Maybod in Yazd Province has been suggested as the center for Adobe International Research Institute, but until now, any definitive answer is not given yet. Generally, if this matter becomes the reality, the establishment of this center would provide an opportunity to reengineer and strengthen of Iranian adobe structures according to international criteria.

is not active in the field of contemporary adobe production, and contemporary building technology bears little relation to the traditional styles of construction. Therefore, the promotion of this construction technique must be considered as a high priority. In Iran not only BHRC, which complies the country's seismic regulation, but also ICHO, which protects the country's cultural heritage, have not tried to provide any acceptable retrofit approaches for treating materials and structural systems that would have been considered either archaic or nonconforming under modern building regulations. As a reality that the traditional adobe-making and building methods are still prevailing in remote rural areas of Iran, no program has even been organized for the identification of the traditional seismic retrofitting measures and their training to local people. We hope that one day it would be as a priority for the country's authorities. It is therefore fundamental to upgrade the image of adobe vernacular architecture among local populations as meaningful testimonies of the local cultural heritage to ensure the transmission of adequate traditional skills. However, it is would be necessary to develop and to define a national code for each Iranian architectural typologies, dedicated to specific climate, especially historic adobe structures 'National Code of Practice for Adobe Architectural Heritage'. National building codes, norms, or standards, which if well legitimize traditional and innovative construction materials and methods, and intervention methods for historic adobe structures, and if well conceived and rigorously enforced can result in re-development of adobe construction technique, and mitigation of the risk of losing lives and properties, which today have reached to an unacceptable level.[487]

The 26 December 2003 Bam earthquake, within Historic urban landscape of Bam city destroyed the physical character of the city's historically or culturally important adobe structures, and damaged the authenticity of Bam Citadel as the largest extend adobe assemblage in the world. One of the key issues that significantly must be taken into account during seismic retrofitting projects of historic adobe structures is the interpretation of the issue of authenticity that belongs to the specified site.[488] This aspect involves the traditional construction and conservation techniques, which is different from culture to culture and site to site that make the monuments unique and meaningful. This basic principle should be preserved because it represents the cultural identity related to ideas, attitudes, rituals, and religious cults of a specific location and setting. Based on what was followed during the recovery projects of Bam Citadel after the earthquake, the technical restoration works led to changes in the final aspect of the monuments; due to severity of the earthquake, most of the monuments were re-erected again. Nevertheless, here two fundamental questions arise: the first is "whether the vast bulk of reconstruction

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[487] To develop earthen building codes in different countries, during the Proceedings of the GSAP 2006 Colloquium, the colloquium participants suggested some main points that should be followed, APPENDIX 2.

[488] Without authentication of the values of historic adobe structures, values that are originated from thousand years of culture, history and tradition of people that lived in a specific region (the values that motivated us to perform intervention works), any unconscious intervention measure may threat the authenticity of the historic structure.

carried out in Bam Citadel can be recognized as a falsification of the original fabric that can compromise the authenticity of the Citadel".

I will answer to this question with raising another question: "if this catastrophic event happened in ancient time, what might Bam's predecessors have did?" As already have been discussed in previous sections of this thesis, the adobe structures, due to their high potential of deterioration, need cyclical maintenance activities, which alter considerably from time to time the surface of the structures, forms and colours through continuous modification. This endless re-rendering of the adobe's façade can lead to an assumption that the authenticity of the original fabric of the adobe monuments is not preserved. Instead, if we look at this issue in a different way, the authenticity of the architectural forms, construction techniques and materials applied in an adobe monument during the years actually fulfils the requirements of the authenticity test. This means that the key issue in preservation of the authenticity of historic adobe structures is related to the safeguarding of the continuity of the culture of traditional conservation technologies, which have kept the monument stable during its lifetime. In the case of Bam Citadel, although the monuments are being restored and reconstructed with some advanced seismic retrofitting measures, the reconstruction techniques used, and even the production of adobe bricks are being followed in traditional ways. In fact, if unlike the mentioned pattern such non-compatible materials like concrete blocks, which has any congruousness with original fabrics of historic adobe structures, and hiding them under traditional surface coating could be identified as falsification of the origin. In addition, it would be worth mention that as the interesting operation method that have been followed during the reconstruction of the monuments of Bam Citadel, within adobe frames the foreign materials applied during seismic retrofitting measures are to be distinguishable from the original fabrics as much as possible; this pattern exactly satisfied the Article 12 and 13 of Venice Charter (1964) about distinguishability of new materials added, so the restoration dose not falsify the artistic or historic values of the monuments. To explain more about the current procedure adopted, in any reconstructed part of Bam Citadel, along walls and roofs there are some uncovered frame that exactly shown the model of operation and new materials applied.

The second question is "to propose an ideal intervention plan for such cases like Bam Citadel in Iran, which model of intervention with high respect to the authenticity would be acceptable?" About adobe structures, it is a fact that the traditional strengthening technique are not solely effective, so the innovative techniques must be considered, either on their own way (e.g. Sistani House) or in combination with traditional techniques (e.g. Payambar Mosque). Over-emphasis on traditional technique at least will result in the same seismic destruction in Bam Citadel in the future. However, any seismic retrofitting measures based on the level of damages must be carefully evaluated from the view of reversibility, compatibility, complexity, local availability, effectiveness, cost-efficiency, etc. However, the rescue project of Bam Citadel well demonstrated that depending on the level of damage, physical condition of monument, and available techniques and materials, the approaches in different monuments could be different from one to another. Unlike the stable historic adobe structures, for which the options for seismic improvement are limited, in reconstruction project of Bam Citadel, every option that could fulfill the international recommendations can be taken into consideration. It should also be mentioned that any seismic retrofitting method in historic adobe structures must be aligned with not only the culture of the specific society but also the technological capabilities with which they possess. In fact, with consideration of these principles, the authenticity of historic adobe structures will be damaged at the very least level.

Bam and its cultural landscape, and especially Bam Citadel as a symbol of the culture, tradition and history of the city, represents and conjures a sense of cultural identity and continuity within the community, thus this representation makes it logical to consider a systematic disaster precaution for the city's cultural heritage landscape. In this program, each step is beneficial as it wins cost and time saving. In the case of Bam Citadel, due to the large extent of the project (there are few monuments with a low level of damages), from monuments to monuments, the most important step along with progression of the restoration works is to establish a maintenance strategy for those restored ones, which now is almost forgotten. Over the years after the earthquake, due to this ignorance, the expansion of deterioration agents can be seen in different restored monuments. Meanwhile, the non-restored monuments also due to lack of initial protective measures are significantly declining (e.g. Caravanserai, West Sabat House, Commander House, etc.). These protective measures can decrease the speed of adobe's erosion and deterioration that have a main role in the stability of the monuments, and possible future reinventing.

In all civilizations, cultural heritage have a very important role in fostering the quality of life due to their historic message that have been transmitted through cultural materials from the past to the present and the future. In Bam City, this issue is mixed with an extraordinary landscape that has been shaped during thousands of years through traditional irrigation system of qanats. Therefore, the protection of this unique cultural landscape in the edge of Iranian desert is of utmost importance. Although the Bam earthquake caused many losses of lives and properties, like most earthquakes, this earthquake has presented a ray of opportunities for the further development of city's exceptional cultural heritage, greater attention to city's unique palm grooves and renovation of the old irrigation systems. In the case of Bam's post-earthquake urban reconstruction, authorities based on huge bulk of urban seismic destruction have encountered many challenges in terms of the differences between designing a new city and reconstructing the existing one, as well as issues and criteria related to urban design. Although during the years following the earthquake, much effort has been made to preserve the city's cultural landscape, there are some deficiencies in legal and administrative matters, which need more supervision and management. Moreover, it should be taken into consideration that during future urban development of the city, the city's authenticity and integrity that is determined by various factors must not be compromised; consequently, any changes should simultaneously respect the inherited townscape and its landscape setting on the other. In Bam city, in terms of historic urban landscape, there are three important issues, which need more considerations:

1) Bam’s qanats: the cultural landscape of Bam has reflected the intimate relationship between the development of a desert city and the access to underground water resources. It should be noted that the diminishing of water table in the region would be the biggest threat, without which settling life would be impossible. Over the few decades, it has dramatically been demonstrated that various technical solutions such as pumps, dams and modern water management are unsustainable and with severe effects for the sustainability and life of qanats (Jomehpour, 2009). The failure or lack of attention to the qanats could have led to the death of the city of Bam at any time during the past 2500 years (Sabri et al., 2006). As an example, by the 2003 earthquake, when qanats were destroyed, villagers became poor, and moved to live inside the city, so many local people have left Bam and are not willing to come back (Fallahi, 2008).

2) Bam’s cultural landscape: the big problem in such cities like Bam is the destruction of its green tissues, so besides damage induced by earthquake to the agricultural lands of the city of Bam, urban development in recent years has also had a negative impact on reduction of green area of the city. In this case, land use changes were without considering the land capacities and the new road systems were uncoordinated with the garden systems (Behbahani & Shirgir, 2009). During these years, there have been some changes in the width and number of streets. On the other hand, despite the fact that palm groves constitute as a part of the Bam’s World Cultural Landscape, unfortunately due to the population growth of Bam city after the earthquake, and the entry of aliens has created a shortage in housing. Hence, in order to alter the land from agricultural to residential use, some landowners have tried to dry up or burn the city’s precious palm dates and bushes. This has been undertaken because of the financial gain from the differences that existed between the agricultural and residential land usage. However, the control of the population growth in Bam city can play an important role in retaining the city’s urban landscape. Therefore, this issue should be at the centre of any preservation program and management strategy of the city’s future policy.

3) Bam’s traditional architecture: although before the earthquake the majority of buildings in the city of Bam could be described as adobe structures with impressive architecture, after the earthquake, most of the buildings in the city have been newly built by the use of engineering principles, new systems and materials, which in terms of form and design have no homogeneousness with the city’s past architectural origins. However, in the recent reconstruction of the city, the new buildings regardless to the spatial organization of Bam’s historic urban landscape have partially deteriorated its visual qualities and values. The reality is that the architecture of new buildings do not have any particular feature. In fact, Bam now with this leading procedure is losing its identity as a desert city of Iran. In spite of the fact that

traditional architectures in the reconstruction process of the city have not mostly been employed, there are relatively scattered buildings in the city that in terms of architectural design have some origin of the past architectural pattern.

At the end, as the Faro Convention states on the value of the cultural heritage for society, in order to make full use of its potential as a factor of in sustainable economic development, any conservation policy should “respect the integrity of the cultural heritage without compromising its inherent values” (art. 10, comma c). This means that it is necessary an interdisciplinary program which could cope with social economic development of the Iranian site. Any intervention should be in integration with consideration of intangible values and based on processes of their identification and interpretation by the local community (Aveta, 2004). Beyond the detection of the more correct technical choices to reconstruct the landscape image of the Arg-e Bam it must understand how it is possible to assess the present authentic values (Marino, 2004) of the Iranian cultural landscape and economic/touristic development.

ABBREVIATION

BHRC	Building & Housing Research Center
CHN	Cultural Heritage News Agency
CRAterre	the Center for the Research and Application of Earth Architecture
EERI	Earthquake Engineering Research Institute
EMAP	East Midland Allied Press
EMS	European macroseismic scale
ENSAG	National Superior School of Architecture in Grenoble
EVCAU	Espace Virtuel de Conception Architecturale et Urbaine
GITS	Global Information and Telecommunication Studies
GSI	Geological Survey of Iran
HCAC	Higher Council for Arts and Culture
HFIR	Housing Foundation of Islamic Revolution
ICCROM	International Centre for the Study of the Preservation and Restoration of Cultural Property
ICG	International Center for Geohazards
ICHHTO	Iranian Cultural Heritage, Handicraft and Tourist Organization
ICHODC	Iranian Cultural Heritage Document Center
ICHO	Iranian Cultural Heritage Organization
ICOMOS	International Council on Monuments and Sites
IFLA	International Federation of Landscape Architects
IFRC	International Federation of Red Cross and Red Crescent Societies
IIEES	International Institute of Earthquake Engineering and Seismology
IMIBI	Interior Ministry Information Base of Iran
ISC	Iranian Static Census
ISCARSAH-ICOMOS	The International Scientific Committee on the Analysis and Restoration of Structures of Architectural Heritage
IsMEO	Istituto italiano per il Medio ed Estremo Oriente
ISNA	Iranian Students' News Agency
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
NDRI	Natural Disasters Risk Index
NGO	Non-governmental organization
NII	National Institute of Informatics
NIKER	**N**ew **I**ntegrated **K**nowledge based approaches to the protection of cultural heritage from **E**arthquake –induced **R**isk
OUV	Outstanding Universal Value
PGA	Peak Ground Acceleration
RPBCH	Recovery Project of Bam Cultural Heritage
SCINM	Society for the Conservation of Iranian National Monuments
SES	Soil Engineering Services Consulting Engineer
SOC	State of conservation Information System
TDMMC	Tehran Disaster Mitigation and Management Center
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey
WFP	United Nations World Food Programme
WHC	World Heritage Committee
WHL	World Heritage List
WHLD	World Heritage List in Danger
WHO	World Health Organization

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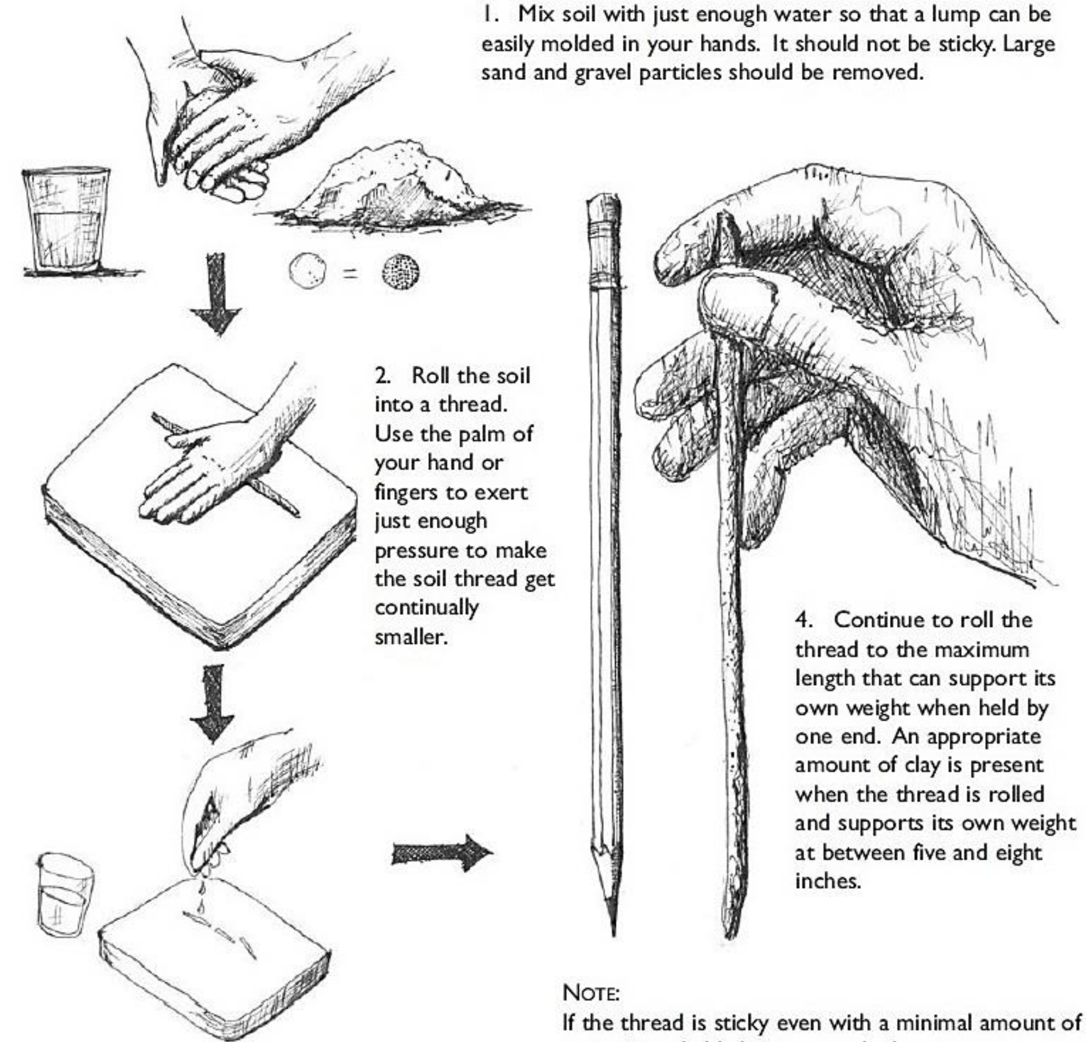
APPENDIX. I

Adhesion/Cohesion testing of adobe soil

Source: Contreras, 2006



1. Mix soil with just enough water so that a lump can be easily molded in your hands. It should not be sticky. Large sand and gravel particles should be removed.

2. Roll the soil into a thread. Use the palm of your hand or fingers to exert just enough pressure to make the soil thread get continually smaller.

3. If the thread breaks before you roll it out to a 1/4-inch diameter, (the size of a pencil), it is too dry and you need to add more water.

4. Continue to roll the thread to the maximum length that can support its own weight when held by one end. An appropriate amount of clay is present when the thread is rolled and supports its own weight at between five and eight inches.

NOTE:

If the thread is sticky even with a minimal amount of water, it probably has too much clay content.

If the thread cannot be rolled to a diameter of 1/4 inch when more water is added, it has little or no clay.

If the 1/4-inch thread can be rolled to a length exceeding eight inches that still supports its own weight, it probably has too much clay.

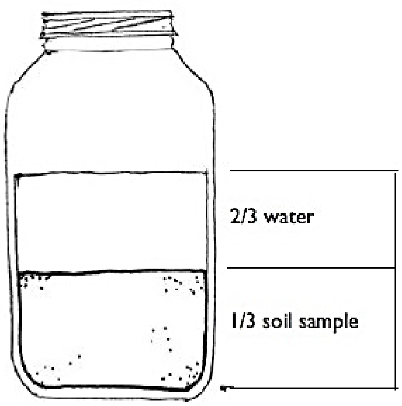
This test is dependent on the sand size as well. If the sand is predominantly coarse, then a thicker and shorter thread will result with the same amount of clay.

APPENDIX. I
Granularity testing of adobe soil
Source: Contreras, 2006

"Shake Jar" testing is used to test the composition of soils or to determine the percentage by volume of silts, clays and sands in the soil.

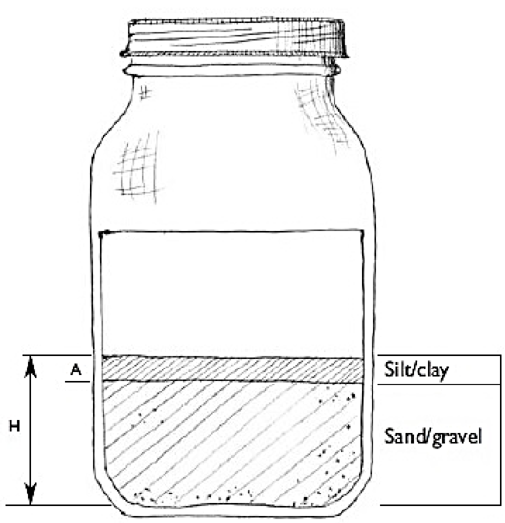
1. Fill the bottom third of a clear glass jar with the soil to be tested. Remove any particles that are larger than 1/4-inch in diameter. Then fill the jar two-thirds with water.

2. Shake jar thoroughly.



3. Allow contents to settle for one hour.

4. Shake again. Allow contents to settle for at least eight hours.



5. Observe the soil suspension in the glass jar. The largest particles or sands will settle to the bottom of the jar and the smallest particles, the clays and silts, will rest on top. A fairly distinct line between the particles will exist. Below the line, the individual sand particles can be seen with the naked eye. Above the line the clay and silt appear as a solid line.

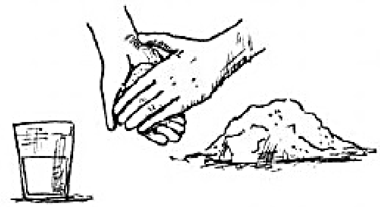
When possible, clay should be calculated separately from silt.

The percentage of silt and clay can be calculated by measuring (A) and (H) and using the following equation: (A) ÷ (H) x 100% = (%)

20% clay to 80% silt and sand is recommended for a successful adobe mud. In some cases, however, more or less than 20% clay content has made a workable mud for adobe. Appropriate clay content will vary due to location and building method.

APPENDIX. I
Plasticity testing of adobe soil
Source: Contreras, 2006

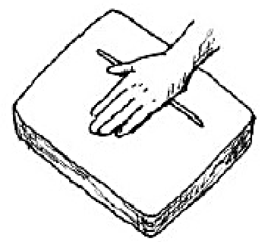
Testing for plasticity helps attain successful adhesion and cohesion properties for adobes and for mud plaster

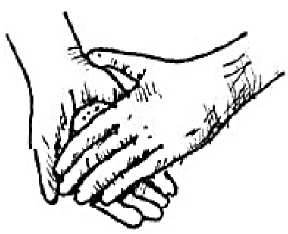


FINGER SQUEEZE TEST

1. Work a sample of soil into a lump.

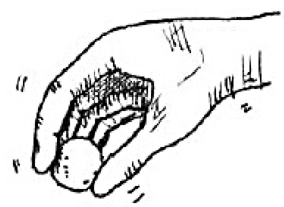
2. Roll the lump until the thread formed crumbles at 1/4-inch diameter or the size of a pencil. The thread will crumble because it dries as you keep rolling it.



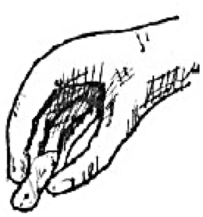


3. When the thread crumbles and breaks. mold the sample into a ball.

4. Apply pressure by squeezing the ball between your thumb and finger.



5. If the ball cracks and easily crumbles, it probably contains too much sand.



6. If the molded ball can be deformed only with a lot of effort and does not crack or crumble, the soil has enough clay to be malleable and plastic.

NOTE:
Some silts can give the impression of plasticity due to their fine texture.

APPENDIX. II

The result of laboratory tests executed at the CRAterre Centre for adobe strenghtening
Source: Archive of RPBCH, Bam, Iran

LABORATORY RESULTS ADOBE		Compressive strength	Tensile strength	Water erosion	Water absorption	Abrasion resistance	Linear shrinkage	Density
Code	Compound	kg/cm2	kg/cm2	%	%	g/cm2	%	
	N	34,7						1,87
a	N+2.5%L			8,8			4	1,6
b	N+20%C			4,6	3,2		5,3	1,6
c	N+5%G						5,2	1,6
d	N+2.5%ST						3	1,6
A1	N+10%B		25,3				5,8	1,8
A2	N+30%B			8			6,6	1,7
A3	N+50%B		13,8			5,3	3,2	1,7
A4	N+10%BB	45,5	19		2,6		6,8	1,8
A5	N+30%BB		16,6			5,7	5,3	1,7
A6	N+50%BB	34,7	18,5	6,8			4	1,7
A7	N+10%BBB		14,6	4,7			6,2	1,7
B1	N+10%S		19,4				6	1,8
B2	N+20%S						5,7	1,8
B3	N+30%S	44,7		5,9			5,7	1,8
B4	N+40%S	38,4					5	1,8
B5	N+50%S						4,3	1,8
C1	N+10%S+3%ST			3,9			1,8	1,6
C2	N+20%S+3%ST			1,3	3,8	10,1	3,2	1,6
C3	N+30%S+3%ST			4,9	3,6		2,3	1,6
C4	N+40%S+3%ST			0,9			2,3	1,6
D1	N+10%SS		14.4	9.6		4.8	5.7	1.6
D2	N+20%SS	37,6	13,3	6,6		5,3	5,5	1,8
D3	N+30%SS	42,7	12,4	9,4	3,7	4,9	5	1,8
D4	N+40%SS				3		7	1,8
D5	N+50%SS				0,9		4,2	1,8
E1	N+10%SS+1.5%ST							
E2	N+20%SS+1.5%ST				3,9	7,8	5,3	1,6
E3	N+30%SS+1.5%ST			3,2	2,9		4,3	1,6
E4	N+40%SS+1.5%ST	34,7	14	6,4	2,7	7,7	2,3	1,7
E5	N+20%SS+1%ST			5,4	2,4	9,9	5,2	1,6
E6	N+30%SS+1%ST			7,7	1,2	6,3	4	1,7
E7	N+40%SS+1%ST			8,6	1,1	9,7	3,5	1,6
E8	N+20%SS+0.5%ST			6,2	2,9	12,1	4,8	1,6
E9	N+30%SS+0.5%ST			5,3	1,6	8,1	5,3	1,7
E10	N+40%SS+0.5%ST			7,25	3,3			1,6
F1	N+30%P	36,9	18,3	3,7		23	5,8	1,8
F2	N+30%SS+25%P	40,1	16,3	13,7	2,2	6,2	4	1,7
F3	N+30%SS+50%P	30,8	13,7	13,2	3,1		2,5	1,6
F4	N+30%SS+60%P	29,2	8,5	10,4	2,7	8,4	2,7	1,5
G	N+30%SS+10%BB							

N=Nezam Abad soil, S=sieve #40 sand, SS=quicksand, B=brick powder, BB=sieve #5 brick powder, BBB=sieve #10 brick powder G=gypsum powder, C=crushed ceramics, P=palm fibres, ST=straw, L=light weight aggregates

APPENDIX. III

Preliminary location of the aftershocks

Source: Website of International Institute of Earthquake Engineering and Seismology (IIEES)

DATE	TIME	LAT-N	LONG-E	DEPTH	mb	Ms	ML	REGION
2003/12/26	01:56:56.1	29.08	58.38	13.2		6.5		BAM
2003/12/26	02:34:20.3	28.98	58.33	15.0			3.8	BAM
2003/12/26	03:06:16.0	28.91	58.32	15.0		5.1		BAM
2003/12/26	03:21:08.7	28.40	58.47	15.0			3.9	BAM
2003/12/26	03:31:21.6	28.36	58.36	15.0			3.4	BAM
2003/12/26	03:37:37.8	28.91	58.19	15.0			3.6	BAM
2003/12/26	03:53:29.7	28.90	58.42	15.0		4.6		BAM
2003/12/26	04:25:51.7	29.03	58.27	15.0			3.6	BAM
2003/12/26	04:51:44.5	28.90	58.37	15.0			3.7	BAM
2003/12/26	09:16:41.6	29.03	58.23	15.0			3.8	BAM
2003/12/26	09:22:29.0	29.00	58.22	15.0			2.8	BAM
2003/12/26	09:25:39.0	29.01	58.28	15.0			3.0	BAM
2003/12/26	09:37:28.4	28.97	58.24	15.0			2.7	BAM
2003/12/26	09:42:48.5	28.84	58.11	15.0			3.2	BAM
2003/12/26	10:00:03.8	28.97	58.17	15.0			3.6	BAM
2003/12/26	14:08:17.0	28.56	58.32	12.0		4.0		BAM
2003/12/27	04:45:47.6	28.65	58.34	15.0			3.5	BAM
2003/12/27	05:42:09.6	28.85	58.27	15.0			3.7	BAM
2003/12/27	06:26:35.1	28.94	58.31	15.0			2.8	BAM
2003/12/27	08:03:16.0	28.65	58.22	15.0			3.2	BAM
2003/12/27	08:10:31.2	29.38	58.03	15.0			2.9	BAM
2003/12/27	09:10:19.8	28.39	58.49	15.0			3.0	BAM
2003/12/27	10:48:36.4	28.50	58.37	15.0			2.7	BAM
2003/12/27	14:10:55.2	29.05	58.10	15.0			2.6	BAM
2003/12/27	15:13:31.1	29.32	58.08	15.0			2.7	BAM
2003/12/28	08:51:58.9	29.09	58.19	15.0			2.5	BAM
2003/12/28	09:25:27.7	28.81	58.38	15.0			3.6	BAM
2003/12/28	10:15:31.5	28.96	58.41	15.0			2.5	BAM
2003/12/28	11:52:25.6	28.84	58.40	15.0			2.5	BAM
2003/12/28	19:00:35.0	28.98	58.37	15.0			2.4	BAM
2003/12/28	19:34:11.6	29.19	58.35	15.0			2.3	BAM
2003/12/28	20:44:03.0	28.21	58.52	15.0			2.4	BAM
2003/12/28	20:53:11.3	28.34	58.37	15.0			2.4	BAM
2033/12/28	23:18:22.0	29.31	58.32	15.0			2.6	BAM
2003/12/29	04:20:33.7	29.21	58.12	15.0			2.4	BAM
2003/12/29	06:45:49.9	28.61	58.61	15.0			2.8	BAM
2003/12/29	07:01:22.7	28.83	58.45	15.0			3.1	BAM
2003/12/29	09:32:51.0	29.37	58.13	15.0			2.6	BAM
2003/12/28	14:56:38.6	28.47	58.48	15.0			3.5	BAM
2003/12/29	13:02:05.2	29.21	58.36	15.0			2.7	BAM
2003/12/29	13:33:51.2	28.80	58.26	15.0			2.4	BAM
2003/12/29	13:49:11.5	29.03	58.23	15.0			2.3	BAM

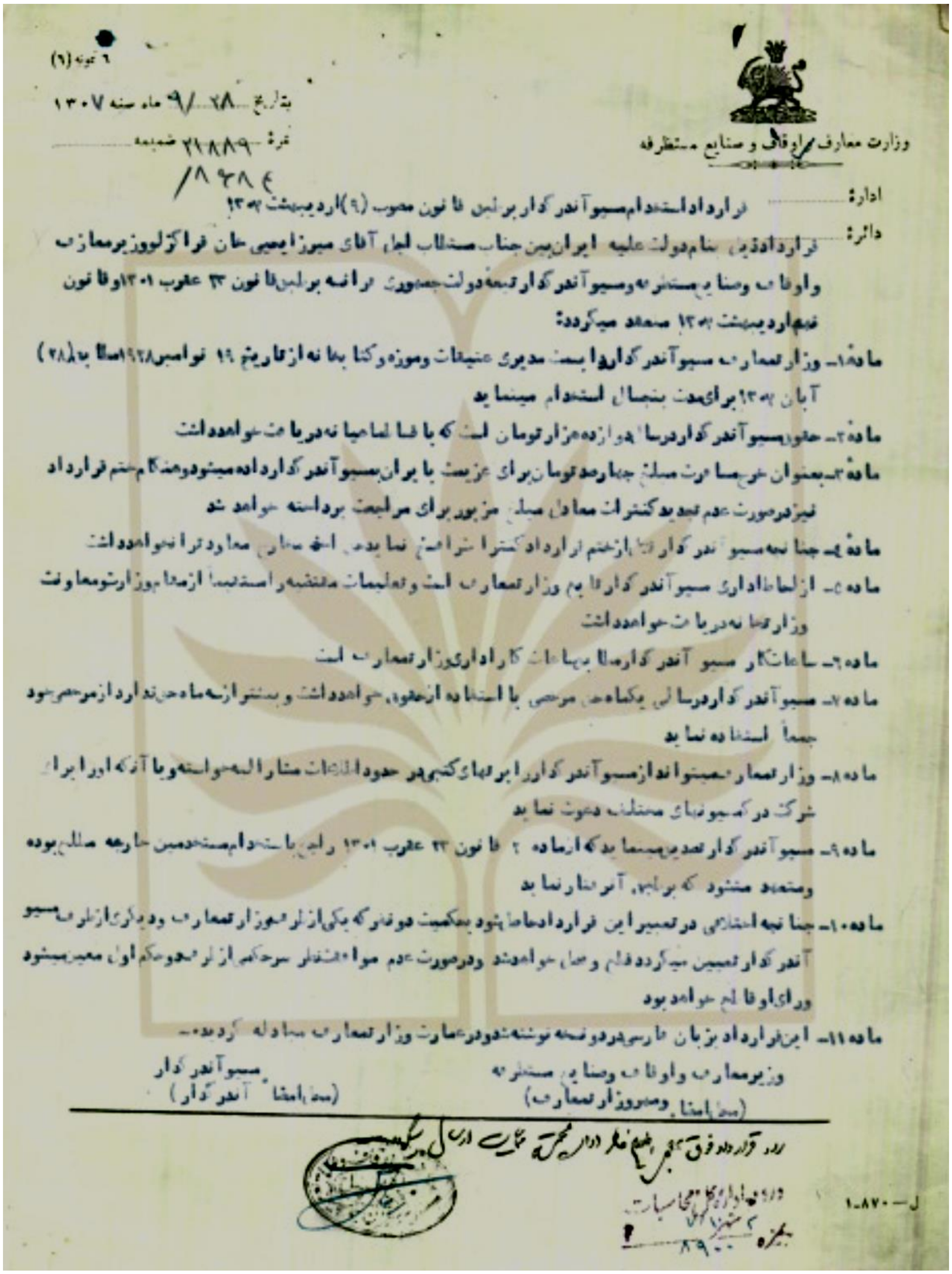
2003/12/29	14:45:24.2	29.36	58.19	15.0			2.3	BAM
2003/12/29	16:52:06.0	29.50	58.44	15.0			2.5	BAM
2003/12/29	17:37:42.3	28.23	58.62	15.0			2.5	BAM
2003/12/29	13:02:05.2	29.21	58.36	15.0			2.7	BAM
2003/12/29	18:42:14.9	29.38	58.18	15.0			2.3	BAM
2003/12/29	19:15:14.1	29.10	58.32	15.0			2.6	BAM
2003/12/29	20:03:27.2	28.50	58.47	15.0			2.7	BAM
2003/12/29	22:50:17.5	28.79	58.12	15.0			2.6	BAM
2003/12/30	00:53:33.9	29.41	58.17	15.0			2.5	BAM
2003/12/30	07:28:08.0	29.21	58.24	15.0			2.3	BAM
2003/12/30	11:41:56.2	29.22	58.23	15.0			2.4	BAM
2003/12/30	12:15:35.9	29.04	58.17	15.0			2.5	BAM
2003/12/30	12:35:22.2	29.24	58.18	15.0			2.6	BAM
2003/12/30	13:32:18.9	29.19	58.26	15.0			2.2	BAM
2003/12/30	14:23:12.3	29.08	58.34	15.0			2.2	BAM
2003/12/30	20:00:29.3	28.94	58.28	15.0			2.9	BAM
2003/12/30	22:20:54.6	28.48	58.66	15.0			2.6	BAM
2003/12/31	03:14:05.7	29.09	58.13	15.0			2.4	BAM
2003/12/31	07:35:54.5	28.61	58.42	15.0			3.2	BAM
2003/12/31	11:46:21.6	29.31	58.30	15.0			2.4	BAM
2003/12/31	13:30:58.6	29.23	58.27	15.0			2.1	BAM
2003/12/31	13:43:44.3	29.17	58.19	15.0			2.6	BAM
2003/12/31	15:38:01.0	28.97	58.26	15.0			2.5	BAM
2003/12/31	18:49:43.7	29.10	58.29	15.0			3.0	BAM
2004/01/01	05:17:07.1	28.69	58.57	15.0			2.3	BAM
2004/01/01	08:00:30.2	29.11	58.24	15.0			2.3	BAM
2004/01/01	09:14:13.0	29.46	58.24	15.0			2.5	BAM
2004/01/01	10:45:52.0	29.26	58.29	15.0			3.2	BAM
2004/01/01	12:10:47.0	28.56	58.56	15.0			2.4	BAM
2004/01/01	13:45:17.3	29.18	58.17	15.0			3.4	BAM
2004/01/01	14:31:28.3	28.70	58.43	15.0			2.3	BAM
2004/01/02	06:12:12.1	28.93	58.43	15.0			2.3	BAM
2004/01/02	09:49:48.2	29.25	58.16	15.0			2.5	BAM
2004/01/02	13:30:59.2	28.90	58.17	15.0			2.7	BAM
2004/01/02	18:21:20.9	28.41	58.51	15.0			3.3	BAM
2004/01/03	00:39:34.2	28.90	58.40	15.0			2.3	BAM
2004/01/03	04:29:09.9	28.92	58.19	15.0			2.4	BAM
2004/01/03	13:48:01.5	29.46	58.17	15.0			2.5	BAM
2004/01/03	19:50:24.5	29.18	58.20	15.0			3.0	BAM
2004/01/03	22:40:28.4	28.85	58.35	15.0			2.6	BAM
2004/01/04	18:29:23.7	28.96	58.30	15.0			3.6	BAM
2004/01/04	20:43:16.3	28.81	58.26	15.0			3.1	BAM
2004/01/05	06:02:02.5	29.10	58.29	15.0			2.7	BAM
2004/01/05	11:42:56.9	28.74	58.15	15.0			2.3	BAM
2004/01/05	18:34:52.6	29.39	54.34	15.0			2.7	BAM
2004/01/05	20:41:36.8	28.78	58.28	15.0			2.6	BAM
2004/01/06	01:00:28.4	28.83	58.30	15.0			2.1	BAM
2004/01/06	17:49:44.2	29.35	58.24	15.0			2.6	BAM

2004/01/07	11:15:53.0	29.16	58.29	15.0			2.7	BAM
2004/01/09	02:51:28.9	29.23	58.26	15.0			2.5	BAM
2004/01/10	12:58:04.6	28.70	58.45	15.0			2.8	BAM
2004/01/11	05:06:17.3	29.14	58.29	15.0			3.6	BAM
2004/01/12	05:10:24.5	29.20	58.23	15.0			2.4	BAM
2004/01/12	21:07:20.5	29.03	58.31	15.0			2.3	BAM
2004/01/13	00:13:51.6	29.20	58.12	15.0			2.3	BAM
2004/01/13	01:36:59.7	29.03	58.10	15.0			2.5	BAM
2004/01/13	06:45:52.0	29.34	58.39	15.0			2.5	BAM
2004/01/14	02:18:07.0	28.66	58.41	15.0			3.2	BAM
2004/01/14	12:34:21.6	29.25	58.26	15.0			2.4	BAM
2004/01/14	21:50:05.2	29.13	58.29	15.0			2.4	BAM
2004/01/16	04:08:10.0	28.48	58.44	15.0			2.7	BAM
2004/01/16	06:50:14.0	29.23	58.30	15.0			2.2	BAM
2004/01/16	06:53:27.9	28.87	58.45	15.0			2.4	BAM
2004/01/17	02:54:04.0	29.11	58.15	15.0			2.4	BAM
2004/01/20	13:23:05.7	29.34	58.02	15.0			3.8	BAM
2004/01/23	00:35:04.3	29.01	58.19	15.0			2.6	BAM
2004/01/28	13:22:44.7	29.03	58.10	15.0			3.1	BAM
2004/01/28	17:29:40.8	28.94	58.24	15.0			3.9	BAM

APPENDIX. IV

The contract between the Iranian government and Andre Godard in December 18, 1928

Source: National Archives of Iran, Tehran, Iran.



۶ توبه (۹)

بتاریخ ۲۸/۹ ماه سنه ۱۳۰۷

نمره ۲۱۸۸۹ ضمیمه

/۸۹۲۸۴

وزارت معارف و اوقاف و صنایع مستظرفه

اداره: قرارداد استخدام مسیو آندره گدار برطبق قانون مصوب (۹) اردیبهشت ۱۳۰۷

دائره: قرارداد ذیل بنام دولت علیه ایران بین جناب مستطاب اجل آقای میرزا یحیی خان قراگزلو وزیر معارف و اوقاف و صنایع مستظرفه و مسیو آندره گدار تبعه دولت جمهوری فرانسه برطبق قانون ۲۳ عقرب ۱۳۰۱ و قانون نهم اردیبهشت ۱۳۰۷ منعقد میگردد:

ماده ۱ـ وزارت معارف مسیو آندره گدار را بسمت مدیری عتیقات و موزه و کتابخانه از تاریخ ۱۹ نوامبر ۱۹۲۸ مطابق (۲۸) آبان ۱۳۰۷ برای مدت پنجسال استخدام مینماید

ماده ۲ـ حقوق مسیو آندره گدار درسال دوازده هزار تومان است که باقساط ماهیانه دریافت خواهد داشت

ماده ۳ـ بعنوان خرج مسافرت مبلغ چهارصد تومان برای عزیمت بایران بمسیو آندره گدار داده میشود و هنگام ختم قرارداد نیز درصورت عدم تجدید کنترات معادل مبلغ مزبور برای مراجعت پرداخته خواهد شد

ماده ۴ـ چنانچه مسیو آندره گدار قبل از ختم قرارداد کنترات را فسخ نماید حق اخذ مخارج معاودت را نخواهد داشت

ماده ۵ـ از لحاظ اداری مسیو آندره گدار تابع وزارت معارف است و تعلیمات مقتضیه را مستقیماً از مقام وزارت و معاونت وزارتخانه دریافت خواهد داشت

ماده ۶ـ ساعات کار مسیو آندره گدار مطابق ساعات کار اداری وزارت معارف است

ماده ۷ـ مسیو آندره گدار درسال یکماه حق مرخصی با استفاده از حقوق خواهد داشت و بیشتر از یکماه حق ندارد از مرخصی خود جمعاً استفاده نماید

ماده ۸ـ وزارت معارف میتواند از مسیو آندره گدار برای کنفرانسهای در حدود اطلاعات مشارالیه خواسته و یا آنکه او را برای شرکت در کمیسیونهای مختلف دعوت نماید

ماده ۹ـ مسیو آندره گدار تصدیق مینماید که از ماده ۲ قانون ۲۳ عقرب ۱۳۰۱ راجع باستخدام مستخدمین خارجه مطلع بوده و متعهد میشود که برطبق آن رفتار نماید

ماده ۱۰ـ چنانچه اختلافی در تعبیر این قرارداد حاصل شود بحکمیت دو نفر که یکی از طرف وزارت معارف و دیگری از طرف مسیو آندره گدار تعیین میگردد قطع و فصل خواهد شد و درصورت عدم موافقت نظر سرحکم از طرف حکم اول معین میشود و رای او قاطع خواهد بود

ماده ۱۱ـ این قرارداد بزبان فارسی در دو نسخه نوشته شده و در عمارت وزارت معارف مبادله گردید

وزیر معارف و اوقاف و صنایع مستظرفه (محل امضاء وزیر وزارت معارف)

مسیو آندره گدار (محل امضاء آندره گدار)

[illegible]

ل ـ ۱۰۸۷۰

APPENDIX. V

The current dossier of Iranian Cultural Heritage's regulation
Source: National Archives of Iran, Tehran, Iran.

جدول۱- فهرست پایه ابنیه تاریخی ایران براساس استاندارد فهرست پایه داده ها، خانه عامری، آرشام بم.

۱. نام‌ها و منابع								
۱٫۱. نام بنا	خانه عامری؛ خانه آرشام؛ خانه اسدالله خان سیستانی؛ خانه سیستانی							
۱٫۲. شماره مرجع واحد	۰۰۳-۲۰۱۱							
۱٫۳. تاریخ تکمیل	۲۰۱۱/۰۵/۱٦							
۲. موقعیت مکانی								
۲٫۱. موقعیت مکانی رسمی								
۲٫۱٫۱. ایالت(استان)	کرمان							
۲٫۱٫۲. بخش (های) اداری ایالت(شهرستان)	بم							
۲٫۲. آدرس								
۲٫۲٫۱. نام پستی	خانه عامری-آرشام							
۲٫۲٫۲. شماره در خیابان/جاده								
۲٫۲٫۳. نام خیابان/جاده	کمربندی طالقانی، خیابان بیست ودوبهمن، کوچه بیست ودوبهمن سه(کوچه سرهنگ بازورخانه تختی)							
۲٫۲٫۴. موقعیت محلی	محله عربخانه، محله باغ خان							
۲٫۲٫۵. شهر کوچک/شهر	بم							
۲٫۳. مرجع وابسته به نقشه								
۲٫۳٫۱. مختصات x	حیاط بیرونی	حیاط اندرونی	حیاط خدمه					
	mE ٦۲۹۸۲۸٫۰۵	mE ٦۲۹۸٤۸٫٤۷	mE ٦۲۹۸٦۷٫۵۱					
۲٫۳٫۲. مختصات Y	۳۲۲۰۱٦۱٫۰۹mN	mN ۳۲۲۰۱۳۹٫٤٥	۳۲۲۰۱۱۱٫۱۸mN					
۲٫۳٫۳. سیستم مختصات فضایی	UTM							
۳. گونه عملکردی								
۳٫۱. گونه بنا	خانه	اداری	موزه، خانه تاریخی	هتل (در دست ساخت)	متروکه			
۳٫۱٫۱. زمان	قاجار	پهلوی تا ۱۳۷٤	۱۳۷٤ تا ۱۳۸۰	۱۳۸۰-۱۳۸۳	۱۳۸۳ تا کنون			
۳٫۲. طبقه بنا	مسکونی	اداری	نمایشگاهی	اقامتگاه عمومی	-			
۴. تاریخچه								
۴٫۱. دوره	حیاط بیرونی	حیاط اندرونی و خدمه						
	زند؟ قاجار	قاجار						
۴٫۲. قرن	اوایل قرن سیزدهم هجری قمری	قرن سیزدهم هجری قمری						
۵. افراد یا سازمان هایی که با تاریخ بنا همراه هستند.								
۵٫۱. فرد یا سازمان	حیاط بیرونی					حیاط اندرونی و خدمه		
	یعقوبخان عامری	بنیاد آرشام	آموزش و پرورش	میراث فرهنگی	دفتر طرح پردیسان	اسدالله سیستانی	کریمخان عامری	دفتر طرح پردیسان
۵٫۲. نقش در تاریخ بنا	بانی	مالک	صاحب وقف	مالک	مالک-مجری	بانی	مالک	مالک-مجری
۵٫۲٫۱. زمان	قاجار	پهلوی دوم	جمهوری اسلامی	۱۳۷٤	۱۳۸۰-تا کنون	قاجار	قبل از ۱۳۸۰	۱۳۸۰-تا کنون
۶. مصالح و تکنیک‌های ساختمانی								
۶٫۱. مصالح و تکنیک‌های ساختاری اصلی (دیوارها)	مصالح اصلی: خشت؛ ملات: گل، گچ و خاک رس؛ اندود: سیمگل در دیوارهای حیاط، گچ در فضاهای داخلی، کاهگل در فضای خدمه							
۶٫۲. مصالح پوششی (سقف)	مصالح اصلی: خشت؛ ملات: گل، گچ و خاک رس؛ اندود: سیمگل در دیوارهای حیاط، گچ در فضاهای داخلی، کاهگل در فضای خدمه؛ سیستم سازه ای: سقف نیم گرده پوش برای اتاق‌های مستطیل شکل، سقف چهاربخشی برای اطاق‌های مربع، طاق آهنگ در راهروها، طاق و طویزه در حوضخانه							
۷. شرایط کالبدی	نابود شده	تخریب شده*	تعمیر و تغییر یافته *	مرمت شده				
۷٫۱. شرایط عمومی	خوب	متوسط	ضعیف	بد*				
۸. حفاظت/وضعیت قانونی								
۸٫۱. نوع حفاظت	فهرست آثار ملی ایران به شماره ۱۸۳۵							
۸٫۲. تاریخی که این نوع حفاظت اعطا شده است	۱۳۷۵-۱۱-۲٤							
۹. سایر موارد								
۹٫۱. خلاصه تاریخی	مجموعه خانه تاریخی عامری- آرشام توسط حاج یعقوب خان عامری (پسر حاج اسحاق خان عامری آخرین حاکم مقیم در ارگ تاریخی بم) و داماد وی، حاج اسدالله خان سیستانی (نوه حاج حسین خان سیستانی حاکم بم در زمان آقامحمدخان قاجار) در دوره فتحعلی‌خان قاجارساخته شده است.							

APPENDIX. VI

The complain of Iranian government about illegal excavation of a foreigner's group in a historic site of Iran
Source: National Archives of Iran, Tehran, Iran.

وزارت مالیه

اداره

دایره

27 Mizan 1302.

His Excellency,
Hakim ed Dowleh,
Minister of Public Instruction.

Your Excellency:

I have the honor to inform you that my attention has been called to an agreement approved by the Council of Ministers on 13 Hoot 1301, No. 14154, with regard to digging for antiques, and in your letter to the Ministry of Finance, No. 2755, dated Sonboleh 16, you state that you have granted the privilege of digging for antiques on the Public Domains in the vicinity of Teheran to Hadji Mohammed Agha Shalfroosh and Nasserol Vezareh, and at present they have been given an authorization to begin digging around Hazrat Abdul Azim.

I beg to inform you that the action of the Council of Ministers in approving the agreement referred to was apparently illegal. According to my contract, I am to be consulted in advance on all such questions, and the second article, which says that after deducting expenses one-half of the things extracted from Domain territories should be given to the Ministry of Education, is clearly illegal and impossible of execution. No money or property can be given to the Ministry of Education in addition to its credits, and no Government property can be disposed of except in accordance with the legal procedure provided for in the Constitution, the Accounting Law, the Treasury General Law, and my own contract.

I suggest that you notify the individuals concerned that the matter will have to be reconsidered, and that no permission will be given them to dig on the Public Domains until there has been such reconsideration of the question.

Please accept, Your Excellency, the assurances of my distinguished consideration.

A C Millspaugh

Administrator General of the Finances.

APPENDIX. VII
"The Law of Antiquity" (3 November1930)
Source: National Archives of Iran, Tehran, Iran.

Ministry of the National Economy

Law concerning the preservation of national antiquities, approved on 12 aban 1309 (3 November 1930)[1/]

Article 1 - All works of art and movable and immovable creations which have been produced in Iran, as well as all historical sites, dating from before the end of the Zend dynasty, are, by virtue of Article 2 of the present law, considered as national antiquities and are placed under the protection and control of the State.

Article 2 - The State will make an Inventory of all Iranian antiquities currently known and identified, which are of specific historical, scientific or artistic interest. Any further antiquities of the same kind discovered in the future will be added to this Inventory. The Inventory will be printed and published.

Article 3 - The listing of property in the Inventory of National Antiquities will be announced by means of an order from the Ministry of Education. However, the listing of property belonging to a private person will be notified in advance to the owner and will become effective only when any protest which the owner might make has been considered. The owner does not have to assume the obligations set forth in this law until the listing of the property has become effective.

Article 4 - The owner of immovable property which, under the provisions of the present law, may be considered as a national antiquity, as well as any person coming to know of the existence of property of this kind must notify the nearest appropriate government office so that the relevant authorities, as defined in the rules for the application of the present law, can decide whether the property in question should be considered as a national antiquity and classified as such.

Article 5 - Private individuals who are owners or who have the usufruct of property listed in the Inventory of National Antiquities retain their right of ownership or usufruct but may not oppose measures which the State considers that it has to take for the preservation of those antiquities. If work undertaken by the State entails expenditure, no reimbursement of that expenditure may be claimed from the owner nor shall the work in question in any way affect his right of ownership.

Article 6 - The acts listed below are forbidden. Any person who performs such acts will be tried and fined from 50 to 1,000 tomans. In addition, he could also be held liable for the cost of the damage caused by him to national antiquities:

(a) destroying or damaging national antiquities, covering them with plaster or paint, or carving designs or inscriptions on them;

1/ Unofficial translation prepared by Unesco.

(b) undertaking works near national antiquities which could damage their structure or modify their appearance;

(c) taking, buying or selling, without the authorization of the State, items or materials belonging to listed buildings. The repair and restoration of buildings classified as national antiquities and belonging to private owners may only be undertaken with the authorization of the State and under its supervision. Any infringement is punishable as described above.

Article 7 - Privately owned movable property considered as a national antiquity must be listed in a separate inventory, in accordance with Article 2 of the present law.

Article 8 - For each item of movable property listed in the Inventory of National Antiquities, a descriptive certificate must be drawn up in duplicate, indicating its place of origin and how it was discovered. One or more photographs should be attached.

One copy of the certificate will be kept in the national antiquities archives and the other will be delivered free of charge to the owner. This copy must accompany the property in all its changes of ownership. A change of ownership in no way affects the status of the property as a listed national antiquity.

Article 9 - If the owner of listed property wishes to sell it to a third party, he must notify the appropriate public authorities in writing. If the State wishes this property to be included in a national collection, it has a right of pre-emption but must give notice to the owner of its intention to exercise that right within ten days of receiving the owner's notification. If the State gives no such notice, the owner is free to sell the property to another purchaser. In all cases, and whatever the means by which the property has been disposed of, the previous owner must notify the State, within ten days of the disposal, of the name and address of the new owner. Anyone who sells a listed property without notifying the Ministry of Education or its representatives will be fined a sum equal to the sale price of the property in question. In addition, the State may seize the property which has been sold, reimbursing the purchaser the sum paid by him. Furthermore, if the purchaser knew that the property in question was listed in the Inventory of National Antiquities but still proceeded with the purchase, he shall be liable to the same fine as the seller, unless he himself notified the State.

Article 10 - Any person happening to discover any movable property which, according to the provisions of the present law, could be considered as a national antiquity, even if that property is on his own land, must notify the Ministry of Education or one of its representatives as soon as possible. Should the relevant public authorities decide that the movable property in question ought to be listed in the Inventory of National Antiquities, half of the property discovered, or of its value as determined by appraisal, shall be due to the finder. The State may, at its own discretion, decide whether to retain the other half or donate it to the finder.

Article 11 - The State is entitled to dig and excavate for antiquities. The State may use this right directly, or delegate it, by special authorization, to scientific institutions, societies or individuals. Such authorization must indicate the site of the excavations, their extent and estimated duration. In addition, the State is entitled to make probes in any place where remains have been found, or where evidence suggests the existence of remains, or which seems likely to conceal remains, for the purpose of discovering antiquities and determining their nature and quality.

Article 12 - Excavations whose sole purpose is to discover antiquities or to conduct scientific research are termed 'scientific excavations'. Excavations whose purpose is the sale of antiquities are termed 'commercial excavations'. Authorization to undertake scientific excavations is granted exclusively to scientific institutions. Commercial excavations in listed buildings or on listed property are probibited.

Article 13 - Excavations on land belonging to private individuals may be undertaken only with the authorization of the State and the consent of the owner. However, the owner of a site listed in the Inventory of National Antiquities or which the State, as a result of probes, has listed or is in the process of listing in the Inventory, cannot withhold his consent. He is entitled only to request an indemnity which shall be equivalent to half the revenue from the land which is no longer available to him on account of the excavations and half the prejudice caused and the expenses incurred in restoring the land to its original state after the excavations.

Article 14 - Items discovered during scientific or commercial excavations, at one and the same site during one and the same period of excavations, belong exclusively to the State if the State has itself itself undertaken the excavations. If the excavations have been undertaken by a third party, the State may select and appropriate up to ten items of historical or artistic value and donate half of the remainder to the finder, keeping the other half itself. If there are not more than ten items in all and if the State keeps them all, the expenses incurred by the excavations are reimbursed to the person who provided the funds. Buildings and parts of buildings are not covered by the above provisions regarding sharing and the State is entitled to appropriate them in toto.

Note - A period of excavations is defined as one which lasts no longer than a year.

Article 15 - Items discovered during scientific excavations and to which the State is entitled must be kept in national collections and museums. They are inalienable. Items donated to the finder become his sole property. Of the items discovered during commercial excavations which revert to the State, the State keeps all those of interest to museums and disposes of the others as it so chooses. The sale of such items shall be by auction.

Article 16 - Any person infringing the provisions of Article 10, or undertaking excavations, even on his own property, without State authorization or without the knowledge of the State, or exporting antiquities fraudulently, will be fined from 20 to 2,000 tomans. In addition, the items discovered will be confiscated by the State. Earth removal and other works of the same type not undertaken for the purpose of finding antiquities are not subject to the above-mentioned fines.

Article 17 - Persons wishing to trade in antiquities must obtain a State licence. A State licence is also required to export antiquities. Any item listed in the Inventory of National Antiquities will be confiscated by the State if any attempt is made to export it without State authorization. The

State will not refuse export licences for items which, under the provisions of Articles 10 and 14 of the present law, are the property of the finder, provided that they are not listed in the Inventory of National Antiquities. If they are listed items, the conditions under which they may be exported are set out in Article 18 below.

Article 18 - The State is entitled to refuse an export licence for items considered as national antiquities, and to purchase them at the price declared by the person concerned in his request for an export licence. If the owner refuses to sell them at the stated price, the export licence will not be granted. If the licence is granted, an export tax will be levied equal to 5 per cent of the value determined by the State-appointed valuer. In the event of disagreement between the owner and the valuer, the matter will be settled by a special commission, the composition of which will be determined by the rules for the application of the present law. The export tax provided for by the present Article is independent of the customs levies laid down for such items by the customs tariffs in force. The export of items discovered during scientific excavations undertaken with the agreement of the State and constituting the finder's share is authorized in all cases and is exempt from any levies and taxes.

Article 19 - The Council of Ministers will draw up and approve rules for the implementation of this law, stating the conditions for trading in antiquities and the conditions for the implementation of all the provisions of the present law.

Article 20 - Authorizations for excavations already granted which do not comply with the present law are hereby revoked.

Text of the law adopted by both houses (Senate and National Assembly).

Rules for the Application of the Law enacted on 12 Aban-Mah 1309 (3 November 1930) on the Preservation of the Antiquities of Persia (Approved by the Council of Ministers on 28 Aban-Mah 1311 - 19 November 1932)1/

DEFINITIONS

Article 1 - All the products of the arts of all the peoples who lived on Persian soil until the close of the Zend period are considered as 'antiquities'.

Antiquities are movable or immovable, immovable when they are fixed to the ground or not easily transportable, movable when they are not immovable.

Natural sites such as underground caves, rock shelters and rocks preserving vestiges of ancient civilizations are classified as immovable antiquities.

Easily transportable construction components or decorative elements, which formed part of buildings or of natural sites considered as immovable antiquities and which were found detached from these antiquities, are considered as movable antiquities.

1/ Unofficial translation prepared by Unesco.

CHAPTER I

Immovable antiquities

Article 2 - An inventory of all the currently known immovable antiquities relating to the national history of Persia shall be drawn up by the Archaeological Department of Persia.

As and when new immovable antiquities having the same historic and national character are discovered, they shall be listed in the inventory.

The antiquities thus listed, and only these, shall be considered as 'Immovable National Monuments'.

The inventory shall be called the 'Inventory of Immovable National Monuments'.

Article 3 - Any site may at any time be listed in the inventory once it has been established beyond doubt that under the ground at this place is an antiquity relating to the history of Persia.

Article 4 - Whoever possesses an immovable antiquity liable to be classified as a 'National Monument', and whoever learns of the existence of such an antiquity must, without delay, notify the Archaeological Department through the nearest representative of the Administration of National Education or, failing this, through officials of the Administration of Finances.

The Archaeological Department, after examining the antiquity in question, shall, where appropriate, propose its listing in the Inventory of National Monuments.

Article 5 - The listing in the inventory of an immovable antiquity or of a site on which is located an immovable antiquity shall be proposed by the Director of the Archaeological Department to the Minister of Education who shall decide on the advisability of listing and, if need be, shall order it by means of a decree.

However, the listing shall only become effective and its effects shall only have full legal force after the owner has been officially notified of the antiquities or sites in question and after consideration of the justification of whatever protest he may make. A period of one month shall be accorded to the owner within which to make his protest.

Article 6 - The officials of the Archaeological Department responsible for drawing up the Inventory of National Monuments must compile a comprehensive record of locally obtained information on each immovable antiquity being considered for listing.

This record must include all the information necessary for preparing the proposal for listing, i.e. as far as possible:

- the name by which the immovable antiquity is known in the locality,
- its real name,
- its exact geographical location,

- the name of its founder,
- the date of its construction,
- a concise plan of it,
- photographs,
- a statement of its legal situation,
- all relevant details which can justify listing and which are not included in this enumeration.

This record may also usefully include:

surveys making it possible subsequently to prepare plans, sections, situation diagrams and details of the construction and decoration of the monument(s);

a list of photographs and, if possible, of stamped inscriptions;

legends relating to the immobile antiquity current in the region;

where restoration was carried out prior to the date of the work, the name of the restorer(s) and indications as to the parts restored, accompanied by relevant drawings and photographs.

In short, the record should include all the documentation that can possibly be gathered, bearing in mind that no detail, however trivial in appearance, and no information, even if manifestly legendary, is to be disregarded.

When an immovable antiquity has been finally listed as a National Monument, the record used in preparing the proposal for listing, to which shall be added the ministerial decree ordering that listing, shall be deposited in the Archives of National Monuments.

After listing, detailed notes on transfers of ownership of the antiquity, conservation measures concerning it taken by the Antiquities Department and repairs carried out, shall be included in the record.

Article 7 - Private individuals who are owners or who have the usufruct of a classified immovable antiquity shall retain their right of ownership or usufruct but may not oppose measures which the State considers obliged to take for the preservation of the antiquity.

If these measures entail expenditure, no reimbursement of that expenditure may be claimed from the owners nor shall it in any way affect their right of ownership.

Article 8 - The Archaeological Department shall be responsible for carrying out the work ordered by the State as necessary for the preservation of the national monuments. When a private individual who owns or has the usufruct of a building classified as a national monument wishes to restore or repair this building at his own expense or change it in any way whatsoever, he shall first submit a detailed plan of the work he wishes to undertake to the Minister of Education and obtain authorization to carry it out.

The Minister of Education may refuse the authorization requested if in his opinion the planned work endangers the structure or poses a threat to the appearance of the building. He may require this work to be executed in the way he considers appropriate and, in particular, require the re-use of old materials or the employment of techniques or materials similar to those used by the original builders.

This work, the details of which will be laid down in the ministerial authorization, shall be executed under the supervision of the Archaeological Department.

If work being carried out is abandoned, the Archaeological Department shall be responsible for continuing it at the expense of the defaulting owner.

If the work is not carried out in accordance with the plan laid down in the ministerial authorization, demolition and proper reconstruction may be required, without prejudice to the penalties established by law for damage to national monuments. Or, should the Minister of Education consider it suitable, the State may itself carry out demolition and construction work at the expense of the owner.

Article 9 - Protective zones, in which it shall be forbidden to put up buildings, plant trees, carry out excavation work and establish cemeteries, may be established in order to protect the National Monuments and sites which are of particular value for the history of Persia.

The Minister of Education shall, in each case, decide on the conditions for the establishment of these protective zones and shall determine the compensation that may be accorded to the parties involved.

It is forbidden

Article 10 - (1) to destroy or damage National Monuments, to cover them with plaster or paint, or to carve designs or inscriptions on them;

(2) to undertake any work near listed buildings which may endanger their structure or alter their appearance;

(3) to appropriate, buy or sell, without the authorization of the Minister of Education, materials belonging, or which formerly belonged, to the buildings listed in the inventory.

Anyone guilty of any of these infringements shall be tried and sentenced to a fine of from 50 to 1,000 tomans. In addition, he may also be held liable for the cost of repairing the damage caused by him to the National Monuments.

Article 11 - The safeguarding of immovable National Monuments located far from any town shall be the responsibility of special caretaker's posts responsible for keeping a constant watch over them.

Where immovable National Monuments are located in or near a town and are unable to see to their own protection, it will generally be sufficient for the ministerial decree ordering the listing to impose on the town council of the area the obligation to guard them by whatever means it considers appropriate, but under the full responsibility of the head of that council. The Minister of Education shall determine in each case the guard system to be adopted, e.g. a special caretaker's post, surveillance by the regular personnel of the monument or surveillance by the town council.

The Archaeological Department shall satisfy itself as to the effectiveness of the measures taken.

CHAPTER II

Movable Antiquities

Article 12 - Movable antiquities relating to national history and located in Persia in the possession of private individuals shall be listed in a special inventory, subject to the provisions of Article 3 of the Law. This inventory shall be called the 'Inventory of Movable National Monuments'. A movable antiquity may be listed in the inventory at any time.

The effects of having been listed shall apply to the antiquity whoever its owner might be.

Article 13 - When a movable antiquity has been finally listed as a 'National Monument', the records used in preparing the proposal for listing, to which shall be added the ministerial decree ordering the listing, shall be deposited in the Archives of National Monuments. Any subsequent change of ownership and, in general, any event relating to a listed movable antiquity shall be the subject of detailed notes to be included as and when necessary in those records.

Article 14 - For each item listed in the inventory, a descriptive certificate shall be drawn up, in duplicate, by the Archaeological Department, indicating, as far as possible, its place of origin and the circumstances of its discovery. One or more photographs should be attached.

One copy of the certificate shall be kept in the Archives of National Monuments and the other delivered free of charge to the owner of the item. This copy will accompany the property in all its changes of ownership.

Article 15 - The movable antiquities listed in the inventory may be modified, restored or repaired only with the authorization of the Minister of Education and under the supervision of the Archaeological Department.

The destruction of a movable National Monument and any infringement of the provisions of this article shall be punishable by a fine proportional to the damage caused.

Article 16 - If the owner of a listed movable antiquity wishes to sell it, he must notify the Minister of Education by registered letter. The sale may not take place until ten days after reception of this letter.

If the government notifies the owner, within this ten-day period, of its intention to purchase the property for inclusion in the national collections, it shall have priority over other purchasers, other things being equal. If it does not give notice within the prescribed period of its intention to purchase the property, it shall be considered as having waived its right of pre-emption.

In all cases, except where the State is the purchaser, and whatever the means by which the property changes ownership, the previous owner must notify the Minister of Education, within ten days of the change of ownership, of the name and address of the new owner.

Anyone who sells a movable National Monument without notifying the Minister of National Education shall be fined a sum equal to the sale price of the property in question. In addition, the government may seize the property, reimbursing the purchaser the sum paid by him. Furthermore, if it is proved that the purchaser knew that the property in question was listed in the Inventory of National Monuments, he shall be considered as an accomplice of the seller and liable to the same fine as him, unless he himself notified the government.

Article 17 - Any person happening to discover movable antiquities, even if such antiquities are on his own land, must notify the Minister of Education without delay through his nearest official representative or, failing this, through officials of the Administration of Finances.

After examination of the items by the Archaeological Department, half of the items, or of their commercial value as determined by appraisal, shall be returned to the finder. The State may, at its own discretion, retain the other half or donate it to the finder.

CHAPTER III

Excavations

Article 18 - The State enjoys the exclusive right to dig and excavate in search of antiquities.

Article 19 - The State may use this right directly and have excavations carried out by its Archaeological Department or delegate it temporarily, by special licence, to individuals or scientific institutions.

Article 20 - The State is entitled to have probes made by its Archaeological Department wherever it believes it worthwhile to seek evidence of the existence, nature or age of an ancient site.

Article 21 - Excavations are termed 'scientific' when their purpose is to discover material permitting the study of the ancient civilizations of Persia and of their relations with other civilizations.

They are termed 'commercial' when their purpose is to discover antiquities for commercial transactions.

Article 22 - Licences to carry out excavations on sites listed in the Inventory of National Monuments shall be granted by the Council of Ministers, and only to scientific institutions. Licences to carry out excavations on sites which are not listed in the Inventory of National Monuments shall be granted by the Minister of Education.

No commercial excavation may be carried out on sites or in monuments listed in the Inventory of National Monuments.

Article 23 - Requests for licences to excavate should be addressed to the Minister of Education.

They must contain the under-mentioned details:

1. The name, first names, occupation, address and nationality of the applicant, or if the applicant is a scientific institution, the names, first names, occupations, addresses and nationalities of its official representative to the Persian Government and of the scientist(s) in charge of the excavations.

2. Exact information, with an accompanying plan or drawing, as to the name, location and boundaries of the site(s) to be excavated.

3. A summary of the purpose of the excavation and of the work plan.

Article 24 - Licences will be granted for one or more sites and for one or more years.

They will state the period of time for which they are valid, the areas in which the excavations may be carried out and the boundaries of the concessions. They will lay down the technical conditions that the Minister of Education may think fit to impose on the excavators.

Article 25 - Excavations on land belonging to private individuals may be carried out only if the person excavating has the authorization of the owner of the land as well as a government licence.

However, the owner of land listed in the Inventory of National Monuments or of a site which, as a result of initial probes, is shown as having to be listed in the inventory, cannot withhold his authorization. He is entitled only to request an indemnity, calculated on the basis of the prejudice caused to his property, which shall be twice the revenue lost as a result of the excavations and the expenses incurred in restoring the land to its original state after the excavations.

Article 26 - Excavations may be inspected at any time by the Director of the Archaeological Department or any person appointed by him. Items discovered should always be available for inspection by him.

In addition, the person excavating must agree to the presence of a representative of the Archaeological Department at each of his sites.

Article 27 - Persons excavating shall themselves be responsible for protecting their sites.

Article 28 - Any licence carries the obligation to work on each of the sites conceded for not less than 60 days a year, except in cases where excavations are completed in a shorter period of time.

Article 29 - Persons excavating are forbidden to treat the antiquities discovered in such a way that they might be damaged.

Article 30 - A person licensed to carry out excavations must leave in position the immovable antiquities whose displacement and temporary removal may have been authorized by the government, and must restore them to the state in which he found them.

At the end of each period of excavations, he shall fill in isolated borings and bury bones or similar debris the sight of which might offend passers-by.

Article 31 - Antiquities discovered during regular *scientific or commercial* excavations, at one and the same site during one and the same period of excavations, shall be shared between the State and the excavator as follows: the State may initially select up to ten items which will thus become its property and then share the remainder equally between the excavator and itself. Immovable antiquities may not be shared in this way. They may be appropriated by the State.

If the items found were not to exceed ten in number and if the State appropriated them all as it would be entitled to do, it would reimburse to the excavator the expenses incurred by him.

The excavator shall be authorized to take away his share of the antiquities which he discovers only after payment of the indemnity due to the owner.

Note: a period of excavations is defined as one which lasts no longer than a year.

Article 32 - As the antiquities discovered during scientific excavations are by definition purely documentary in character, items of this kind which revert to the State shall, as of right, form part of the national collections and may not be sold.

After selecting the items to be included in national collections from those antiquities reverting to it from commercial excavations, the State shall dispose of the remainder as it sees fit.

Article 33 - At the end of each period of scientific excavations, the excavator shall give the Management of the Archeological Department:

1. a plan of the excavation site(s) with a legend indicating the positions of the buildings and of the main items discovered;

2. a list of all the buildings and objects found, including those falling to him as his share;

3. a concise report on the background to the excavations, indicating the principal findings, with reference to the plan and the list of items.

Article 34 - The persons excavating and the scientific institutions that they represent shall send to the Archaeological Department two copies of each of the books, contributions to journals and sets of photographs or drawings published by them on the facts noted and items found during their excavations.

Article 35 - In the event of any infringement of the provisions of any of the foregoing articles, the excavations may be suspended by decision of the Minister of Education until the infringement has ceased.

The licence to excavate may even be withdrawn in the event of a serious infringement.

Article 36 - Any person infringing the provisions of Article 10 of the Law or Article 17 of the present rules, or carrying out excavations without due authorization, or exporting antiquities fraudulently, shall be fined from 20 to 2,000 tomans.

The items discovered shall be seized and confiscated by the State.

Article 37 - Probes, excavations and earth removals shall not be considered as having had the search for antiquities as their purpose if the person carrying them out had no reason to believe that the site could contain antiquities. The person in question shall not be liable to the penalties provided for in the previous Article.

CHAPTER IV

Trading in antiquities

Article 38 - Any person wishing to trade in antiquities as a business must obtain a licence, which it is up to the Ministry of Education to grant or refuse.

Licences to trade in antiquities shall be strictly personal.

Article 39 - Applications for licences must be addressed to the Minister of Education. They should contain:

1 The name, first names, address and nationality of the applicant.

2. Information concerning the place where the applicant wishes to trade.

Article 40 - Licences to trade in antiquities shall conform to the model appended to the present regulations. The Minister of Education shall, however, continue to reserve the right to modify the text of the licence whenever he thinks this fit, in order to exercise better supervision of the antiquities trade.

Article 41 - The following may be traded in:

1. items which are or have been a part of immovable National Monuments when trade in them has been authorized by the Minister of Education;

2. antiquities of licit origin which are on the market when the law concerning the preservation of antiquities is promulgated;

3. antiquities discovered by chance, which shall be the property of their finders in accordance with Article 10 of the Law and Article 17 of the present rules;

4. those antiquities discovered during excavations carried out by the State which shall be judged to be of no value for the development of the national collections and which shall be put on to the market by the State;

5. the share of the antiquities, discovered during commercial explorations, to which the excavators are entitled;

6. those antiquities from commercial excavations to which this State is entitled and which it shall put on the market;

7. those antiquities seized and confiscated by the State, by virtue of Articles 16 of the Law and 36, 48 and 50 of the rules which it shal put on sale.

Article 42 - Any person trading in antiquities must possess a register, of the kind approved by the Archaeological Department, in which he shall note, on a day-to-day basis and with serial numbers, the entry and departure of antiquities bought and sold by him and whose sale price is more than 20 tomans

All details of size, substance and colour, enabling the antiquities in question to be identified, shall be noted in this register as well as information making it possible to establish that they can be traded in legally.

Before the register is used, each page must be initialled by an inspector from the Archaeological Department.

Article 43 - Where a person trading in antiquities exercises his trade in several places, the transport of antiquities from one place to another must be mentioned in the registers of the two establishments as if it were a sale and purchase.

Article 44 - Inspectors of the Archaeological Department, accompanied or unaccompanied by policemen, may at any time have entrance to all the parts of a building used for trading in antiquities to inspect the register of purchases and sales, to check that it is being properly kept and to check the trader's stock.

The trader must facilitate this inspection and provide any explanations requested concerning his trade.

After each inspection, the official of the Archaeological Department shall initial the register of the business.

Article 45 - Trading in antiquities without the necessary licence, and any infringement of the provisions of the present Chapter, shall be punished by the appropriate court.

The judge may order the withdrawal of the licence to trade in antiquities

Article 46 - Any broker or trader who acts as an intermediary in any capacity whatsoever in the sale of antiquities found during illegal excavations shall be considered as an accomplice of the excavator and liable to the same penalties as him.

Article 47 - Any person wishing to export antiquities must apply for a licence to do so from the Minister of Education.

This application, accompanied by a list indicating the number of items, their nature, origin and commercial value, shall be submitted to the Archaeological Department for examination together with the cases or packages containing the antiquities about to be exported.

Provided that on examination, no item of fraudulent or suspect origin is found, and once the declared commercial value has been confirmed by the government appraiser, the cases and packages shall be sealed and the export licence granted, on payment of an export duty amounting to 5 per cent of the value of the items.

This export duty shall be independent of customs duties.

Article 48 - If the examination by the Archaeological Department reveals the presence of items of fraudulent origin, these items shall be seized and confiscated by the State. Their owners or exporters may have charges brought against them in pursuance of the law concerning the preservation of antiquities.

Objects of suspect origin may be kept until satisfactory explanations have been obtained concerning them.

Article 49 - In cases of disagreement between the exporter and the government appraiser concerning the value of an item about to be exported, the dispute shall be brought before an arbitrator chosen by both the exporter and the Director of the Archaeological Department.

Article 50 - The government may, when it considers it relevant to the development of the national collections, buy at the price declared by its owner any antiquity listed in the inventory of National Monuments for which an export licence has been requested.

In the event of an owner refusing to sell it to the State, the export licence would not be granted.

Article 51 - Any antiquity which it is attempted to remove from Persia without the proper licence may be seized and confiscated by the State.

Article 52 - Persian antiquities being returned to Persia must be shown to the Archaeological Department. Their owners will be given an import certificate. This certificate must be shown in the event of re-exportation.

APPENDIX. VIII

Ratified Conventions, Protocols and Agreements by state party of Iran
Source: UNESCO Cultural Heritage Laws Database (UNESCO/CLT/NATLAWS), designed by Author

Iran (Islamic Republic of) - Ratified Conventions			
1	Convention for the Protection of Cultural Property in the Event of Armed Conflict with Regulations for the Execution of the Convention. The Hague, 14 May 1954.	**Date of deposit** 22/06/1959	**Type of deposit** Ratification
2	Protocol to the Convention for the Protection of Cultural Property in the Event of Armed Conflict. The Hague, 14 May 1954.	22/06/1959	Ratification
3	Agreement for Facilitating the International Circulation of Visual and Auditory Materials of an Educational, Scientific and Cultural character with Protocol of Signature and model form of certificate provided for in Article IV of the above-mentioned Agreement. Beirut, 10 December 1948.	30/12/1959	Acceptance
4	Agreement on the Importation of Educational, Scientific and Cultural Materials, with Annexes A to E and Protocol annexed. Florence, 17 June 1950.	07/01/1966	Ratification
5	Convention against Discrimination in Education. Paris, 14 December 1960.	17/07/1968	Acceptance
6	Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property. Paris, 14 November 1970.	27/01/1975	Acceptance
7	Convention concerning the Protection of the World Cultural and Natural Heritage. Paris, 16 November 1972.	26/02/1975	Acceptance
8	Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar, 2 February 1971.*	23/06/1975	Ratification
9	Protocol to amend the Convention on Wetlands of International Importance especially as Waterfowl Habitat. Paris, 3 December 1982.	29/04/1986	Accession
10	Protocol to amend articles 6 and 7 of the Convention on Wetlands of International Importance especially as Waterfowl Habitat. Regina, Canada, 28 May 1987.	20/07/1994	Ratification
11	Second Protocol to the Hague Convention of 1954 for the Protection of Cultural Property in the Event of Armed Conflict. The Hague, 26 March 1999.	24/05/2005	Accession
12	Convention for the Safeguarding of the Intangible Cultural Heritage. Paris, 17 October 2003.	23/03/2006	Ratification
13	Convention on the Protection of the Underwater Cultural Heritage. Paris, 2 November 2001.	16/06/2009	Ratification
14	International Convention against Doping in Sport. Paris, 19 October 2005	23/03/2010	Accession
*The States marked with an asterisk have accepted the amendments to Articles 6 and 7 of the Convention adopted by the Extraordinary Conference of the Contracting Parties (Regina, Canada, 1987). These amendments entered into force on 1 May 1994.			

APPENDIX. IX

Non-ratified Conventions, Protocols and Agreements by the state party of Iran

Source: UNESCO Cultural Heritage Laws Database (UNESCO/CLT/NATLAWS), designed by Author

Iran (Islamic Republic of) - Non-Ratified Conventions	
1	Universal Copyright Convention, with Appendix Declaration relating to Article XVII and Resolution concerning Article XI. Geneva, 6 September 1952.
2	Protocol 1 annexed to the Universal Copyright Convention concerning the application of that Convention to the works of stateless persons and refugees. Geneva, 6 September 1952.
3	Protocol 2 annexed to the Universal Copyright Convention concerning the application of that Convention to the works of certain international organizations. Geneva, 6 September 1952.
4	Protocol 3 annexed to the Universal Copyright Convention concerning the effective date of instruments of ratification or acceptance of or accession to that Convention. Geneva, 6 September 1952.
5	Convention concerning the International Exchange of Publications. Paris, 3 December 1958.
6	Convention concerning the Exchange of Official Publications and Government Documents between States. Paris, 3 December 1958.
7	International Convention for the Protection of Performers, Producers of Phonograms and Broadcasting Organizations. Rome, 26 October 1961.
8	Protocol Instituting a Conciliation and Good Offices Commission to be Responsible for Seeking the Settlement of any Disputes which may Arise between States Parties to the Convention against Discrimination in Education. Paris, 10 December 1962.
9	Convention on Technical and Vocational Education. Paris, 10 November 1989.
10	Convention relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite. Brussels, 21 May 1974.
11	Regional Convention on the Recognition of Studies, Diplomas, and Degrees in Higher Education in Asia and the Pacific. Bangkok, 16 December 1983.
12	Regional Convention on the Recognition of Studies, Diplomas and Degrees in Higher Education in Latin America and the Caribbean. Mexico City, 19 July 1974.
13	Protocol to the Agreement on the Importation of Educational, Scientific and Cultural Materials, with Annexes A to H. Nairobi, 26 November 1976.
14	International Convention on the Recognition of Studies, Diplomas and Degrees in Higher Education in the Arab and European States bordering on the Mediterranean. Nice, 17 December 1976.
15	Regional Convention on the Recognition of Studies, Certificates, Diplomas, Degrees and other Academic Qualifications in Higher Education in the African States. Arusha, 5 December 1981.
16	Universal Copyright Convention as revised on 24 July 1971, with Appendix Declaration relating to Article XVII and Resolution concerning Article XI. Paris, 24 July 1971.
17	Convention on the Recognition of Studies, Diplomas and Degrees in Higher Education in the Arab States. Paris, 22 December 1978.
18	Convention on the Recognition of Studies, Diplomas and Degrees concerning Higher Education in the States belonging to the Europe Region. Paris, 21 December 1979.
19	Convention for the Protection of Producers of Phonograms against Unauthorized Duplication of their Phonograms. Geneva, 29 October 1971.
20	Protocol 1 annexed to the Universal Copyright Convention as revised on 24 July 1971 concerning the application of that Convention to work of stateless persons and refugees. Paris, 24 July 1971.
21	Multilateral Convention for the Avoidance of Double Taxation of Copyright Royalties, with model bilateral agreement and additional Protocol. Madrid, 13 December 1979.
22	Protocol 2 annexed to the Universal Copyright Convention as revised on 24 July 1971 concerning the application of that Convention to works of certain international organizations. Paris, 24 July 1971.
23	Convention on the Recognition of Qualifications concerning Higher Education in the European Region. Lisbon, 11 April 1997.
24	Convention on the Protection and Promotion of the Diversity of Cultural Expressions. Paris, 20 October 2005
25	Revised Asia-Pacific Regional Convention on the Recognition of Qualifications in Higher Education. Tokyo, 26 November 2011
26	Revised Convention on the Recognition of Studies, Certificates, Diplomas, Degrees and Other Academic Qualifications in Higher Education in African States. Addis Ababa, 12 December 2014

APPENDIX. X
Law on the statute of Iranian Cultural Heritage Organization (ICHO)
Source: UNESCO Cultural Heritage Laws Database (UNESCO/CLT/NATLAWS)

Law on the statute of Iranian Cultural Heritage Organization (ICHO)
Date: Jul 19, 1988
No: 3487- S

Article 1 *- Definition: Cultural heritage consists of relics which indicate man's historical progress and serve as a basis for a better knowledge of human identity and their path of cultural progress, thus providing for Man's admonition. The Iranian Cultural Heritage Organization established by virtue of the law approved on Jan 30, 1986 and hereinafter referred to, as "Organization" in this Statute, shall be managed according to the regulations thereof.*

Article 2 *- Objective: To learn from man's cultural progress, and to preserve and elevate the cultural identity of the society,*

Article 3 *- Duties of the Organization: The duties of the Organization - concerning cultural heritage - including research, supervision, conservation, revitalization and presentation are as the following:*
1 - Designing and performing research plans on the remnants from the past;
2 - Surveying and exploring historical sites, hills, buildings and complexes; and building up their comprehensive inventory and the archeological map of the country;
3 - Performing archeological researches and scientific excavations;
4 - Undertaking anthropographical surveys, anthropological and bio-anthropological researches, and acquaintance of vernacular cultures in different parts of the country;
5 - Researching on traditional arts, and providing the condition for preservation, revitalization and growth of these arts,
6 - Registering the country's movable and immovable properties of cultural-historical significance in the National List for Cultural Heritage and other relevant lists,
7- Having exclusive standing to perform all legal affairs concerning cultural heritage, and initiating penal actions against the violators of the regulations regarding the country's cultural heritage, as accuser or private plaintiff according to the case,
8 - Taking necessary measures to identify and restitute Iran's cultural properties, at national and international levels, by referring to the pertinent authorities,
9 - Identifying and taking possession of all properties considered as cultural heritage which are of outstanding cultural and historical value, confiscated by other governmental organizations,
Note - All courts, customs, police forces and other governmental organizations, which under any title confiscate such properties, shall be obliged to transfer the properties of cultural historical value to the Iranian Cultural Heritage Organization.
10 - Designing and implementing plans to safeguard, preserve, repair, restore and revitalize the works, buildings and complexes which are of cultural and historical value,
11 - Giving opinions concerning all development comprehensive and master plans for cultural and historical zones, and making final decisions about valuable sites, fabrics and places in those zones, and protecting them against any kind of destruction,

12 - Delineating the protected areas for registered historical buildings, complexes, sites and hills; and formulating specific regulations for architecture and design inside the protected areas,

13 - Presenting works of cultural and historical value through museums, exhibits, and the like,

14 - Establishing, developing and administering the museums of the country,

15 - Establishing a Documentation-Center for Cultural Heritage of the Country (to keep documents like scientific reports, maps, photos of buildings, etc.) in order to provide scientific and research services in this regard,

16 - Publicizing the values of the country's cultural heritage - at national and international levels by publication of performed studies and researches, with the aid of audio-visual equipments and through the mass media,

17 - Compiling and publishing the encyclopedia of Iranian historical works and monuments,

18 - Developing research activities on various fields of cultural heritage, and encouraging researchers, artists and craftsmen,

19 - Designing and implementing educational programs to train personnel efficient for the activities concerning cultural heritage, with the co-ordination of relevant organizations,

20 - Encouraging the community to participate in the activities related to exploration, conservation, and revitalization of cultural heritage, which shall be supervised by the Organization,

21 - Establishing and expanding associations for cultural heritage throughout the country,

Note - Method of establishment and the extent of duties and powers imposed and entrusted to these associations shall be determined by the Council of the Organization.

22 - Establishing communications and scientific / cultural exchanges with relevant institutions and organizations at national and international levels, especially Islamic and regional countries; planning and organizing congresses and periodic seminars as necessary,

23 - Co-operating with the Ministry of Culture and Islamic Guidance on national and international tourism,

24 – Providing consultative, investigative, technical and educational services; selling cultural products; collecting entrance and admission fees of monuments, sites, museums and exhibits; and also receiving and accepting contributions, donations and the like,

Article 4 *- Constituents of the Organization:*

The Organization has 2 constituents:

1 - Council of the Organization, and

2 - Head of the Organization

Article 5 *- Council of the Organization: For further co-ordination in the activities concerned with cultural heritage of the country, a Council of the Organization to be composed of the 8 following members shall be convened:*

1 - Minister of Culture and High Education (Head of the Council);

2 - Minister of Culture and Islamic Guidance;

3 - Minister of the Interior;

4 - Minister of Justice;

5 - Minister of Foreign Affairs;

6 - Minister of Housing and Urban Development;

7 - Managing Director of Islamic Republic of Iran Broadcasting Organization (IRIB);

8 - Head of the Organization (Secretary of the Council).

Note 1 - If the vote is equally divided, the Head of the Council shall have the casting vote.
Note 2 - On a regular basis, meetings of the Council shall be held at least twice a year.
Following the recommendation of the Head of the Organization, it shall be the duty of the Minister of Culture and High Education to call a meeting of the council, and to preside over the sessions.
Note 3 - The Council may call upon persons whose presences in the sessions seem - by some means -necessary. These persons do not have the right to vote.
Note 4 – In each meeting of the Council, 5 members shall constitute a quorum, and the decisions of the Council will be valid by the vote of at least 4 present members.

***Article 6** - Duties of the Council: The duties of the council are as follows:*
1 - Defining strategies and general policies based on the law on establishing the Iranian Cultural Heritage Organization, and the Organization's Statute;
2 - Examining the reports on the Organization's activities, and expressing opinions about the reports.
Note - All the approvals of the council to be communicated shall be signed off on by Minister of Culture and High Education.

***Article 7** - Head of the Organization: Minister of Culture and High Education shall appoint The*
Head of the Organization.

***Article 8** - The units of the Organization throughout the country: According to situational demands and upon approval of the State Organization for Administrative and Employment Affairs, the Organization shall - with the favorable opinion of the Minister of Culture and High Education -establish its units any where in the country as it may deem proper. On the basis of the Organization's Statute and according to its approvals, these units shall be responsible for the affairs regarding cultural heritage in their respective territories of activity, under supervision of the Head of the Organization.*

***Article 9** - Upon the approval of this Act, all inconsistent laws and regulations shall be repealed.*

APPENDIX. XI

Sub-organization of ICHHTO and their interest and undertakings, designed by Author

The Name of sub-organization	Interests and Undertakings
Anthropology Research Centre, affiliated to the Research Institute to the Iranian Cultural Heritage, Handicrafts and Tourism Organization (RI-ICHHTIO)	Library and field ethnographic and anthropological research and documentation on the territories where Iranian cultures are observed
Linguistics, Inscriptions and Texts Research Centre, affiliated to the Research Institute to the Iranian Cultural Heritage, Handicrafts and Tourism Organization (RI-ICHHTIO)	Library and field research and documentation on the oral and written linguistic heritage on the territories where Iranian cultures are observed
Tehran ICH Centre Regional Research Centre for Safeguarding Intangible Cultural Heritage in West and Central Asia, Under the Auspices of UNESCO (Category 2)	Research for the safeguarding of the Intangible Cultural Heritage in West and Central Asia, and following the UNESCO programmes and strategy for Category 2 Centres on ICH
Deputy for Cultural Heritage affiliated to the Iranian Cultural Heritage, Handicrafts and Tourism Organization (ICHHTIO)	Policy-making and programming with an aim to safeguard Iranian cultural heritage, and supervising and guiding the related efforts at headquarter and field levels, while executing field projects to materialize and promote its undertakings and goals
Office for Inscriptions and Preservation and Revitalization of Intangible and Natural Heritage affiliated to the Deputy for Cultural Heritage, ICHHTO	Identification of tangible, intangible, and natural heritage elements and taking the necessary measures for their inscriptions on national and international inventories and lists, while supporting their preservation and revitalization
Iranian National Commission for UNESCO	Identification of national and international educational, scientific and cultural priorities and concentration of efforts on them based upon UNESCO strategies and programmes, while keeping the 5 functions of mediator, organizer, advisor, information source, and planner, executor and evaluator.
UNESCO Tehran Cluster Office	Execution and follow up of UNESCO programmes at the level of the region encompassing Afghanistan, Iran, Pakistan and Turkmenistan while taking the necessary direct and indirect measures to promote the related goals in collaboration with the related National Commissions for UNESCO and the interested governmental organizations.
School of Traditional Medicine Tehran University of Medical Sciences UNESCO Tehran Cluster Office	Academic research and documentation on Iranian Traditional Medicine.
Traditional Iranian Medical Society	Academic research and documentation on Iranian Traditional Medicine.
Research Institute for Islamic and Complementary Medicine, Iran University of Medical Sciences	Academic research and documentation on Iranian Traditional Medicine.
Iran House of Music	NGO for Research, documentation, and training on Iranian Music; follow up focal point for preservation and propagation of Iranian Music.
General Office for Music Iranian Ministry of Culture and Islamic Guidance	Preservation and propagation of Iranian Music.
Department of Music Art Faculty, Islamic Propagation Organization	Preservation and propagation of Iranian Music.
Pishin Pajouh Cultural and Art Institute NGO	Iranian Studies, with special focus on Iranian tangible and intangible cultural heritage and traditional arts; the outcomes being publications, audio-visual products, and documentation and research projects.

APPENDIX. XII

The scope of duties of organizations active in adobe cultural heritage conservation and explanation of the ongoing joint projects in this subject

CRAterre-ENSAG: CRAterre (International Centre on Earthen Architecture) is a research laboratory on earthen architecture based within the National Superior School of Architecture in Grenoble (ENSAG), which today is known as CRAterre-ENSAG (International Centre for Earth Construction–School of Architecture of Grenoble). This research center is assembled of a multidisciplinary group of researchers, professionals, lecturers and trainers that work on the dissemination of knowledge and know-how on earthen construction techniques in France and all over the world.

ICOMOS-ISCEAH: The aims and expectations of ICOMOS for ISCEAH (The International Scientific Committee of Earthen Architectural Heritage) is to maintain broad membership, carry out scientific inquiries, specialized studies, and to share information thereby contributing to the development of better practice and methods for the protection and conservation of the world's earthen architectural, archaeological and cultural landscape heritage.

UNESCO-WHEAP: The World Heritage Programme on Earthen Architecture (WHEAP) aims for the improvement of the state of conservation and management of earthen architecture sites worldwide. Pilot projects on earthen architectural sites inscribed on the World Heritage List, or included in States Parties' Tentative Lists, will help identify best practices and set examples for the development and dissemination of appropriate methods and techniques in conservation, management, and capacity building. Scientific research will further the endeavor to ameliorate know-how in the field. Expected results include a better understanding of the problems facing earthen architecture, the development of policies favoring its conservation, the definition of practical guidelines and the organization of training and awareness activities, particularly in local communities through workshops, exhibitions, conferences and technical publications to raise the recognition of earthen architecture, as well as the creation of an active global network for the exchange of information and experience.

GIAIA Project: The GIAIA Project, the subject of a plenary address, illustrates the joint efforts of ICCOROM and CRAterre-ENSAG to promote an integrated program of training, research, documentation, development of standards and technical cooperation at international, national, and regional levels.

WHE Project: The World Housing Encyclopedia (WHE) is a joint project of EERI (Earthquake Engineering Research Institute and IAEE (International Association for Earthquake Engineering. This project is a collection of resources related to housing construction practices in the seismically active areas of the world. The mission is to share experiences with different construction types and encourage the use of earthquake-resistant technologies worldwide.

GSAP Project: The Getty Seismic Adobe Project (GSAP) seeks to combine traditional construction techniques and materials with high-tech methodologies to design and test easy-to-implement seismic retrofitting techniques and maintenance programs to improve the structural performance and safety of earthen buildings while minimizing loss of historic fabric. The Results of this research have been disseminated in a series of publications, both in English and Spanish.

Terra Project: The Terra series of international conferences continues to be held under the aegis of the ICOMOS International Scientific Committee on Earthen Architectural Heritage. In recent years the Getty Conservation Institute, CRATerre EAG and UNESCO World Heritage Centre have been very valued supporters of the Terra series. The papers produced from these conferences reflect the range of work being carried out, the extraordinary international partnerships being forged and the approaches to earthen architecture in an international context. The Terra papers and other contributions to these conferences represent the significant part of the literature and research related to the field of earthen architectural study.

In order to develop earthen building codes in different countries, the colloquium participants suggested the following:

- Model guidelines and standards should be crafted to serve as references for governments developing their own building codes for earthen structures.

- Model guidelines and standards should be based on sound engineering principles and draw upon the best existing codes, guidelines, and standards to formulate their content. Guidelines and standards should allow for revision over time, based on any new understandings gained from earthquakes and testing programs.

- Codes must address the care and sensitivity to character-defining features required when existing historic buildings are retrofitted. This is generally different from requirements for new construction or for the retrofitting of non-historic vernacular buildings.

- Complementary building codes, standards, guidelines, and manuals addressing the conservation of historic earthen sites in seismic regions should be designed to target different audiences (i.e., professionals, builders, and the general public). If this is not possible, illustrations should be included in the code itself to make the content accessible to users with different levels of technical understanding.

- Slenderness ratios specified in existing codes should be standardized in relation to local seismic zones, to allow real comparison among codes and case studies.

- While addressing the structural components of earthen buildings, codes should consider the masonry, mortar, and plaster as one complete wall assembly. Tests such as those recently carried out at PUCP have shown that earth- or lime-based plasters dramatically improve the strength of earthen walls and control cracking during earthquakes while protecting walls from direct contact with water.

- Codes should consider the local and regional cultural contexts and settlement patterns, and the resulting building traditions. A national code may well need to address several very different regional patterns, construction techniques, and building cultures.

- Codes for earthen architecture borrow heavily from codes for stone masonry, brick, and concrete. It is important to study the possibility that aspects of codes for earthen architecture, especially in reference to historic resources, could influence the codes for other building materials as well.