Dancing to the Desert

A Proposal for Self-Help Reconstruction of Post-Earthquake Cities in Hot-Arid Climates

by

Sara Khakbaz Nejad

A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Master of Architecture

Waterloo, Ontario, Canada, 2011

Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Natural hazards kill 82,500 people globally in a typical year,[1] with earthquakes as the largest cause of death amongst all natural hazards in Central and Southern America, East Asia, Europe, and the Near East.[2] Damages are highest in middle-income countries due to lack of resources for hazard prevention and mitigation.[3] *Dancing to the Desert* concentrates on Bam, Iran, as a typical post earthquake city, searching for architecture appropriate for post-disaster cities of hot-arid climates.

Dancing to the Desert is a discourse on current seismic, urban, and architectural design conditions in hot-arid climates of the globe, and searches for an appropriate architecture for post-disaster cities in developing regions of the desert climate. Chapter One includes analysis on global seismic hazard conditions, focusing on the hot-arid climates in the world and concentrating on the city of Bam, Iran. Chapter Two includes a detailed analysis of the traditional as well as contemporary architecture of Bam, searching for appropriate architectural elements to use in the proposed architecture. Chapter Three proposes a Pilot Project for an orphanage in Bam, based on the architectural elements and strategies discussed in Chapter Two.

Through scientific research, case studies, a site visit to Bam, and discussions with local residents, this thesis finds an appropriate proposal adaptable to all post-disaster cities of the hot-arid climate. It also suggests various strategies for disaster prevention and mitigation through public education. These strategies educate the public in employing cultural and environmental friendly resilient architecture, which will subsequently reduce damage and fatalities on brisk of disaster. It also familiarizes the public with the proposed disaster prevention and mitigation strategies and facilitates the adoption of the proposed design in future post-disaster conditions.

1 Natural Hazards, Unnatural Disasters, 23.
2 World Bank staff based on EM-DAT/CRED, study from 1970 to 2010.
3 World Bank staff based on EM-DAT/CRED - damages from disasters scaled by GPD from 1970 to 2008.

Acknowledgements

Thanks to:

My Professors:

Terri Meyer Boake, Dr. Elizabeth English,
Dr. Jeff Lederer, Lloyd Hunt, Rick Haldenby, Dr. Tammy Gaber.

My Family:

Saeed Khakbaz, Fahimeh Dabiran, Parisa Nejad.

My Friends:

Shahab Baradaran, Niousha Bayanati, Golchehreh Farrokhkish,
Elnaz Ebadizadeh, Mostafa Goodarzi, Maryam Karimi, Leila Moslemi,
Prithula Prosun, Parisa Kohbodi, Ardavan Mozafari, Tania Fiuzi, Saghar Shokrollahi.

My Inspirations:

Sara Divsalar and Ali Divsalar at Rahavard Mehr Va Danesh Institute, Bam, Iran.
Students of Rahavard Mehr va Danesh Institute, Bam, Iran.
Mr. Moazzemi and Mr. Enayat at Bam's Disability Center, Bam, Iran.
Mr. Bolourchi, local resident of Bam, Iran.

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Introduction

Earthquakes are natural phenomena that occur spontaneously across the globe, causing loss of lives and destruction of buildings in structurally inappropriate buildings. In addition to physical distress, victims of earthquakes experience psychological trauma for loss of loved ones, lack of jobs, and lack of resources during the post-earthquake period.

The horrifying reality of earthquake destruction first occurred to me in 2003, when a 6.9 Richter earthquake destroyed over 80% of the city of Bam, Iran, and killed over 40,000 people. As an architecture student I found the interest and enthusiasm in myself to take actions to reduce the damage caused by earthquakes by providing better architecture for seismic prone areas. At the time, I was in my first year of undergraduate studies at the University of Waterloo Architecture program, and I did not really know what constituted 'better' architecture.

As time passed and I proceeded with my architectural studies, I heard of more cities destroyed by earthquakes. After the completion of my undergraduate studies, I decided to pursue a detailed research in seismic architecture and post-disaster construction in developing hot-arid regions, searching for a way to reduce fatalities and destruction caused by seismic tremors. Many major disasters, such as the 2010 earthquakes in Chile and Haiti and the 2011 Tsunami in Japan, occurred during my study period, underlining the importance of my subject of study. Even though these earthquakes occurred at different geographical locations and had different outcomes, it was evident that poor construction methods were the cause of fatality and damage in all of them.

After all these disasters, global donations were collected to provide medical assistance, food, and temporary shelter. Most post-disaster shelters were made of prefabricated units that were imported from other countries, and were to be replaced by permanent houses in the near future. This seemed like a good solution for solving the housing problem on temporary basis, but it did not address many other existing issues such as lack of jobs, post-trauma psychological conditions, and socio-cultural living conditions of the inhabitants. My goal was to find a proposal to solve all these problems with an architectural solution.

My research started with the study of the global seismic trends and hazards maps, demonstrating that developing countries in the hot-arid regions of the world face the highest risk of seismic damage. Interestingly enough, Bam is located in this region, which makes it the ideal city for the focus of this thesis. In 2008, I went to visit Bam for the first time. What astonished me as I traveled through the streets of Bam was the high number of people still residing in temporary post-disaster shelters five years after the earthquake, the number of unemployed residents, and the general poor psychological state of the local citizens.

I was most touched by a day-care orphanage taking care of 112 young survivors of the Bam earthquake. Through a series of survivor case studies in Bam, global, as well as regional research in seismicity and architecture, case studies of seismic resistant earth architecture, self help and asset-based construction, a literature review of psychological effects of self-help, and a study of traditional and contemporary architecture of Bam, I found a solution that addressed most post-disaster conditions. These conditions included homelessness, trauma, and unemployment. Through the research and design associated with this thesis, I proposed a pilot project for the orphanage in Bam, which was commended by the administration of the Orphanage Institute. The project is currently in the process of fund-raising for construction.

This thesis addresses key factors that should be considered in the reconstruction of post-disaster housing, and proposes a strategy for survivors of earthquakes in hot-arid climates to reconstruct climate appropriate homes through self-help, asset-based construction. Its goal is to prevent and mitigate damage and improve post-disaster reconstruction in low-income regions of the hot-arid climate.

1. Global Issues

1.1. Natural Hazards

1.1.1. Facts

Natural hazards such as earthquakes, floods, and hurricanes killed about 3.3 million people between 1970 and 2010. This represents an annual average of 82,500 deaths worldwide in a typical year.[1] Amongst all natural disasters, storms and earthquakes cause the greatest damage in the order mentioned.[2] Hazards are possible anywhere on the globe, but some areas are more prone to specific natural hazards than others; East and South Asia, Central America and Western South America are more subject to natural hazards than other regions.[3]

Study of damage caused by different natural disasters in various regions of the world from 1970 to 2010 demonstrates earthquakes are most destructive in East Asia, Europe, and Near East.[4] The study of death and damage rates from1970 to 2010 demonstrates fluctuations in both numbers, but also demonstrates the rise of damage in spurts (Fig. 1.01). Damage has increased greatly in the past two decades due to increased exposure to hazardous areas as a result of urbanization.[5] Today half of the world's population lives in cities, where only 30 percent of the world's population resided in cities in 1950. Fig. 1.02 shows that exposure to cyclones and earthquakes in large cities may rise from 680 million people in 2000 to 1.5 billion people by 2050. Studies demonstrate that damage due to natural hazards are highest in middle income countries (Fig. 1.03). Most large and rapidly growing cities are in the developing countries, where disaster prevention and mitigation is a struggle.[6] In such circumstances, where the built environment is not adaptable to the changes in the natural environment, natural hazards create disasters because of poor construction quality.

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1 Apurva Sanghi, Natural Hazards, Unnatural Disasters: The Economics of Effective Prevention, 23.
2 Sanghi, Natural Hazards, 27.
3 Sanghi, Natural Hazards, 32.
4 The World Bank, Natural Hazards Unnatural Disaster, 30.
5 Sanghi, NaFtural Hazards, 32.
6 Sanghi, Natural Hazards, 26.

FIG. 1.01. Deaths due to disasters have fluctuated, while the number of people affected has increased from 1970 to 2010.

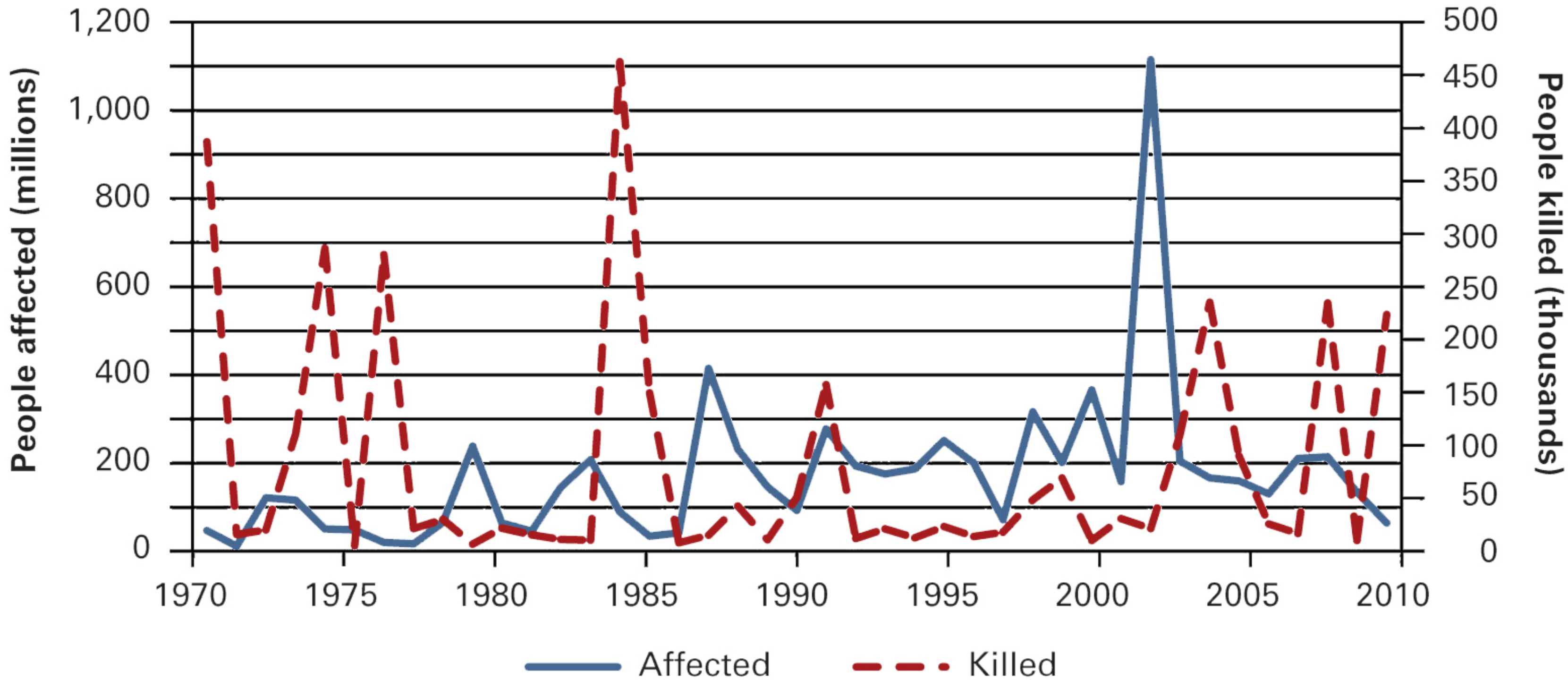


Fig. 1.01

FIG. 1.02. Exposure to cyclones and earthquakes in large cities may rise from 680 million people in 2000 to 1.5 billion people by 2050.

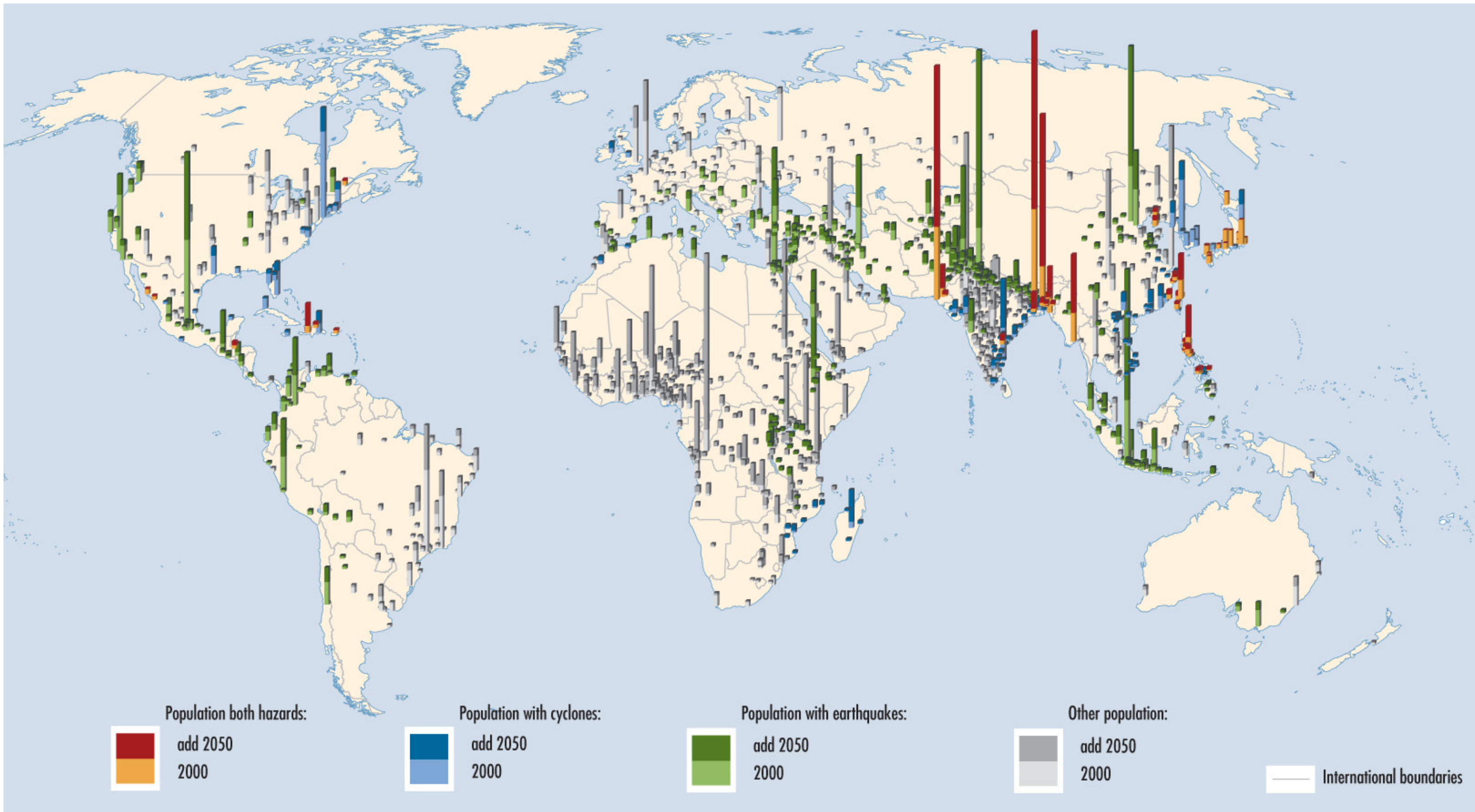


Fig. 1.02

FIG. 1.03. Damages due to natural hazards are highest in middle income countries.

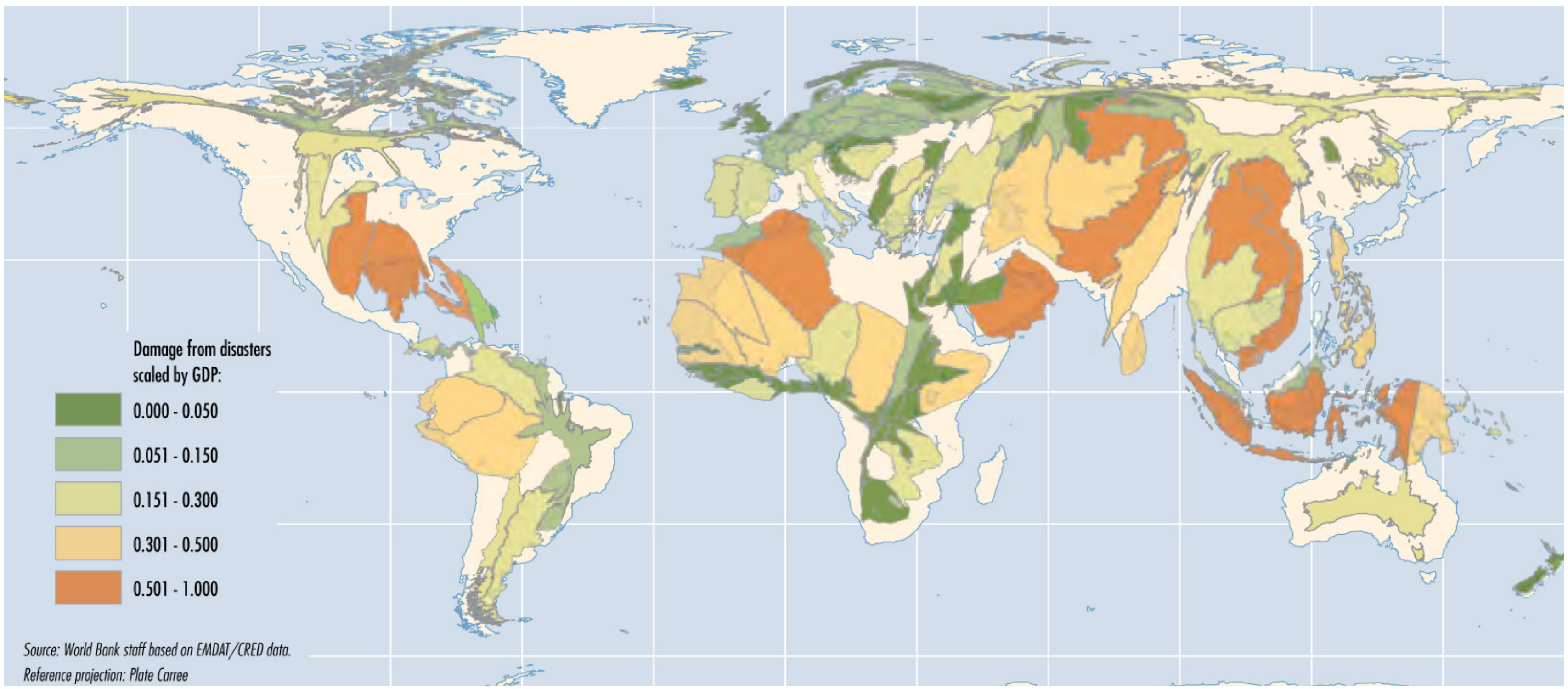


Fig. 1.03

1.2. Global Seismicity

1.2.1. Earthquake Science

Earthquakes are considered one of the most traumatic of natural phenomena because in a matter of seconds, with no prior warning, they can cause extremely high levels of devastation including death and destruction of property. The Earth is made of many layers, with the most outer layer called the tectonic plates. Tectonic plates are giant rocks that are constantly moving, sliding or colliding against one another. The movement of these plates is usually gradual and unnoticeable at the surface, but sometimes immense stress that has built up between the plates can be released quickly, sending massive vibrations, called seismic waves, through the rocks and up to the surface, causing what is called an earthquake.[7]

Earthquakes are usually measured on the Richter scale. This scale is calculated from the amplitude of the largest seismic wave recorded for the earthquake. The Richter magnitudes are based on a logarithmic scale, meaning that for each whole number on the Richter scale, the amplitude of the ground motion recorded by a seismograph goes up ten times, releasing 32 times more energy.[8] Fig. 1.05 describes the effects of seismic tremors with various magnitudes on the built environment. Seismic hazard is defined as the probable level of ground shaking associated with their re-occurrence of earthquakes.[9] In general, the larger seismic hazard values in the world occur in areas that have been, or are likely to be, the site of the largest plate boundary earthquakes.[10] About 80 percent of all the planet's earthquakes occur along the rim of the Pacific Ocean.[11]

7 National Geographic Society, "Earthquakes, Seismic Destruction," http://environment.nationalgeographic.com/environment/natural-disasters/earthquake-profile.html, accessed on 2 October, 2011.

8 Department of Geological Engineering and Sciences at Michigan Technological University, UPSeis: An Educational Site for Budding Seismologists, <http://www.geo.mtu.edu/UPSeis/intensity.html>.<http://www.geo.mtu.edu/UPSeis/intensity.html>, accessed on 6 October

9 Belen Garcia, ed., Earthquake Architecture: New Construction Techniques for Earthquake Disaster Prevention,10-11.

10 Ibid, 10-11.

11 National Geographic, "Earthquakes".

The earth has three important seismic zones: the circum-Pacific belt, which includes the Pacific coast from Chile to Alaska as well as many Asiatic islands such as Japan, the Philippines, New Guinea, and New Zealand; the trans-Asiatic (Alpide), which passes through the Himalayas, Iran, Turkey, and Mediterranean, and southern Spain; and the submerged Mid-Atlantic ridge belt, situated in the centre of the Atlantic ocean.[12] Fig. 1.04 demonstrates seismic areas, tectonic plates, stresses and faults within the quake belts.

1.2.2. Global Seismic Hazard

To understand the frequent effect of seismic activities, it is important to acknowledge the frequency of earthquakes at various magnitudes. Fig. 1.06 includes the number of earthquakes in each magnitude observed since 1990. According to this chart, the chances of a great earthquake with a magnitude of eight or higher is very rare, while over a million minor earthquake occur annually. People usually do not notice these minor earthquakes; it is the seismic activities with greater magnitudes that cause the destruction.

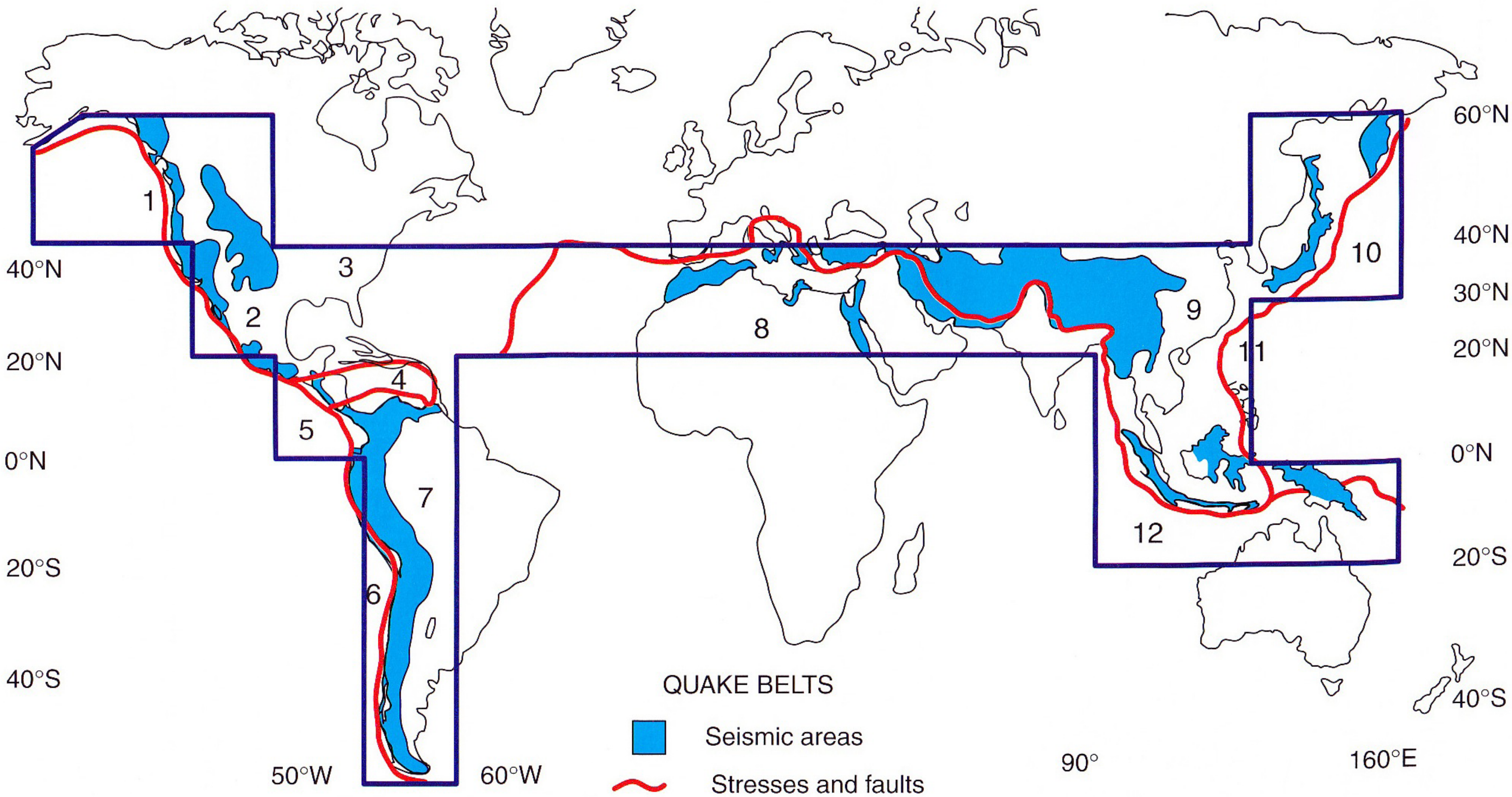
It is estimated that during the 20th century the number of earthquake victims reached 50 million.[13] The amount of damage caused by an earthquake is a result of many factors such as building design, distance from the epicenter, and the type of materials the building rests on.[14] Different construction materials and building techniques vary in seismic resistance; some building materials such as steel are more resistant to seismic pressures than others such as earth. In fact, earthen buildings are the least appropriate types of buildings for seismic prone areas. Interestingly, very large areas within the seismically active regions use earth as the main construction material. Employing earth as the primary construction material has a deep root in traditional architecture of these areas, as it is the most commonly available resource. Steel and other modern structural materials are not always locally available or affordable.

12 Ibid, 9.

13 Ibid, 8.

14 Department of Geological Engineering, UPSeis, http://www.geo.mtu.edu/UPSeis/intensity.html.

FIG. 1.04. Areas in the quake belts: map of the quake belts including seismic areas, tectonic plates, stresses and faults as they affect the area defined in the belts.



Tectonic Plates: areas in the Quake Belts

1 Garda Plate
2 San Andreas Plate
3 North American Plate
4 Caribbean Plate
5 Cocos Plate
6 Nazca Plate
7 South American Plate
8 Africa Plate
9 Euro-Asian Plate
10 Pacific Plate
11 Philippine Plate
12 Indo-Australian Plate

Fig. 1.04

FIG. 1.05. Average scale of destruction based on earthquake magnitude.

FIG. 1.06. Frequency of occurrence of earthquakes.

Magnitude	Earthquake Effects
2.5 or less	Usually not felt, but can be recorded by seismograph.
2.5 to 5.4	Often felt, but only causes minor damage.
5.5 to 6.0	Slight damage to buildings and other structures.
6.1 to 6.9	May cause a lot of damage in very populated areas.
7.0 to 7.9	Major earthquake. Serious damage.
8.0 or greater	Great earthquake. Can totally destroy communities near the epicenter.

Descriptor	Magnitude	Average Annually
Great	8 and higher	1 [1]
Major	7 - 7.9	17 [2]
Strong	6 - 6.9	134 [2]
Moderate	5 - 5.9	1319 [2]
Light	4 - 4.9	13,000 (estimated)
Minor	3 - 3.9	130,000 (estimated)
Very Minor	2 - 2.9	1,300,000 (estimated)

[1] Based on observations since 1900.
[2] Based on observations since 1990.

Fig. 1.05 (top) Fig. 1.06 (bottom)

Fig. 1.07 and the corresponding diagram (Fig. 1.08) locate the largest and deadliest seismic tremors from 1990 to 2005, demonstrating that the deadliest earthquakes have occurred along the trans-Asiatic belt, while the largest earthquake have occurred at the rim of the Pacific Ocean. The Trans-Asiatic belt includes many developing countries located within a desert climate. As resources are limited in these countries, and the most easily available local resources is earth, most of the buildings are constructed of un-reinforced adobe and brick, causing high levels of destruction upon seismic activities.

Earthquakes can be foreseen to some extent through the study of the history of seismic activities in a region.   Seismic tremors cannot be prevented, but can be prepared for. The map of anticipated great earthquakes (Fig. 1.09) also demonstrates that many threatened cities are located in developing countries with earth as the main construction material. Most urban areas that seismologists predict to have a 1 in 10 chance of an earthquake in the next 40 years are located along the Eurasian belt. These urban cities have over one million inhabitants and large districts of poorly constructed buildings, a large number of which are made of earth. Even a moderate tremor in these places can result in a catastrophic destruction of buildings.[15]

15 The New York Times, "Where Shoddy Construction Could Mean Death – Map," The New York Times, February 24, 2010. Accessed 1 sept 2011. http://www.nytimes.com/interactive/2010/02/24/world/20100224-quake-map.html

FIG. 1.07. Largest and deadliest earthquakes 1990-2005.

	Largest Earthquakes				Deadliest Earthquake			
Year	Date	Magnitude	Fatalities	Region	Date	Magnitude	Fatalities	Region
2005	03/28	8.7	1,313	Northern Sumatra, Indonesia	03/28	8.7	1,313	Northern Sumatra, Indonesia
2004	12/26	9.0	283,106	Off West Coast of Northern Sumatra	12/26	9.0	283,106	Off West Coast of Northern Sumatra
2003	09/25	8.3	0	Hokkaido, Japan Region	12/26	6.6	31,000	Southeastern Iran
2002	11/03	7.9	0	Central Alaska	03/25	6.1	1,000	Hindu Kush Region, Afghanistan
2001	06/23	8.4	138	Near Coast of Peru	01/26	7.7	20,023	India
2000	11/16	8.0	2	New Ireland Region, P.N.G.	06/04	7.9	103	Southern Sumatera, Indonesia
1999	09/20	7.7	2,297	Taiwan	08/17	7.6	17,118	Turkey
1998	03/25	8.1	0	Balleny Islands Region	05/30	6.6	4,000	Afghanistan-Tajikistan Border Region
1997	10/14	7.8	0	South of Fiji Islands	05/10	7.3	1,572	Northern Iran
	12/05	7.8	0	Near East Coast of Kamchatka				
1996	02/17	8.2	166	Irian Jaya Region Indonesia	02/03	6.6	322	Yunnan, China
1995	07/30	8.0	3	Near Coast of Northern Chile	01/16	6.9	5,530	Kobe, Japan
	10/09	8.0	49	Near Coast of Jalisco Mexico				
1994	10/04	8.3	11	Kuril Islands	06/20	6.8	795	Colombia
1993	08/08	7.8	0	South of Mariana Islands	09129	6.2	9,748	India
1992	12/12	7.8	2,519	Flores Region, Indonesia	12/12	7.8	2,519	Flores Region, Indonesia
1991	04/22	7.6	75	Costa Rica	10/19	6.8	2,000	Northern India
	12/22	7.6	0	Kuril Islands				
1990	07/16	7.7	1,621	Luzon, Philippine Islands	06/20	7.4	50,000	Iran

Fig. 1.07

FIG. 1.08. Location of largest and deadliest measured earthquakes in history demonstrate that the largest earthquakes are not necessarily the deadliest ones.

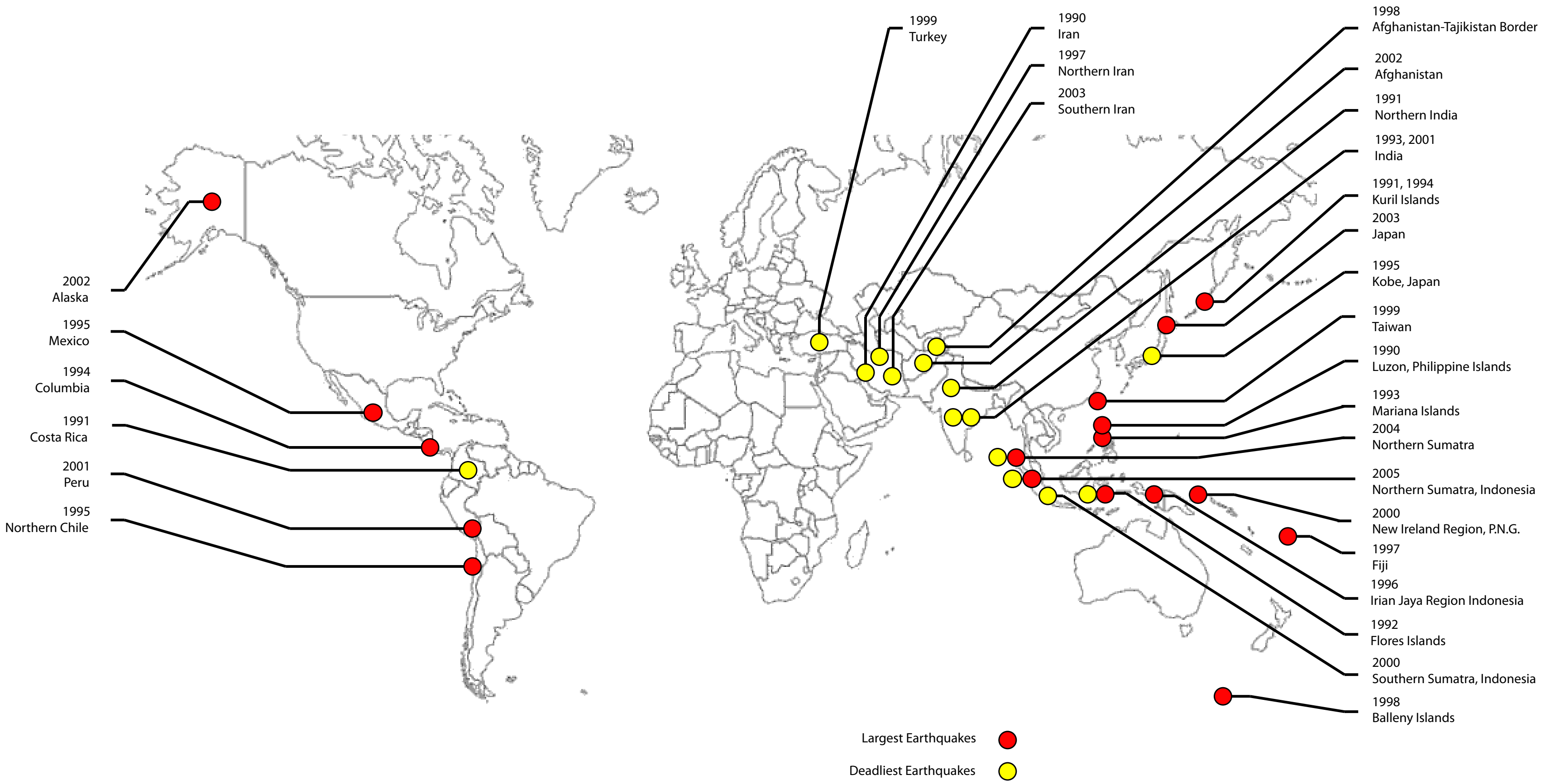


Fig. 1.08t

FIG. 1.09. Urban areas facing a 1 in 10 chance of an earthquake in the next 40 years.

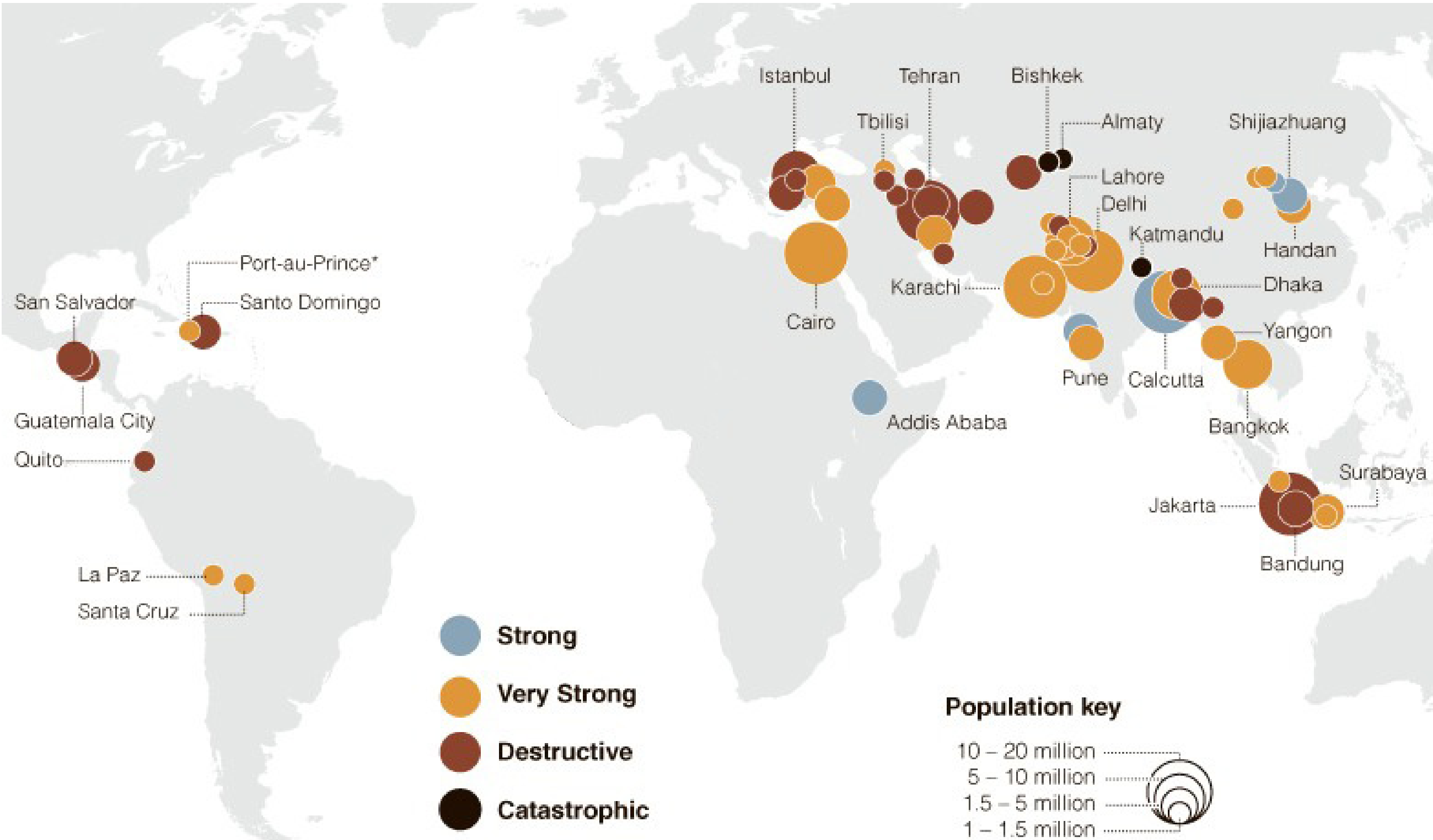


Fig. 1.09

1.3. Climate, Seismicity, and Architecture

Bam's 2003 earthquake left 40,000 dead and destroyed over 80% of all buildings, including the Bam Citadel, the largest earth structure of its kind in the world, and on the list of UNESCO's World Heritage Sites.

The significance of building construction and technique is evident in a comparison of the earthquakes of similar magnitude in different regions of the globe; of regions with un-reinforced earth as the main construction techniques such as Iran, verses regions with seismic proof buildings such as California. Bam's earthquake in 2003 is also comparable with the San Simeone earthquake. Both of these earthquakes were 6.5 magnitudes that occurred at approximately the same 5-mile depth. The results of these two earthquakes were dramatically different due to building construction techniques and vulnerability of buildings to seismic activity. In the California quake, where most buildings are seismically resistant, two people were killed and 40 buildings were severely damaged. Damaged buildings were mostly un-reinforced masonry structures that were built of brick and mortar with no special support features or metal strengthening. Bam's 2003 earthquake left 40,000 dead and destroyed over 80% of all buildings.[16] Buildings in Bam were typically adobe structures, made of dried mud bricks with little or no reinforcing. Fig. 1.10 demonstrates a comparison of various earthquakes with similar magnitutes in California and different regions of Iran. Even though Loma Prieta and Northridge have a denser urban fabric than Tabas, Rudbar, and Bam, their death toll average was 55 people, while the Iranian cities had an averge death toll of 34,000 people. It is evident that the significant different is a result of building seismic safety and stability.

16 Thomas O'Rourke, "EERI sends engineering team to Iran," Press Release, Earthquake Engineering Research Institute. Accessed 3 December 2010. http://www.eeri.org/lfe/pdf/iran_bam_press_release.pdf.

Today with the help of modern technology, buildings of all types and scales can be built to resist seismic tremors. Millennium Tower in Tokyo, Japan, by Foster and Partners, challenged the possibilities of earthquake resistant structures in terms of height in 1990.[17] Fruits Museum in Yamanashi, Japan, challenged the building location of seismic resistant architecture. This building was located 18 miles from Mount Fuji, in one of the most active seismic zones in the world.[18] Advanced architectural and construction technologies allow for a wide range of seismic resistance designs. However, these technologies are not affordable in a low-income population in the developing world, especially in post-disaster conditions. The financially restricted class tends to use commonly available natural resources to construct their homes. In some regions such as Japan, the lower class is blessed with accessibility of resilient and tensile natural resources such as bamboo. However, in the hot-arid climates, bamboo is not accessible at all, and availability of wood is very limited. In these areas, un-reinforced earth, which is the weakest construction technique against seismic tremors, is used as the main construction technique.

17 Garcia, Earthquake Architecture, 153.
18 Ibid, 159.

FIG. 1.10. Death toll comparison for earthquakes in Iran vs. California.

FIG. 1.11. Millenium Tower, Tokyo, Japan.

FIG. 1.12. Fruits Museum, Yamanashi, Japan.

Earthquakes in Iran				
Earthquake	**Date**	**Mw**	**Deaths**	**Environment**
Tabas	1978	7.2	11,000	Rural
Rudbar	1990	7.3	40,000	Rural
Bam	2003	6.5	50,000	Town
Earthquakes in California				
Earthquake	**Date**	**Mw**	**Deaths**	**Environment**
Loma Prieta	1989	6.9	62	Urban
Northridge	1994	6.7	51	Urban

Fig. 1.10

Fig. 1.11

Fig. 1.12

1.3.1. Geographical Focus of this Thesis

This thesis searches for an architectural proposal for the low-income population of disaster prone areas of the globe. A series of geographical and seismic studies were performed to determine the areas of focus for this thesis. As discussed earlier, the highest seismic hazard risk occurs along plate boundaries and fault lines, the weakest construction material in terms of seismic resistance is un-reinforced earth, and the cities that suffer the most from hazards are located within the developing world. To find the areas that are seismic prone, have desert soil, and earthen architecture, the map of quake belts (Fig. 1.04), the map of seismic hazard regions with desert soils (Fig. 1.13) and areas with earth buildings (Fig. 1.14) were overlapped. It is interesting that most of the regions that have all conditions are located within the developing world, where availability of resources is limited. Fig. 1.15 shows two areas that are seismically active with desert soil as the predominant construction material for building, one in America and one in Asia, covering parts of Europe and Africa.

FIG. 1.13. Map of soils in quake belts across the globe.

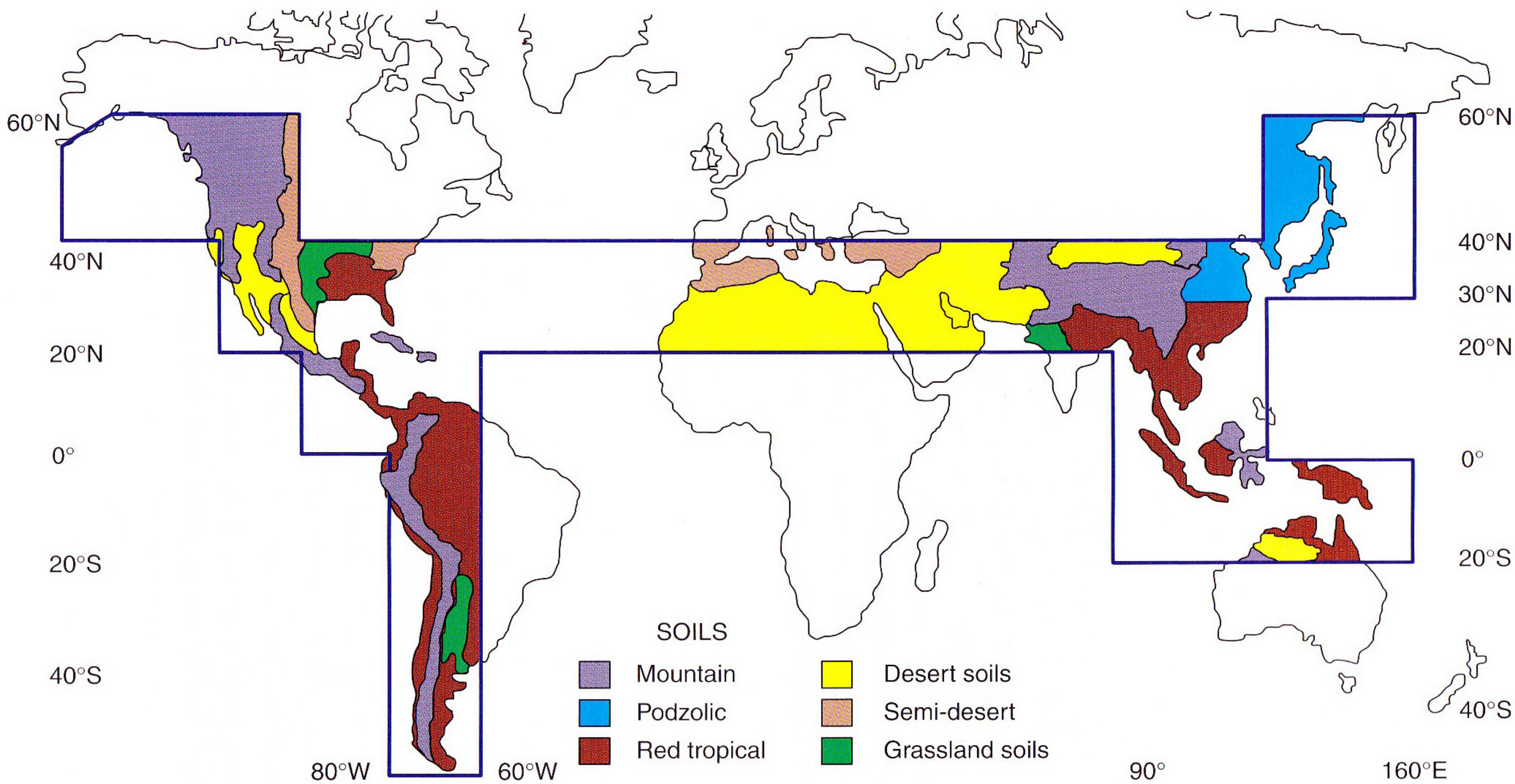


Fig. 1.13

FIG. 1.14. Map of earthen buildings in seismic areas of the globe.

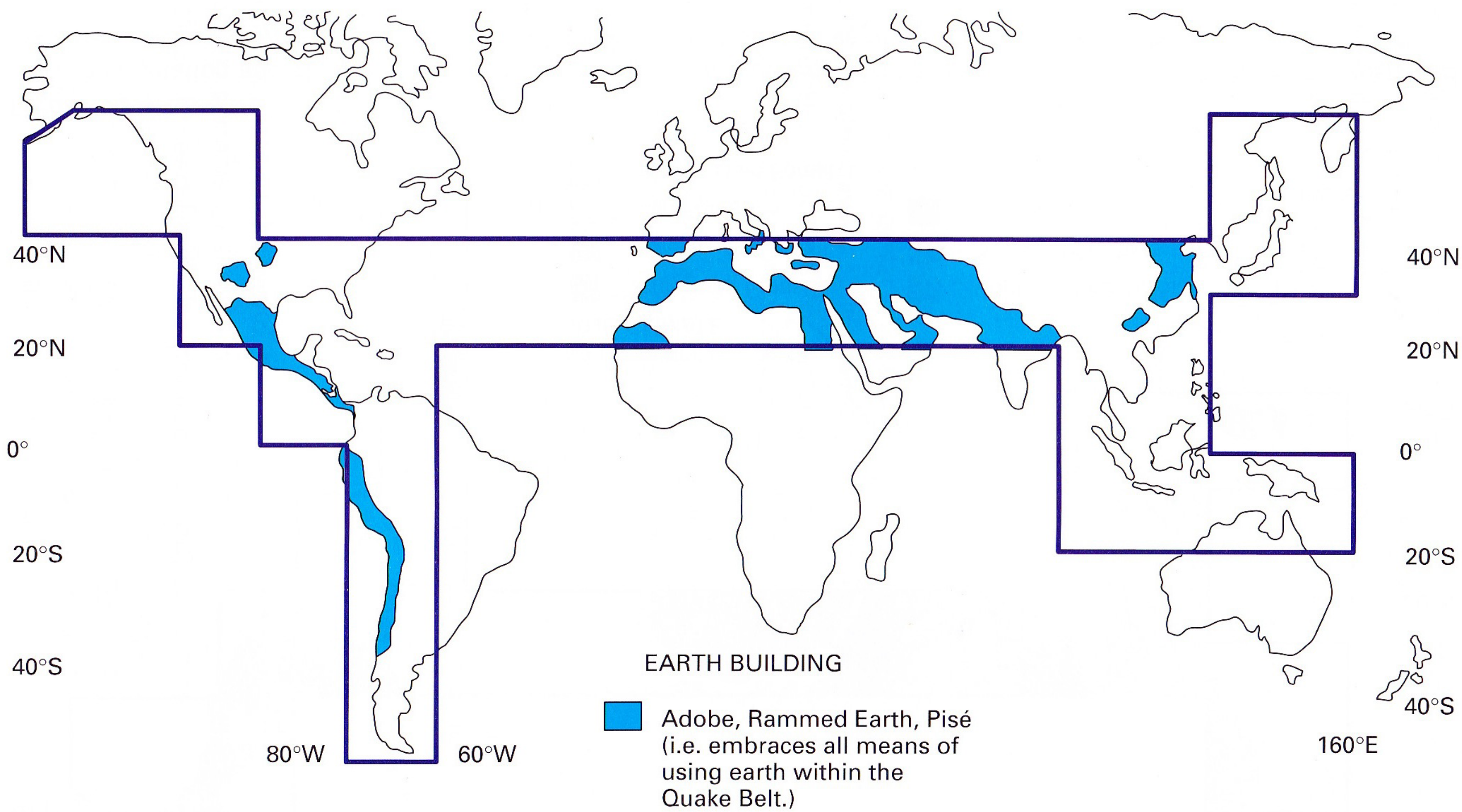


Fig. 1.14

FIG. 1.15. Seismic prone areas with desert soil and earthen architecture are suitable for this thesis.

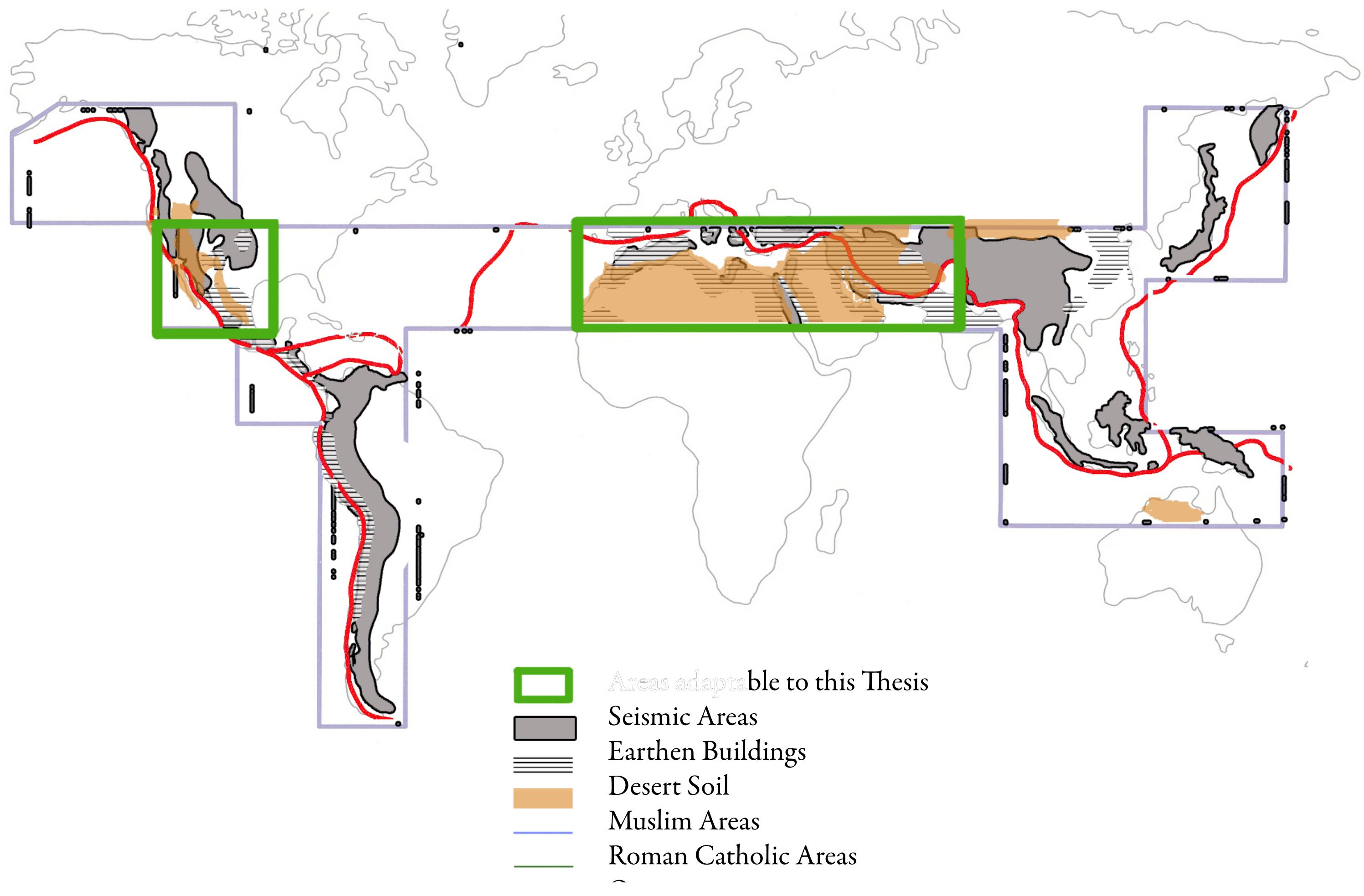


Fig. 1.15

Even though the two adaptable areas share similarities such as geographical conditions and building construction techniques, they vary from one another in culture and religion. The Eastern area is mostly Muslim and the Western area is mostly Roman Catholic. It is interesting that even though these two areas are so geographically, culturally, and religiously distant from one another, their architecture is very similar due to climatic similarities. The two communities of Boshrouyeh in the desert of Iran (Fig. 1.16) and Taos in the New Mexico desert of the United States (Fig. 1.17) have two entirely different cultures, religions, and race of inhabitants, but have very similar architecture both spiritually and physically.[19] Both communities have an inward architecture; residences are located around a courtyard in Boshrouyeh and around a 'nansipu' in Taos. Both deploy earth as the main construction material and are oriented according to sun and wind directions. Both communities are built with maximum common walls and minimum exposure to the outside. They also use minimum material to provide maximum usable space. Both communities follow the philosophy of living in harmony with the permanent natural forces. Buildings in Taos symbolize the "rising from the ground" spirit, and the buildings in Boshrouyeh represent "dust-to-dust" philosophy and the spirit of returning to the earth. The architectural similarities between Taos and Boshrouyeh prove that climatic context is the most influential element on the architecture of these regions.

This thesis expresses the importance of culture and its effects on architecture. It proposes a general guideline appropriate for the adaptable regions, but also stresses alteration of the guideline to reflect the social and cultural context of the individual location. This thesis further concentrates on Bam, Iran, as a typical post-disaster city with un-reinforced earthen buildings within the hot-arid climate of the developing world. It proposes a pilot project for this city that is adaptable for all locations with similar conditions.

FIG. 1.16. Collage of Boshrouyeh, Iran.

FIG. 1.17. Taos Pueblo, New Mexico.

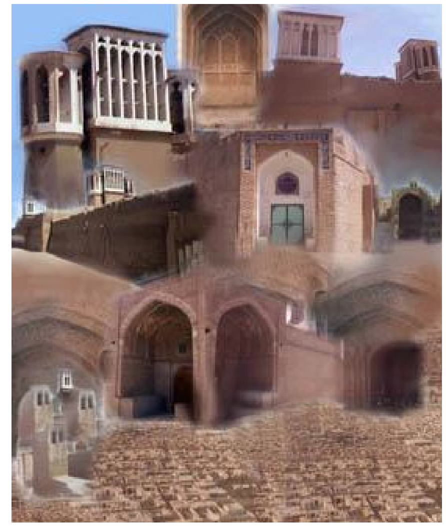


Fig. 1.17 (top) Fig. 1.16 (bottom)

19 Khalili, Ceramic House and Earth Architecture: How o Build Your Own, (Hesperia, California: Cal Earth Press, 2000), 7.

2. Typical City- Bam, Iran

2.1. Geographic Context

2.1.1. Seismicity

This thesis focuses on Bam, an ancient city in the province of Kerman, Iran (Fig. 2.01), as a typical post-earthquake city with earthen buildings in the developing world. Iran is located in an extremely hazardous zone due to its geographical location (Fig. 2.02, Fig. 2.03). The city of Bam, located in the Persian Plateau, on the Trans-Asiatic tectonic plate is within one of the most seismically hazardous regions of Iran. Fig. 2.04 demonstrates that Bam and its surroundings are threatened by different types of active faults. These faults consist of thrust and reverse faults, strike-slip faults, and inferred faults (Fig. 2.05). It also includes the location of past earthquakes along Golbaft Fault, north-west of Bam . Even though Bam is located in a seismically active region, it had not been affected by a major earthquake in the past 500 years, until a 6.6 Richter earthquake hit this city in 2003.[1] Fig. 2.06 shows a satellite image of Bam after the earthquake of 2003. The fault scarps are so deep that they are visible in the satellite image. Fig. 2.07 shows a 5 meter high scarp in Bam fault east of the city of Bam, and Fig. 2.08 shows the damage caused by the earthquake.

In addition to Bam's seismically active location in the developing world, this city is the ideal focus for this thesis due to its historical significance, its desert vernacular architecture, and its contemporary post-disaster reconstruction, all of which are common conditions in post-disaster cities within the hot-arid, developing countries.

1 Talebian, M., et al. (2004), The 2003 Bam (Iran) earthquake: Rupture of a blind strike-slip fault, Geophys. Res. Lett., 31, L11611, doi:10.1029/2004GL020058.

FIG. 2.01. Location of Iran in Asia, Province of Kerman in Iran, City of Bam in Kerman.

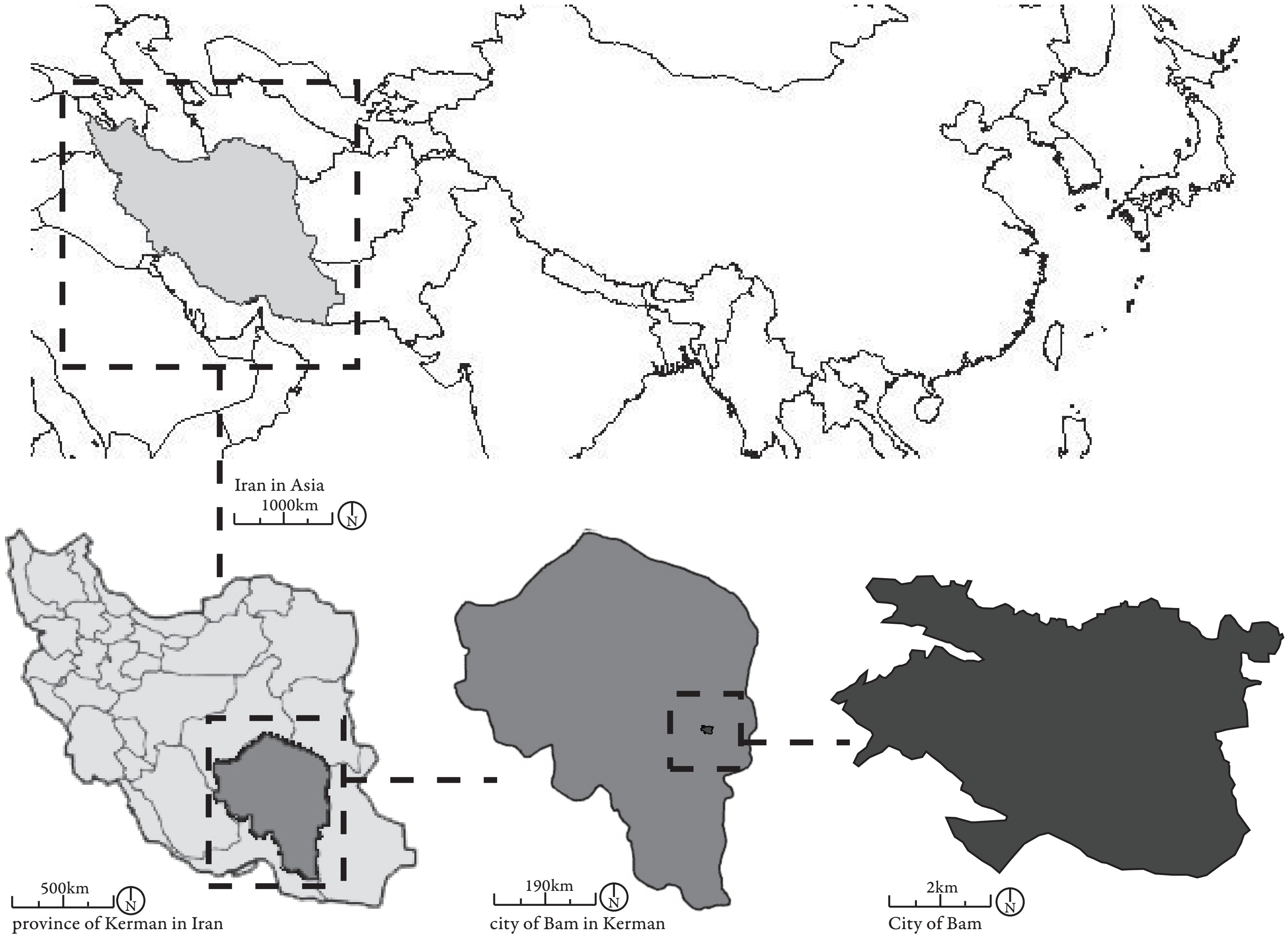
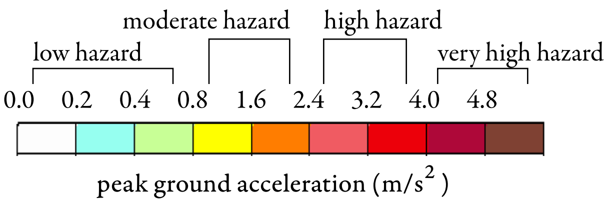


FIG. 2.02. Global seismic hazard map.

FIG. 2.03. Iran seismic hazard map.



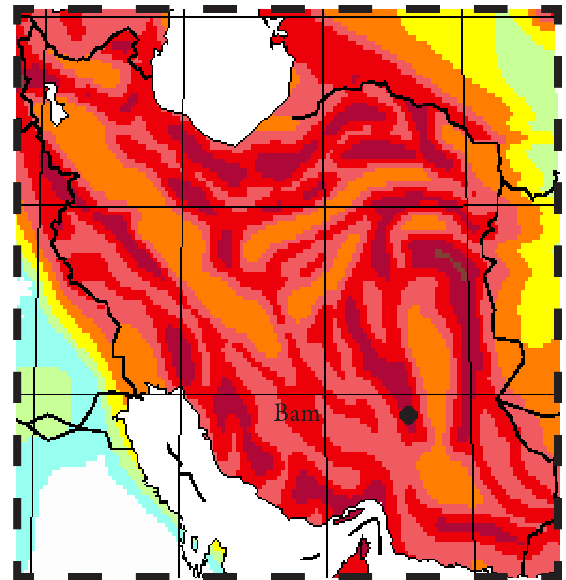


Fig. 2.03

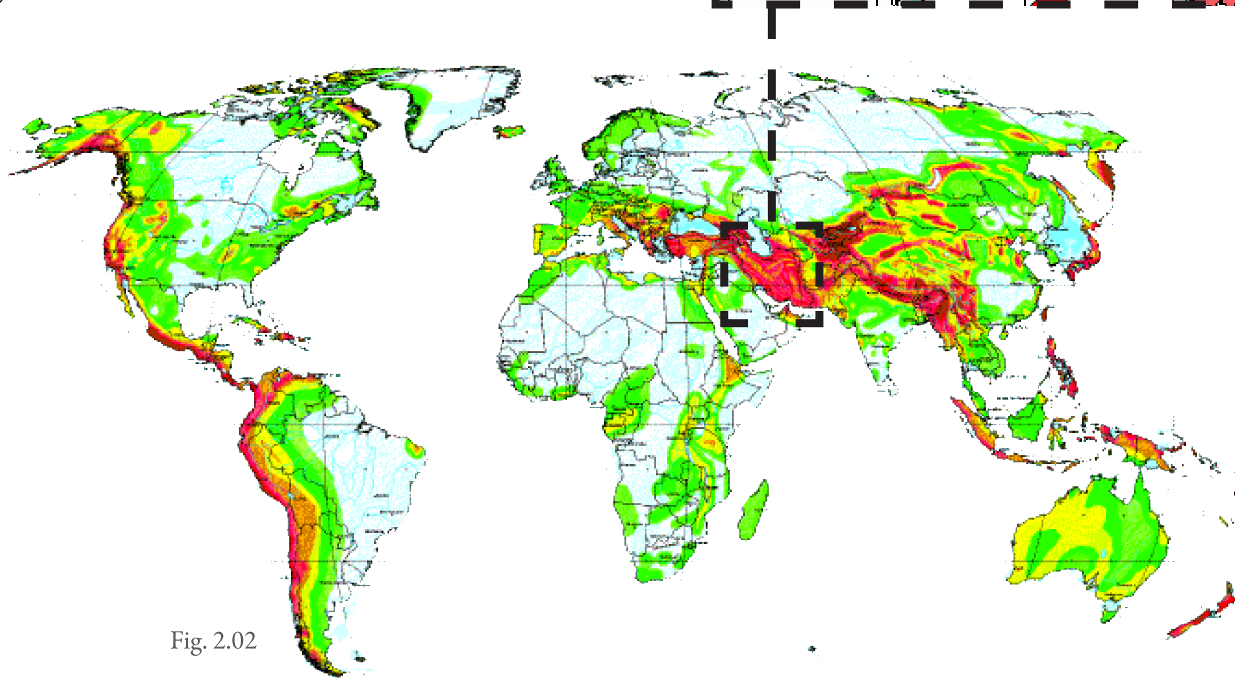


Fig. 2.02

FIG. 2.04. Major active faults of Iran.

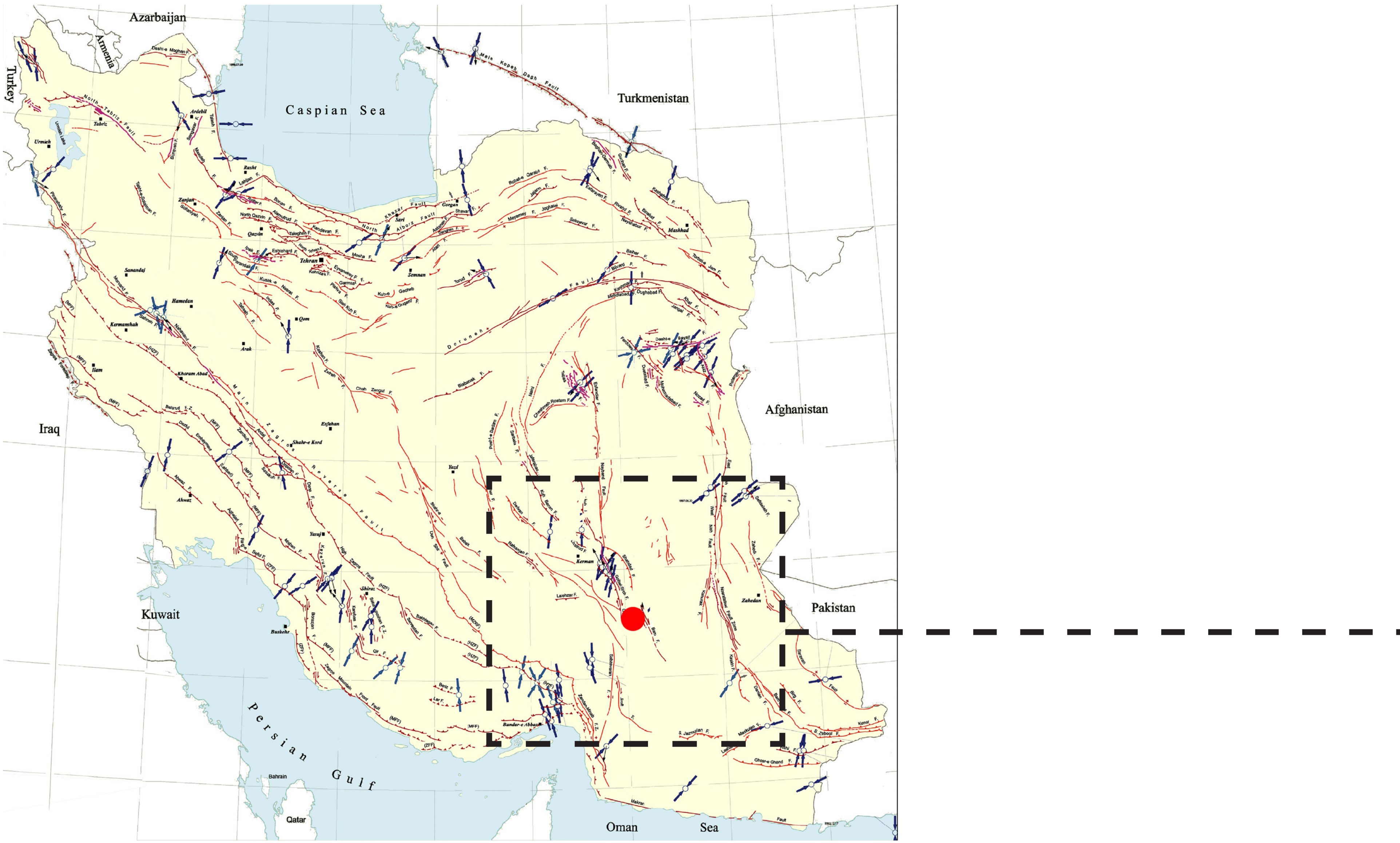


FIG. 2.05. Bam is located close to seismically active strike-slip faults, thrust and reverse faults, documented Quaternary faults, and many recorded earthquake locations.

Bam

types of active faults

earthquake fault
(surface rupture associated with earthquake)

seismically active fault
(fault show seismic activity has
been documented
but not resulted in surface rupture)

documented Quaternary fault
(fault which has been active during the
Quaternary times)

fault mechanism and notation

thrust and reverse fault

fault without spcification

strike-slip fault with sense of motion

relative upthrown and downthrown sides

inferred fault location

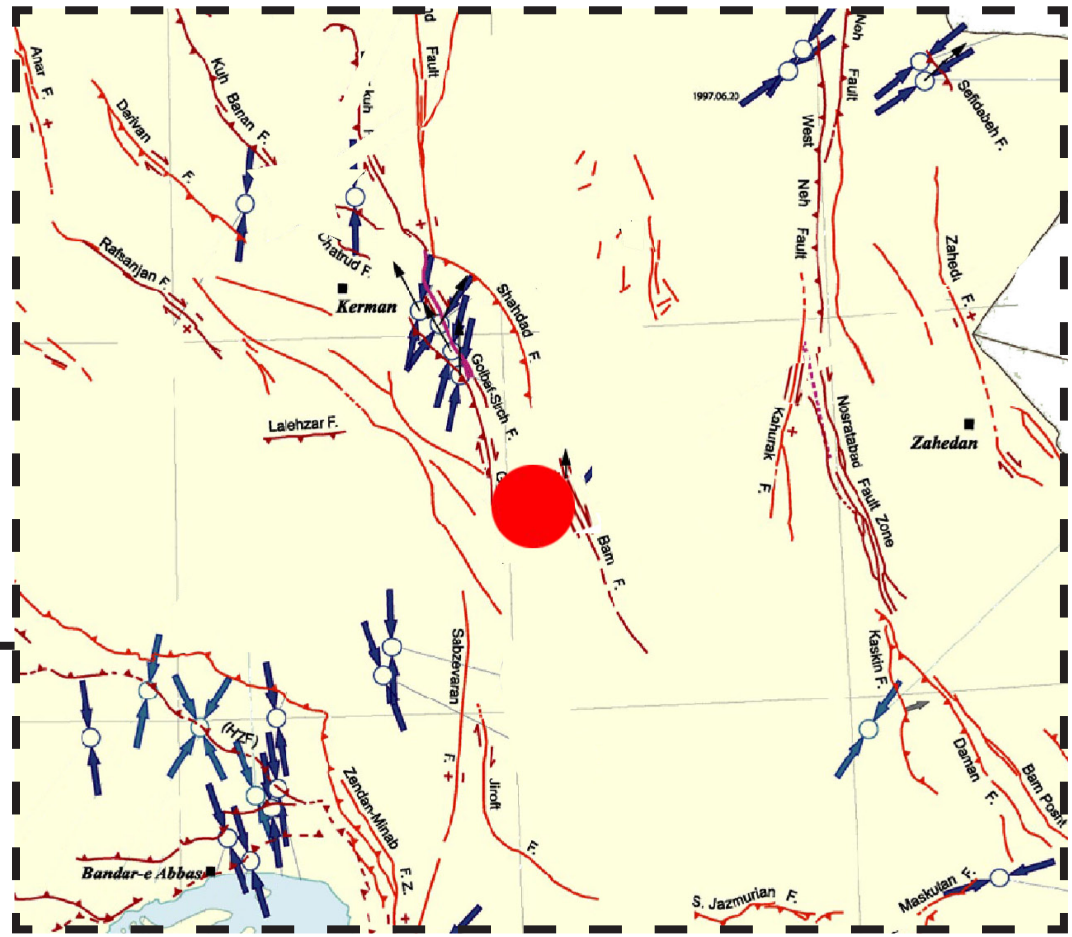
seismological legend

earthquake location

horizontal component of slip vector

horizontal component of compressive axis

0 25 50km



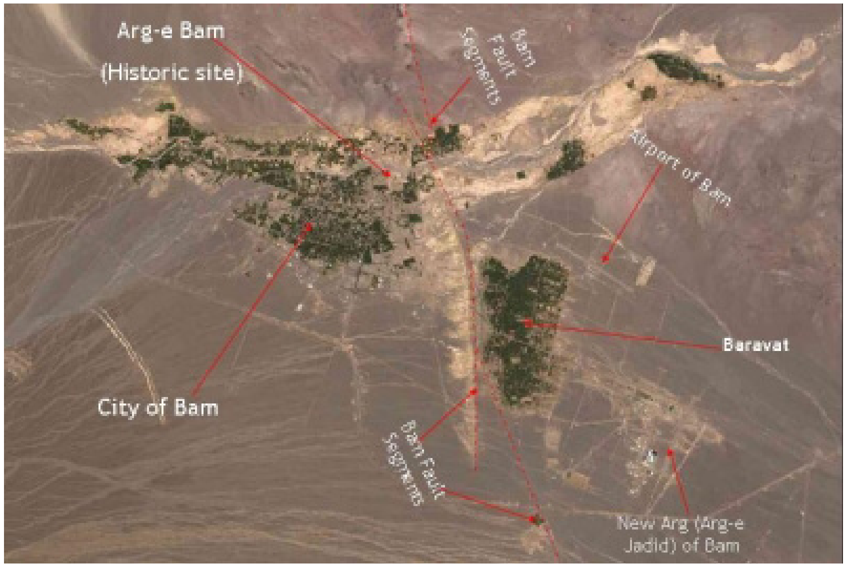


Fig. 2.06

Fig. 2.07

Fig. 2.08

FIG. 2.06. The Bam fault is evident in the satellite image of Bam after the earthquake in 2003.

FIG. 2.07. The 5 meter Bam Fault to the east of Bam.

FIG. 2.08. Damage caused by the 6.6 earthquake in Bam, 2003.

2.1.2. Solar Conditions

Bam is located south of the Central Iranian Desert, in a region that has a hot and dry climate with very little rainfall. This city's latitude is 29° N and its longitude is 58° E, Bam's average temperature is 22.6°C. Its average high temperature is 39.5° and its average low temperature is 4.9°C. Bam has long, hot summers, and cold, short winters. This city has an annual average rainfall of 64.1 mm with the average highest daily rainfall of 15.4 mm. Due to its geographical location, Bam has very sharp sun angles. Its weather is sunny over 80% of warm days and 60% of cold days, and it has a clear sky most of the time.[2] The summer sun rises 28° north of east and sets 28° north of west with an angle of 84.5 degrees at noon on June 21st (Fig. 2.09, Fig. 2.10). The winter sun rises 62° south of east and sets 62° south of west with 84.5 degrees sun angle at noon on December 21st (Fig. 2.11, Fig. 2.12).

2.1.3. Wind Conditions

Wind is a significant natural element in Bam. The prevailing wind blows from north during summer and from west during other seasons. Average speed of wind is 8 m/s during winter, and is less than 5 m/s during other seasons. Dusty winds blow from the south in the summer, while favorable winds blow from the north (Fig. 2.13). On hot days, the wind does not cause any discomfort if warm air or dust do not accompany the wind, but on cold days if the temperature drops below 16°, the winds will be undesirable, and if it drops lower than 5° it will be very unpleasant. The southeast wind is very hot and unfavorable. In traditional houses the rooms have their backs to this direction.[3]

2 Ibid., 61.
3 Ibid.

FIG. 2.09. The sun shines at a 47.5 degrees angle in Bam at noon on June 21st.

FIG. 2.10. Path of Sun and direction of sunlight in Bam on 21 June.

FIG. 2.12. Path of Sun and direction of sunlight in Bam on 21 December.

FIG. 2.11. The sun shines at a 47.5 degrees angle in Bam at noon on December 21st.

FIG. 2.13. Direction of wind in Bam.

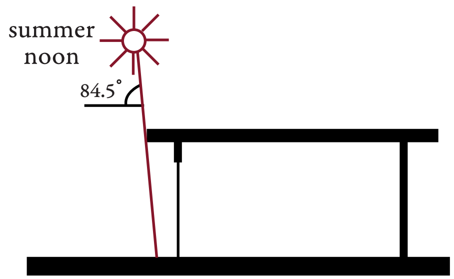


Fig. 2.09

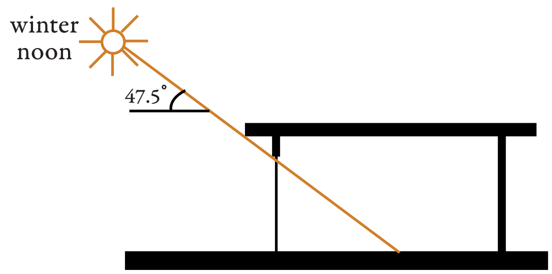


Fig. 2.11

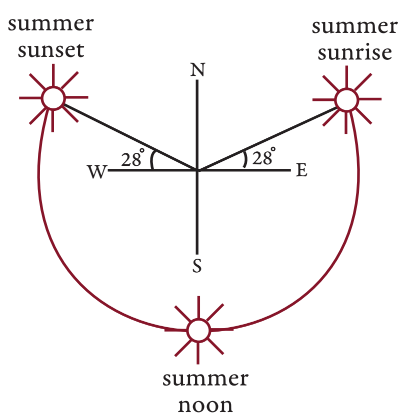


Fig. 2.10

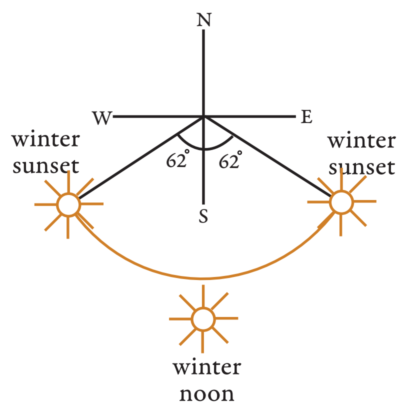


Fig. 2.12

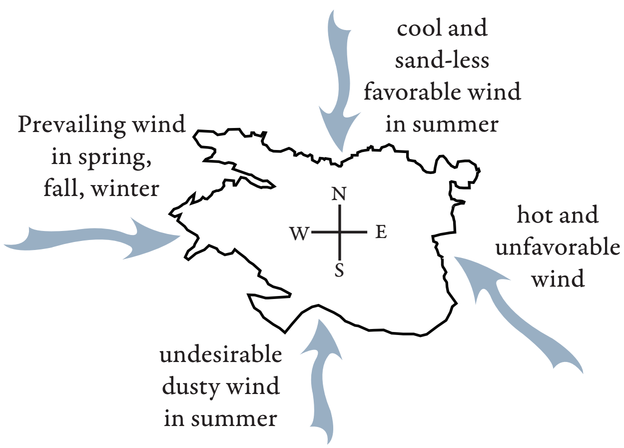


Fig. 2.13

2.2. Historical Context

2.2.1. Bam, an Ancient City

Bam has been of great significance since antiquity due to its crucial location on the route of the Silk Road (Fig. 2.14). The urban and architectural heritage of Bam dates back to antiquity, when the ruler resided in the Citadel and the citizens lived in residential areas to the west of the Citadel (Fig. 2.15). Around 1106 A.D., the residential area was relocated to surround the Citadel (Fig. 2.16). The first commercial, religious, and urban centers of Bam were created between 1842 and 1901 A.D. The city of Bam increased its growth in the 1920s (Fig. 2.17), and the first urban plan of Bam was created in 1956 (Fig. 2.18). This city was connected to adjacent cities with highways in 1966 (Fig. 2.19). Bam gradually increased its growth both in terms of scale and in terms of industry and economy. In 1985, the economical boundary of Bam was almost twice the size of its township boundary (Fig. 2.20), demonstrating this city's economical success.[4] Bam has been a significant trading center through the ancient history of Persia as well as during the modern history of Iran. The ancient Citadel of Bam, dating back to about 2500 years ago[5], is another major attraction for this city.

4 Mahallati, 98.

5 Global Security, Bam, http://www.globalsecurity.org, accessed on 3 september 2011.

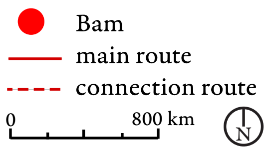


FIG. 2.14. Map of Silk Road trading routes demonstrates Bam's significance in history as it was located on one of Silk Road connection routes.

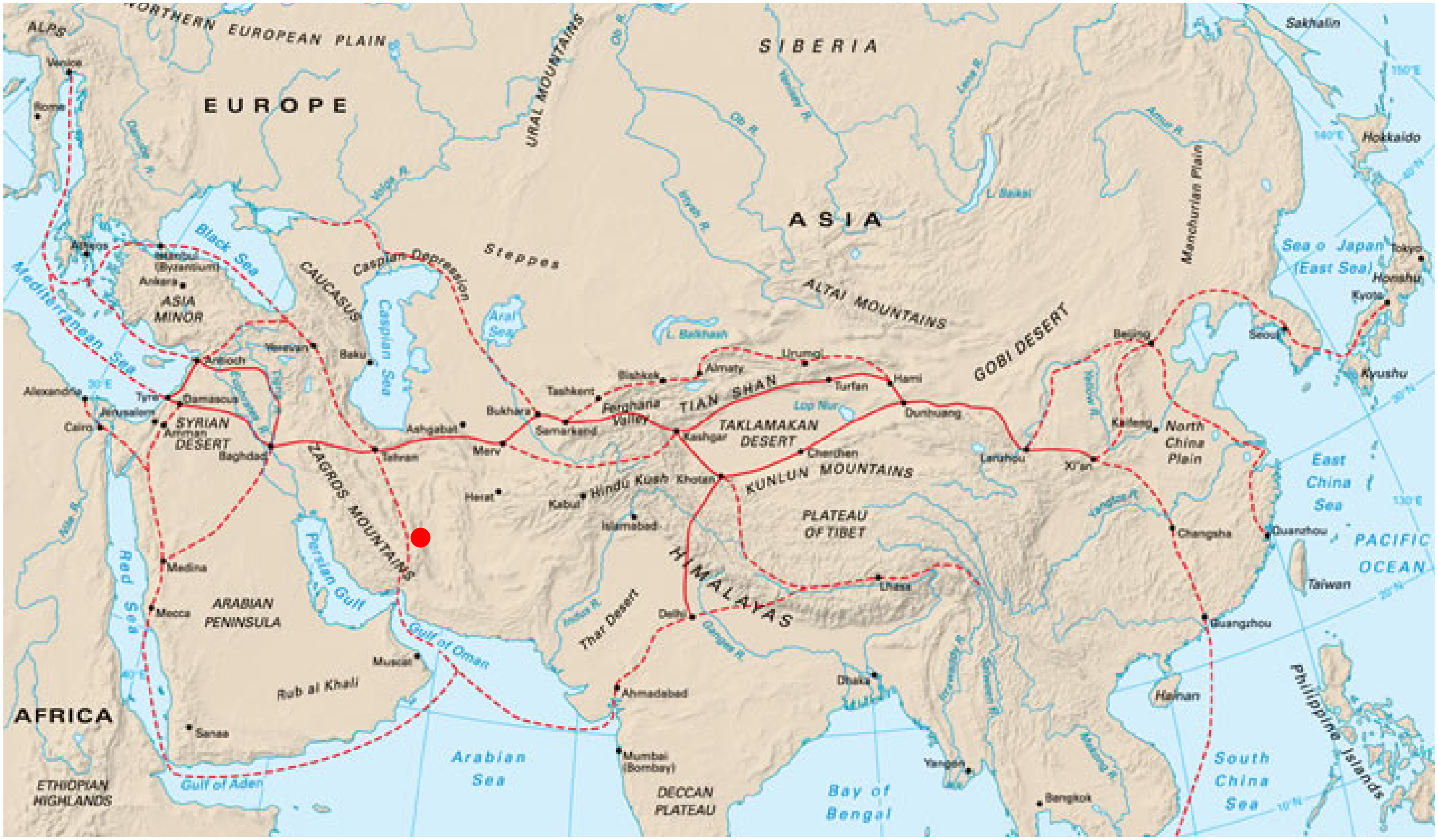


FIG. 2.15. Ancient residential areas of Bam were located to the west of the Citadel, where the ruler resided.

FIG. 2.16. Around 1106 A.D., the residential area of Bam was relocated to surround the Citadel.

FIG. 2.17. Boundaries of Bam during its peak growth at the end of Qajar Dynasty, around 1920 A.D.

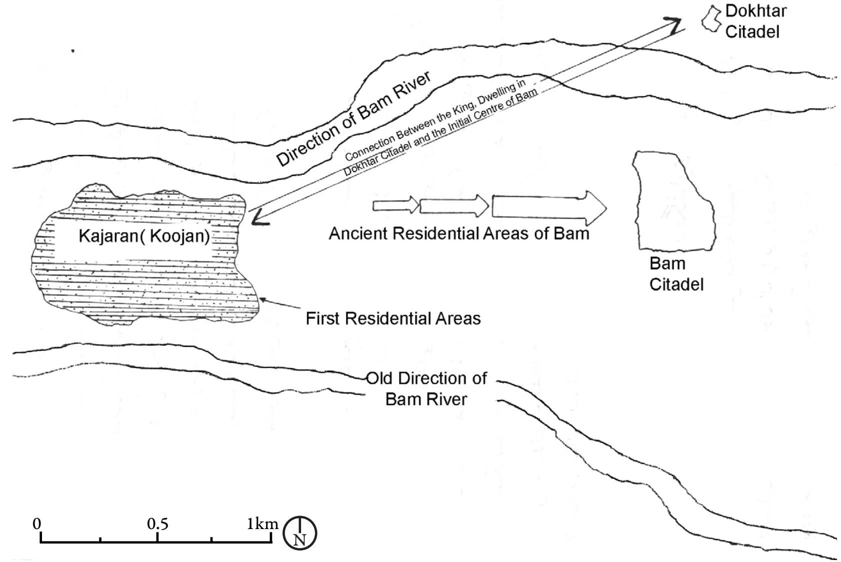


Fig. 2.15

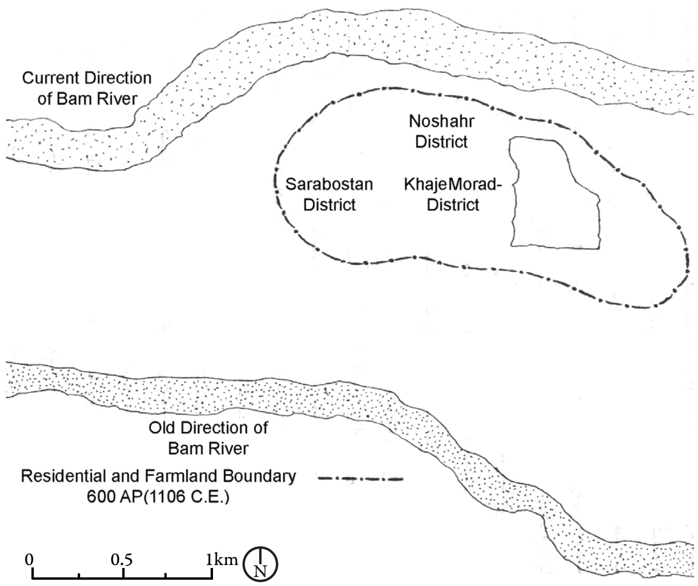


Fig. 2.16

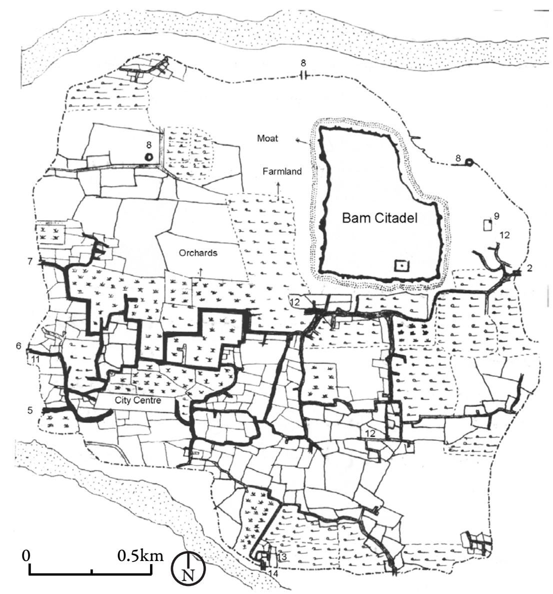


Fig. 2.17

FIG. 2.18. First urban planning of Bam in 1956 A.D.

FIG. 2.19. Bam in 1966 A.D., connected to other cities with highways.

FIG. 2.20. Economic boundary of Bam exceeds its township boundary in 1985.

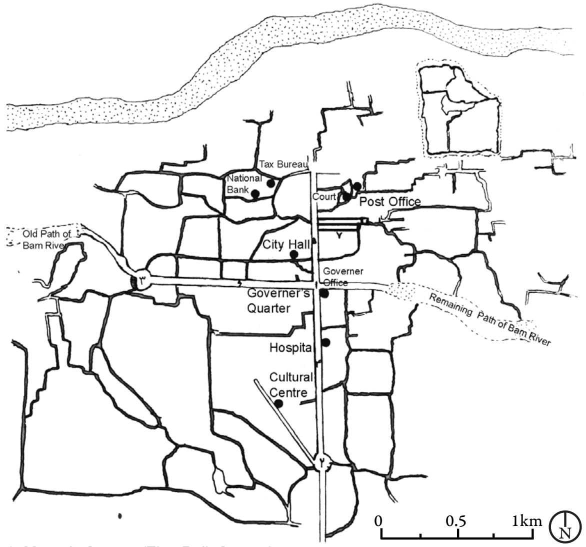


Fig. 2.18

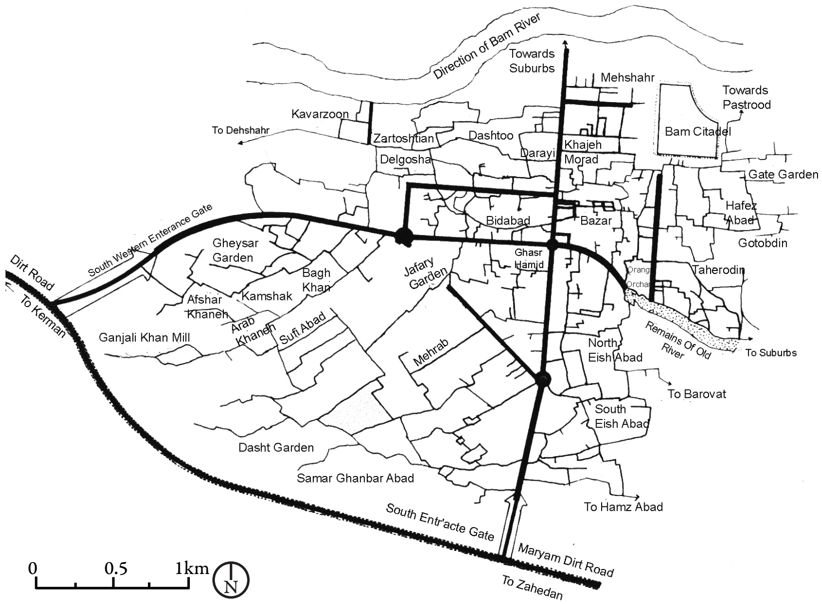


Fig. 2.19

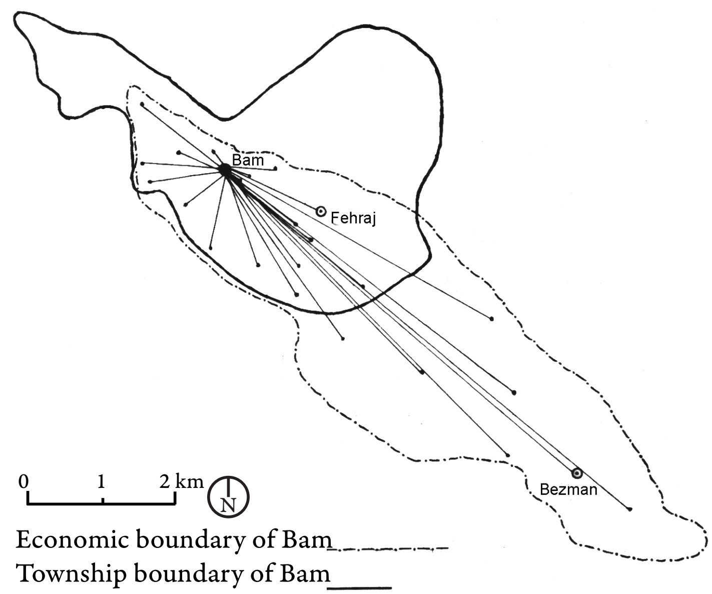


Fig. 2.20

2.2.2. Effects of the 2003 Earthquake on Bam

2.2.2.1. Death and Destruction

An earthquake of 6.6 magnitude on the Richter Scale catastrophically destroyed the city of Bam at 05:26:26 local time on 26 December 2003, injuring 50,000 people, leaving 100,000 people homeless in Bam and its nearby cities, and killing 40,000 people, which was almost half of the 100,000 population of Bam at the time.[6] Over 90 percent of all buildings in Bam collapsed, and numerous others were un-inhabitable after the earthquake.[7] The extent of damage and building destruction is visible in the aerial images (Fig. 2.21 and Fig. 2.22). Fig. 2.24 shows a mass grave to bury the large number of dead bodies after the earthquake, and Fig. 2.24 is an image of a father carrying his two dead sons for burrial.

The Citadel of Bam, the largest adobe building in the world,[8] on the list of UNESCO's world heritage sites, and over 2500 years of age, was almost completely destroyed in the earthquake.[9] Fig. 2.25 and Fig. 2.26 show images of the Bam Citadel before and after the earthquake. Destruction the ancient Citadel of Bam caused significant and irrepairable damage to the heritage of this city. Fig. 2.21 and Fig. 2.26 are images of Bam's ancient bazaar within the Bam Citadel before and after the earthquake, portraying the unrepairable damage caused by the earthquake.

In addition to being a tourist center due to the ancient Bam Citadel, Bam was also an industrial center, including some major industries such as an automobile factory, which was also destroyed in the quake. The destruction of the factory left thousands of people unemployed, and caused significant economical damage to the city. The majority of commercial buildings, healthcare centers, and education facilities were also destroyed, leaving citizens of all occupations unemployed. The destruction was so sudden and its scale was so immense that even today, a large population still remains unemployed.

6 Orfeus, Vol 6, No 1.

7 EERI.org, 6 January 2004, http://www.eeri.org/lfe/pdf/iran_bam_press_release.pdf, accessed on 3 september 2011.

8 Pbase Photo Gallery by Roozbeh Shivayi, "Bam Citadel, and very sad December 26, 2003 Earthquake," blog entry by Roozbeh Shivayi. accessed on 24 Feb 2011. http://www.pbase.com/roozbeh/bam_citadel.

9 Ibid.

FIG. 2.21. View along the bazaar street in Bam Citadel before and after the 2003 earthquake.

FIG. 2.22. Aerial views of three different neighborhoods in Bam before and after the earthquake.

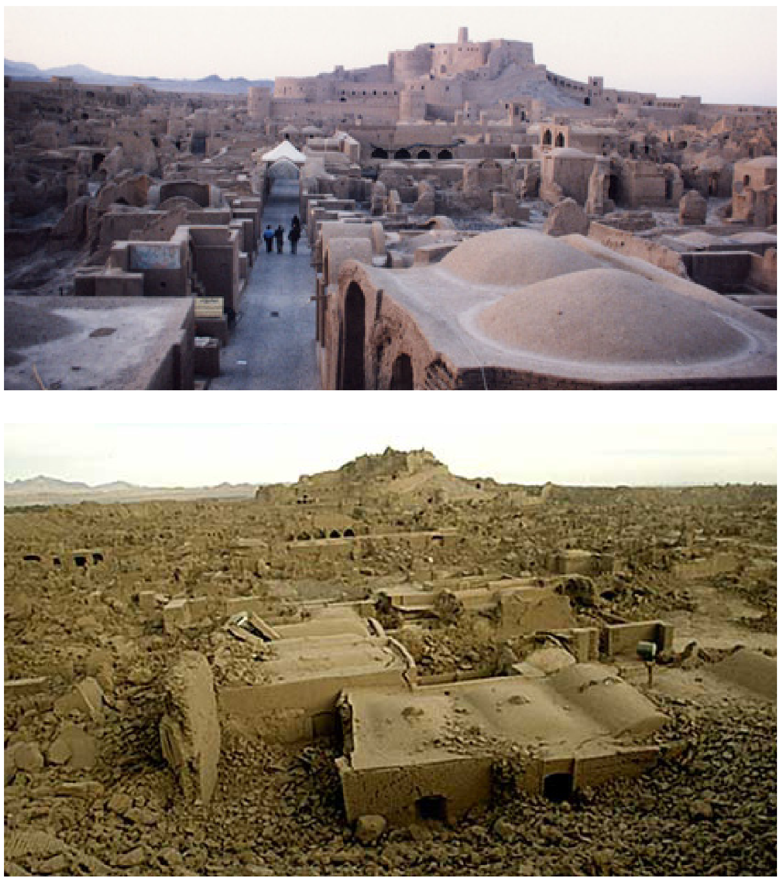


Fig. 2.21

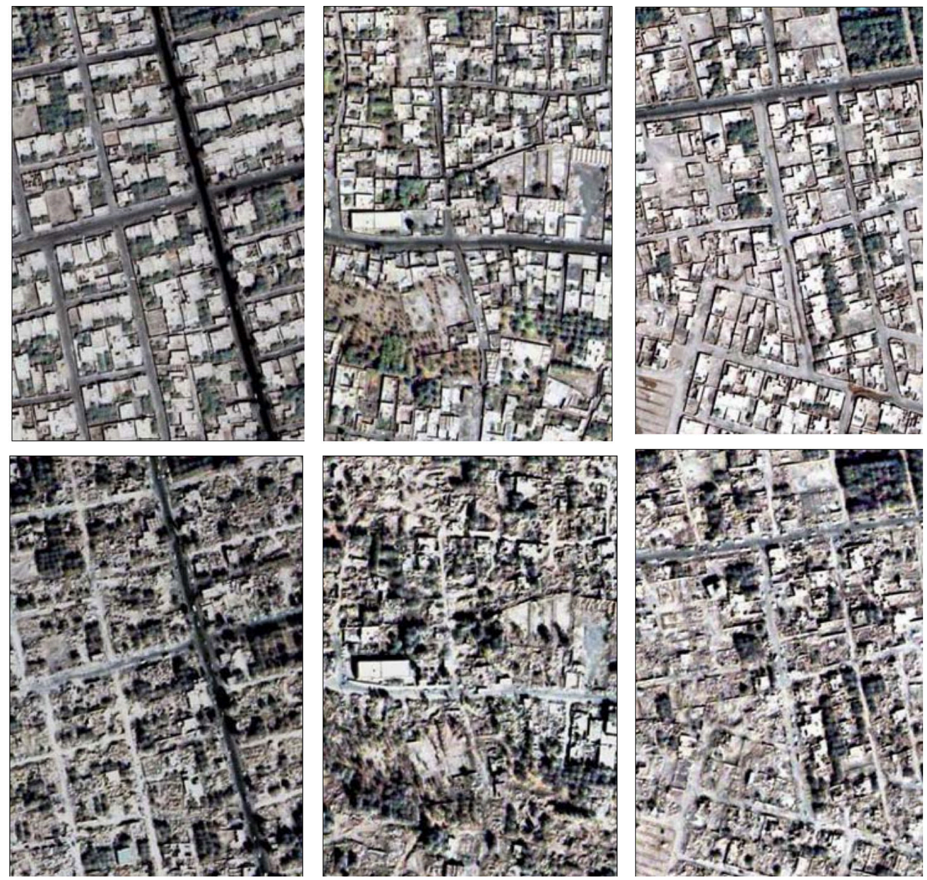


Fig. 2.22

FIG. 2.23. Mass burial after Bam's earthquake.

FIG. 2.24. A father carrying his two sons killed under the ruins of Bam's earthquake in 2003.

Fig. 2.24

Fig. 2.23

FIG. 2.25. Bam Citadel before the 2003 earthquake.

FIG. 2.26. Bam Citadel after the 2003 earthquake.

Fig. 2.25 (top)

Fig. 2.26 (bottom)

FIG. 2.27. Map of Bam's Qanats, bringing the water from the mountains located to the west of the city.

FIG. 2.28. Blockage of Qanats has caused many palm gardens to dry, and many palm trees to die.

2.2.2.2. Damage to Qanats and Agriculture

The main source of income of the residents of Bam is agriculture. Dates and citrus products of Bam are renowned globally and are one of the most important exports of the country. According to the Ministry of Agriculture of Bam, over 80% of Bam's population are farmers.[10] The agricultural lands of Bam are still irrigated using the ancient Qanats (ancient Persian underground water channels) that bring the water to the city from the Zagros Mountains located to the west of Bam. Fig. 2.27 shows the map of Bam's agricultural wells, potable water wells, path of qanats, and direction of water within the qanats. More than 500km of irrigation channels were blocked by the earthquake,[11] preventing the water from accessing urban areas and agricultural lands, drying the gardens and killing the trees, therefore eliminating any source of food or income from agriculture (Fig. 2.28). The rejuvenation of the Qanats is very difficult, as they are an ancient underground infrastructure spread throughout the city and its suburbs.

10 Ivor Morgan, "Hope for Harvest in Bam, Iran," Medair,

11 Ibid

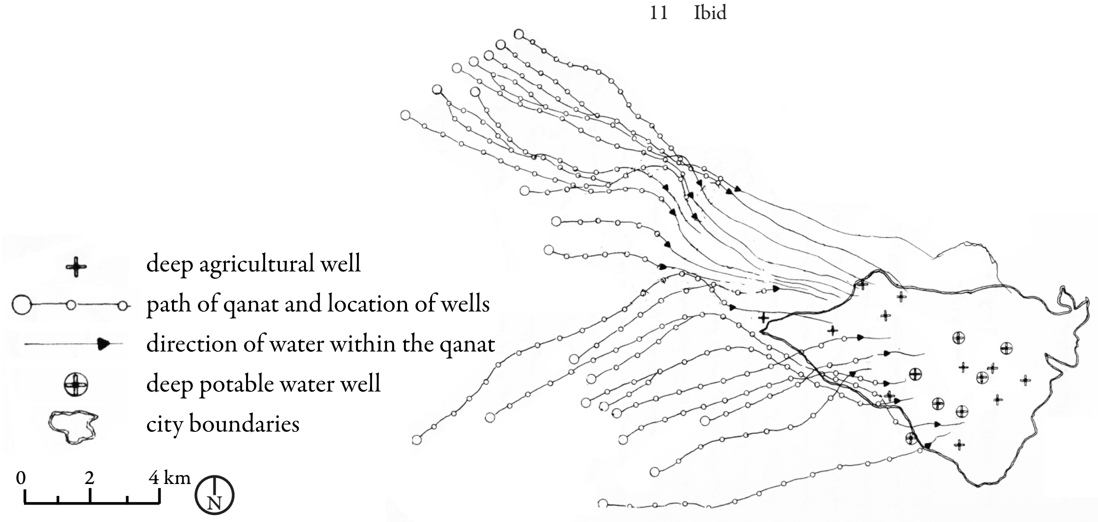


Fig. 2.27

Fig. 2.28

2.2.3. Bam, a Typical Post-Disaster Desert City

Bam is a good example of a low probability, yet high consequence natural hazard location. Although earthquakes in Bam are infrequent in historical terms, they are inevitable.[12] Bam is a typical developing post disaster city in the hot-arid region of the globe, due to its geographic seismically hazardous location, vernacular earth architecture, and its contemporary post-disaster construction. Most indigenous and vernacular buildings in seismic prone regions of the world are not structurally reinforced, and the few that are reinforced, are not adequately resistant to seismic tremors. Typical contemporary architecture of these cities has improved structural stability, but has disadvantages of being foreign to the culture and climate of the city. The case of Bam is a wakeup call to all seismic-prone areas to be aware of the possible seismic tremors and to prepare for hazard prevention and mitigation. Unfortunately most cities with infrequent seismic activities do not prepare for possible natural hazards, which results in a catastrophe when the earthquake occurs. For such cities, it is crucial to have a post-disaster plan for reconstruction of damaged or destroyed buildings.

2.2.3.1. Typical Vernacular Desert Architecture

Destruction caused by the earthquake in Bam demonstrates what happens frequently in seismic prone regions with desert soil and earthen buildings. The vernacular architecture of the desert is most suitable for its culture and climate, but is not the most structurally suitable type of architecture for seismic prone regions. The high rate of fatalities due to destruction of vernacular buildings during earthquakes proves that changes must be made in the construction of these buildings to make them seismic-proof for earthquake prone areas.

12 O'Rourke, "EERI sends."

2.2.3.2. Typical Post-Disaster Contemporary Reconstruction

Through the last few decades, there has been increasing awareness of the need to design seismic-proof buildings within seismically hazardous areas. Guidelines and codes have been proposed and reinforcement of earthen buildings has become mandatory in many cities such as Bam and Tehran. These codes and guidelines are being followed throughout the world and have improved the structural behavior of buildings in response to seismic tremors. Most of these guidelines suggest use of concrete, steel, and reinforced masonry to replace the existing vernacular adobe structures.

Alteration of building techniques and materials in order to meet the earthquake resistance codes is a positive step towards improving vernacular architecture. However, the disadvantage is that most architects and designers who adopt these codes omit all elements and features of the vernacular architecture, replacing them with contemporary architectural forms and elements that are normally climatically inappropriate and often based on Western styles.. This creates buildings that consume excessive energy for lighting and cooling, do not correspond to the social and customs of the inhabitants, and create a very unpleasant space to live in, both physically and psychologically.

2.3. Social Context

To attain a good understanding of the conditions of survivors, three distinct social groups were observed for this thesis: the members of Bam's Disability Center, the orphans at the Rahavard Mehr Va Danesh Institute, and the local residents of Bam. These specific groups were selected to provide a wide range of age, gender, physical, and psychological conditions. In order to provide a comprehensive understanding of the society as a whole, informal conversations were performed with individuals within these groups during the author's visit to Bam in 2008.[13] The conversations with locals provided the author with a thorough understanding of the users' needs, in order to find a proposal appropriate for all users, in spite of their differing social, psychological, or physical status.

The short film, The Ravaging Pulse, includes some of these conversations, along with live scenes of disasters caused by seismic tremors to portray the reality of earthquakes and its destructive effects on the built environment.[14] The Ravaging Pulse starts with scenes of nature and a computer generated model of the movement of the continents, showing the beauty of natural cycles of the earth and the harmony of these movements with the natural world. Images of modern cities and human civilizations are then portrayed, suddenly destroyed by graphic scenes and sounds of seismic tremors and broadcast news of earthquakes across the globe. Live footage of various recent earthquakes and tsunamis are included to depict the enormity of the destruction caused by these natural phenomena. The film then focuses on Bam's 2003 earthquake, showing conversations with the survivors, where they explain their personal experience of the quake. The Ravaging Pulse offers a graphic portrayal of the essense of the destruction caused by earthquakes.

13 Author's conversations with locals, Bam, 2009.

14 Sara Nejad, The Ravaging Pulse, 2011.

FIG. 2.29. Author's meeting with administration of Bam's Disability Center. Mr. Moazzemi, Head of Disability Center, looking towards the camera in this image, was the administrator of the meeting.

FIG. 2.30. Members of Disability Center in Bam, gathering in the basketball court.

FIG. 2.31. Members of the Disability Center playing basketball, a group activity created by Bam's Disability Center.

2.3.3.1. Conversations with Survivors
The Disabled

Bam's Disability Centre was created after the earthquake in 2003 as a social organization for individuals disabled by the disaster. The primary purpose of this association is to create job opportunities, and to improve the living conditions for the disabled population of Bam.[15] Mr. Moazzemi, the Head of Bam's Disability Center strongly believes that employment can provide the biggest assistance in improving the disabled's physical and psychological conditions.[16] Physical activity prevents skin rashes caused by constant sitting on the wheelchair. Some people lost their lives to these rashes in the first few months after the earthquake, when improper wheelchair seats were donated to the survivors, and the traumatized patients did not take the time and care to move their bodies in different positions to allow the skin to breathe. The Disability Center has created many job opportunities and physical activities such as basketball games to improve the condition of the disabled.

15 Author's interview with the Head of Bam's Disability Center, Bam, 2009
16 Ibid.

Fig. 2.28

Fig. 2.30

Fig. 2.31

Mr. Moazzemi mentioned many individuals who were disabled as a result of trauma and nervous breakdowns, but gained their health back and were gradually able to walk after they found employment and improved their mental state.[17] Reza[18], a thirty-five year old man, and father of two, owned an automobile repair center prior to the earthquake. He lost his entire family as well as his legs in the earthquake. He was in a traumatic psychological condition until the Disability Center recently employed him in an automobile battery repair shop. Employment significantly improved his psychological as well as physical condition.[19]

FIG. 2.32. Author's visit to Reza's house. Reza is sitting on the bed, with Mr. Moazzemi and another member of the Disability Center in wheelchairs.

FIG. 2.33. Reza at the automobile battery shop.

17 Ibid.
18 Real names of invidivuals have not been used.
19 Bam's Disability Centre - Semi-annual report, 2008, p 21.

Fig. 2.32

Fig. 2.33

FIG. 2.34. Sepehr, working on a hand-made wooden frame.

FIG. 2.35. Wooden boats made by Sepehr in his new wood shop.

FIG. 2.36. Sepehr's wife, looking at a hand-made wooden plaque dedicated to her from her husband.

Sepehr, a former carpenter, lost his workshop and was disabled in the earthquake. His psychological status improved significantly after being provided with a small space to make handcrafts to sell to the public (Fig. 2.34, Fig. 2.35).[20] His wife is very proud of his work, and believes that being able to work again has given them a chanace to rebuild their lives (Fig. 2.36). According to Mr. Moazzemi, Head of the Disability Center, the suicide rate among members of the Disability Center has been reduced as the rate of employment has increased.[21] Many of the jobs created by the Disability Center do not provide the individual with substantial financial assistance. However, it is the psychological effect of employment that improves one's mental and physical health.

20 Authors' Interview with Administration of Bam's Disability Center, Bam, 2009
21 Authors' Interview with Administration of Bam's Disability Center, Bam, 2009

Fig. 2.34

Fig. 2.35

Fig. 2.36

Orphans

Rahavard Mehr Va Danesh Institute in Bam is a non-profit organization that operates as a day-care educational program for the orphans of the earthquake (Fig. 2.37). Sara and Ali Divsalar, founders of this private Institute, are a young couple who moved to Bam after the earthquake in 2003 to make a documentary film of the disaster. Having seen the catastrophe and the devastation caused by the quake, they decided to stay in Bam permanently and help revitalize the city by establishing an institute to help orphans of the earthquake. For this thesis, the author performed casual conversations with Ali and Sara along with many orphans supported by this organization in order for the author to understand the present conditions of the students and administrators. Rahavard Mehr Va Danesh was selected for this study because of the young age of its members, ranging from kindergarten to secondary school.

FIG. 2.37. The Author and orphans at Rahavard Mehr Va Danesh Institute.

Fig. 2.37

FIG. 2.38. Mr. Bolourchi, a survivor of Bam's earthquake.

Survivors

Conversations with locals such as Mr. Bolourchi (Fig. 2.37), who lost 84 of his relatives including his brothers and sisters, nieces and nephews, as well as his house and occupation in the earthquake, demonstrate the current condition of most survivors of Bam's earthquake. Mr. Bolourchi's biggest complaint about the current conditions in Bam is lack of employment and poor housing conditions for the public.[22] According to Mr. Bolourchi, the majority of the financially restricted survivors of Bam are unemployed and have no source of income. Many have become addicted to alcohol and drugs, and many have committed suicide to escape their current living conditions. There have been some recent job opportunities in revitalized industries such as the automobile industry, but the number of job openings does not satisfy the number of applicants.

2.3.3.2. Social Needs and Potentials

Fig. 2.37

Surviving residents of Bam were sentenced to live with the trauma of the catastrophe, loss of their loved ones, homelessness, and unemployment. After the disaster, many who had the opportunity moved to other cities to escape the memory of the catastrophe. Those who could not afford to move were forced to live within the ruins of their city, awaiting help from external sources. Much financial help was provided from both public and private sectors globally, but this assistance was not sufficient for rebuilding the city. Most of the financial support was provided for reconstruction of public buildings including schools, hospitals, universities, and recreation centers. Some government grants and loans were provided to the public for the reconstruction of the residential sector, but the funding did not reach all families in need.

Today, eight years after the earthquake, magnificent public buildings exist throughout the city, while many residents are still living in shipping containers and shelters made of disposed materials and plants. Fig. 2.42 and Fig. 2.43 show images of public stadiums constructed after the earthquake to provide recreation centers for the public. On the contrary, Fig. 2.39 shows a shipping container used as a supermarket in the streets of

22 Author's interview with the local residents, Bam, 2009.

Bam, close to a shanty house made of dried palm branches and blankets (Fig. 2.40). The siginifant gap between the current staus of public buildings and residential buildings is due to the inappropriate division of available funding, with preference for the reconstruction of public buildings over residential areas.

There is also a considerable gap between the living condition of low income families who can not afford to rebuild their houses and the middle or high income class of the society. Fig. 2.41 shows an image of a series of houses in the New Arg District, a wealthier district near Bam, made after the earthquake. Comparison of this image with Fig. 2.40 demonstrates the difference in living conditions of various social classes in Bam.

With improper and insufficient governmental funding provided for reconstruction of their home, the low-income family is practically left on their own for the reconstruction of its home, with some minor assistance from non-governmental and private sectors.

Conversations with the disabled community, the orphans, and the locals lead to the conclusion that the post- earthquake city of Bam is not only in need of the construction of buildings, but has a deeper need of psychological support, skill training and job creation. There is a significant number of unemployed workers who are seeking jobs and are willing to work without compensation in order to learn skills for possible future job opportunities. The unemployed population provides a good work force for reconstruction of the city. Available resources- no matter how minimal- could be used in conjunction with unemployed manpower to reconstruct the city. This thesis proposes reconstruction of post-earthquake cities such as Bam through self-help and utilization of available resources.

FIG. 2.39. Shipping container used as a local supermarket in the streets of Bam.

FIG. 2.40. Shanty house made of blankets and dried palm leaves, where a low income family resides. The brick wall of a new house can be seen in the background.

FIG. 2.41. Residences constructed after the earthquake by middle to high income people.

FIG. 2.42. Bam's Basketball statium constructed after the earthquake.

FIG. 2.43. Bam's soccer statium constructed after the earthquake.

Fig. 2.41

Fig. 2.42

Fig. 2.39

Fig. 2.40

Fig. 2.43

2.4. Urban Context

Architecture and urban design are inevitably interrelated. One cannot understand the essence of architecture without acknowledging its urban context. Bam is a typical Iranian Islamic city, and to understand its existing urban context, one must understand the process of evolution of Iranian Islamic cities. Bam is a city with thousands of years of history, having evolved and transformed through many different eras. This thesis studies the urban growth of Bam from antiquity to present, analyzing its growth and expansion patterns. Through understanding this city's natural growth patterns, one can reckon the possible future growth and expansion patterns. This is important to this thesis as it searches for architecture that is appropriate and suitable for future urban growth patterns of this city.

Appendix A.1. portrays the urban growth of this city from antiquity to present. The oldest evidence of Persian urban centers dates back to 728 BCE, during Median's dynasty. These urban centers were built based on the emperor's decisions and did not consider cultural or environmental factors. During the Seleucid Empire, the use of cardinal axes for main access routes was adopted. During Parthian's dynasty there is evidence of a commercial street (bazaar) along the major routes leading to the city gate. Cities built during Sassanian's period were built based on three hierarchic divisions: the Citadel at the center, surrounded by the city, and with the suburbs at the perimeter of the city. The typical Persian urban plan with cardinal street orientation, line of bazaar leading to city gates, and the Citadel at the core of the city was deeply rooted in the Persian urban plan that after the Arabian invasion, the Persian urban plan did not change drastically. Gradually, with the advent of Islamic culture in Persia, elements of Islamic urban planning influenced Persian urban planning, and resulted in a plan that had both Persian and Islamic influences.

In pre-Islamic urban plans of Persia, the commercial spine was located close to the city gates, and along major routes that were directed to city centers. As a result of Islamic influence and special considerations of economy and finance, the bazaars gradually expanded into the city and became urban centers.[23] Many cities were destroyed during the Mongolian invasion, followed by a peak in architecture and urban planning during Safavid's period. Isfahan, the capital city of Safavids, is a great example of Iranian-Islamic cities of this time. The financial district of the bazaar was the spine of the city, with the City Square and Grand Mosque as the other main elements of the city. The difference between the urban plan of Old Isfahan and Isfahan of Safavid's time is visible on this city's urban plan, as the new city was built adjacent to the old.

Gradually the Sassanids cities, with three spatial divisions of citadel, city, and suburb, were replaced by Islamic cities, in which the mosque, the bazaar and the citadel were the three main urban elements.[24] Other urban centers such as schools, caravansaries (inns with a central courtyard for travelers in the desert), warehouses, water basins, and tea houses were gradually added to the spine of the city, creating a holistic image of an economically, socially, and religiously united traditional society.[25]

As the urban population grew, and the cities became financially strengthened, the power of merchants increased and feudal cities were shaped. During Qajar's period there was a great decline of urban planning in Iran- Tehran was selected as the capital, and a new stage in urban planning started. The new feudal cities had four centers: the residential areas, the educational and religious centers, the financial line of the bazaar, smaller businesses in the alleys. As cities started to become more modern, streets became wider and the urban plan became more vehicle-friendly. Grid-shaped urban plans were used for new cities, and wider vehicle friendly streets were extended into the old fabric of traditional cities such as Kerman and Qazvin. Today, most cities in Iran and many other historic cities in the world exhibit an awkward juxtaposition of old urban fabric and modern urban fabric.

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23 Naser Mashhadizadeh, Urban Planning Characteristics in Iran, (Tehran: ,Elm & San'at University Press, 2002), 245.

24 Mashhadizadeh, Urban Planning Characteristics, 248.

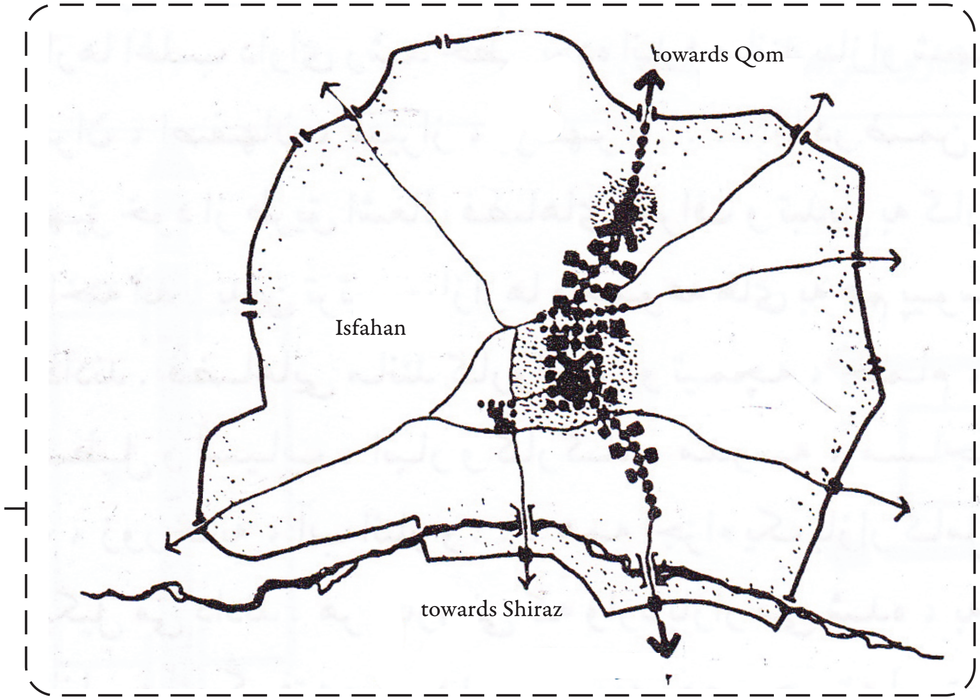
25 Ibid, 246.

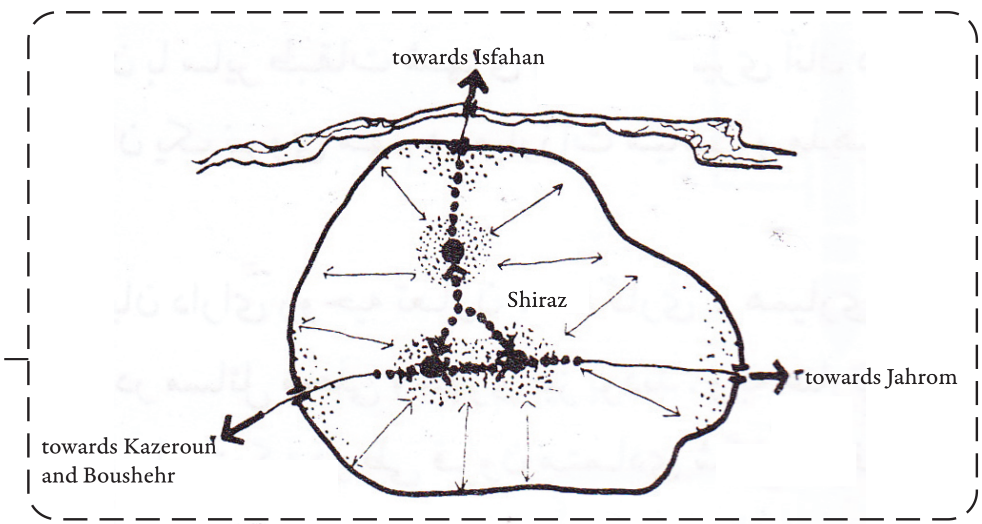
Today most urban centers of Iran, including the ancient city of Bam, follow an Islamic urban plan with the Bazaar acting as the central spinal growth of the city. Bazaars are located along the main transportation routes of the city, where the urban mass starts its growth. The continuation of the route of the bazaar connects each city to its adjacent cities, creating a continuous path of public commercial space. Isfahan and Shiraz (Fig. 2.44) are two traditional adjacent cities connected through the public path of the bazaar. Fig. 2.45 demonstrates the growth pattern of a typical Islamic city, starting from the walls, gates, and a citadel (a), access routes to connect the city to adjacent cities (b), primary roads connecting the gates to one another through the city (c), commercial line of Bazaar created along the main access routes (d), caravanserais and other semi-public spaces created in between the public path of bazaar and the residential neighborhood behind (e), and residential spaces along minor and more private access routes (f).

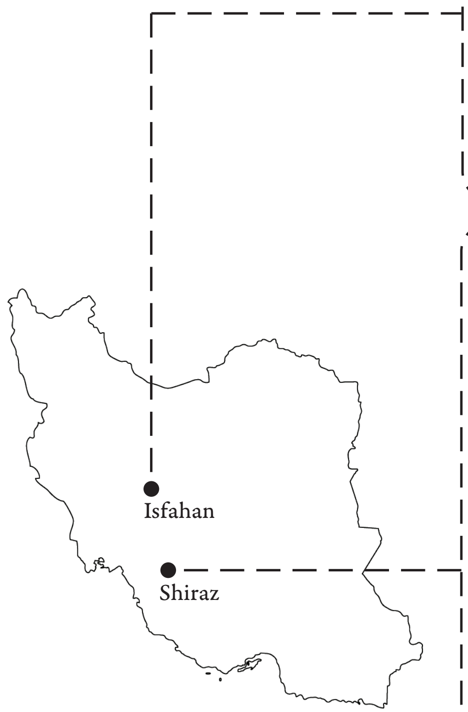
Most of what is remaining of Bam today is remainders of the Safavid period, dating back to 16th and 17th century (Fig. 2.48).[26] Bam Citadel is a fortified city with entrance gates and a citadel (Fig. 2.48). It has all elements of a typical Iranian Islamic city, including a bazaar (Fig. 2.47), a mosque, and caravansarais. The programs are wisely located throughout the fortified city to provide an ideal location on the hill for the residence of the king, a primary access route leading the visitors through the commercial line of the bazaar, and small neighborhoods with smaller public squares. Fig. 2.49 shows the residential neighrborhood of Bam at the right and the left of the image, separated by the path of the Bazaar at the center of the image. The tower of the Citadel is visible at the foreground, and the modern city of Bam with its palm orchards can be seen in the background, separated from the ancient city of Bam by the city walls.

26 Archnet Digital Library, http://archnet.org/library/sites/one-site.jsp?site_id=7861, accessed on 8 September, 2011.

FIG. 2.44. Isfahan and Shiraz demonstrate typical cities that started their growth from the bazaar. The path of the bazaar continues to grow, and eventually connects to intra-city routes. Route of Isfahan's bazaar connects this city to Qom from North, and to Shiraz from south. Shiraz' bazaar continues outside of the city boundaries and connects this city to Jahrom from east and Kazeroun and Boushehr from west.







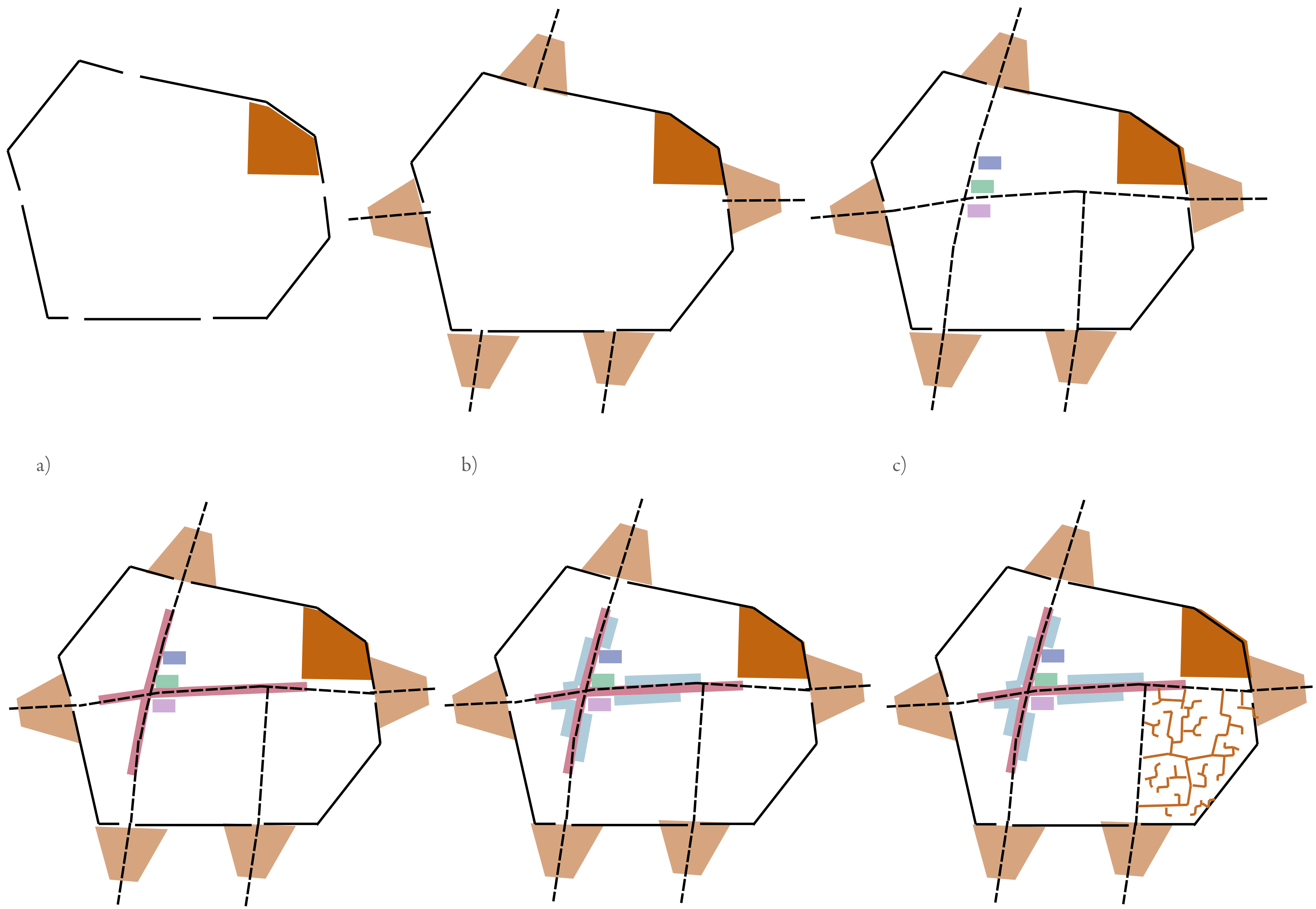


Fig. 2.45

FIG. 2.45. Typical growth pattern in Islamic cities starts with a wall, gates, and a citadel. (previous page)

FIG. 2.46. Plan of Bam Citadel.

FIG. 2.47. Commercial path of Bazaar at the Citadel of Bam before the earthquake.

FIG. 2.48. Fortification wall and main gate of Bam Citadel.

FIG. 2.49. View from the Citadel towards residental areas and the line of bazaar.

city wall
gates
citadel
roads
suburbs
primary roads
mosque
administration center
school
bazaar
caravansarai
residential neighborhood

city walls
streets
Bazaar
main city gate
mosque
gymnasium
mansion
stable
caravansarai
military square
four season residence
ruler's residence
north west
neighborhood square

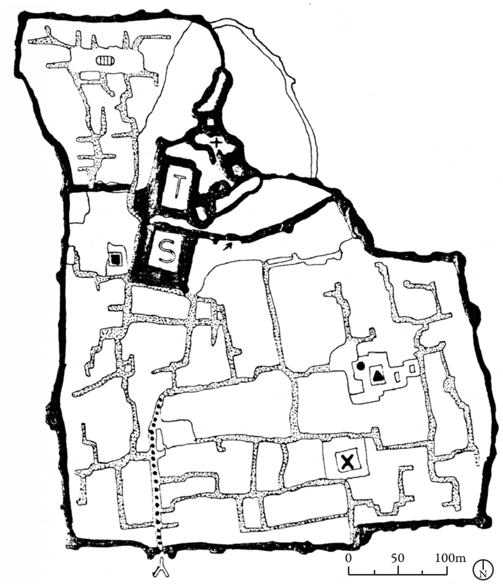


Fig. 2.46

Fig. 2.47

Fig. 2.48

Fig. 2.49

2.5. Bam's Vernacular Architecture

Vernacular architecture of Bam is most descriptive of the culture and social habits of its residents, as well as the climate and the available natural resource in the surrounding context. The traditional architecture of Bam is very important in maintaining the social and cultural heritage of Bam, as well as in providing a sustainable and environmentally friendly building environment for the inhabitants. Balkrishna V. Doshi's description of traditional architecture emphasizes the significance of traditional architecture for Bam and other traditional cities:

> "At the physical level, it embodies centuries of learning with regard to orientation, climate, building materials, and construction techniques. At the spiritual level, the built form can be in total harmony with the lifestyle in all its daily as well as seasonal rituals, unifying the social, cultural and religious aspirations of the individuals and the community. To achieve this unity and to integrate physical and spiritual needs, due importance was given to nature and its basic laws. Nature was accepted as it is. Lifestyle and activity followed in consonance with nature and architecture with nature".[27]

The following sections demonstrate the vernacular architecture of Bam in detail and analyze its advantages and disadvantages for the city of Bam today.

27 Balkrishna V. Doshi, "Cultural genome and regional identity in architecture," in Regionalism in Architecture, ed. Robert Powell, (Singapore: concept media, 1985), 87-91.

2.5.1. Residential Districts and Building Typologies

Appropriate architecture is one that fits in its surrounding environment and urban plan. It is important to analyze the existing urban fabric of Bam in order to design buildings that are suitable for the existing urban context. The city of Bam can be divided into three zones with distinct land plots and residential building typologies (Fig. 2.50).

Zone One is located at the historic center of Bam and the buildings in this zone are influenced by the Bam Citadel. Land plots have irregular shapes and various sizes. The urban fabric is very dense and traditional house is the dominant residential typology in this zone. Ashram's House is a typical traditional house in Zone One. The dense urban fabric makes it difficult to distinguish the site boundary of Ashram's House with the adjacent Ameri's House (Fig. 2.54 and Fig. 2.52). Ashram's House has a typical courtyard typology with the living spaces surrounding a central courtyard (Fig. 2.55). Distinctive elements and features of a traditional house are visible in the sections of the house (Fig. 2.56). These features include the Talar (main hall), the courtyard, the reflecting pool, the wind catcher, the pool house, Hashti (entrance vestibule), and the garden.

Zone Two covers the southeast and southwest regions of Bam. These areas are the most recent expansions of Bam, and includes linear plots and mostly contemporary houses. Dr. Esmaili's House is a typical contemporary house in Zone Two (Fig. 2.58). The plan of the house is asymmetrical and the plot size is much smaller than traditional residential plot sizes. The building is located away from the edge of the site, allowing light access and possibility of green space on two sides of the building. The architectural features and elements of traditional architecture such as the wind catcher, pool house, and central courtyard are eliminated. There is a small reflecting pool on the southeast corner of the building, but it is not located at the center of the garden, as it would be in a traditional house. The exterior facade also has a more geometric and modern appearance with larger square windows, rather than tall arched windows or small circular windows (Fig. 2.59). The exterior facade is modern oven-baked brick with modern, geometric, decorative patterns to replace the vaults, arches, and domes of the traditional house (Fig. 2.59).

District Three is located mostly on the northwest edge of the city along the path of the Bam River. This district includes large irregular plot, as the shape and size of the plots are derived from the land contour along the river. Garden Houses are the dominant house typology in this district, as easy access to the seasonal Bam River facilitates the irrigation and maintenance of the plants. Ansari House is a typical Garden House in District Three. A traditional garden house has all the traditional architectural elements of a regular traditional house, in addition to a large garden that is used as a sources of income for the inhabitants (Fig. 2.61, Fig. 2.62). The facade and appearance of the house follows the traditional residential design. Arched windows, vaults, and domes are visible in the images of the facade (Fig. 2.63) and the entrance vestibule (Fig. 2.64).

Garden House is essentially a Traditional House with a larger and more significant garden. Therefore the residential typologies of Bam can be divided in two categories of traditional and contemporary. The following sections analyze the advantages and disadvantages of the traditional versus contemporary residential architecture of Bam.

FIG. 2.50. Residential districts of Bam and dominant resdidential typology in each zone.

FIG. 2.51. The dominant residential typology in Zone 1 is the traditional house.

FIG. 2.52. The dominant residential typology in Zone 2 is the contemporary house.

FIG. 2.53. The dominant residential typology in Zone 3 is the garden house.

Building
Outdoor Space

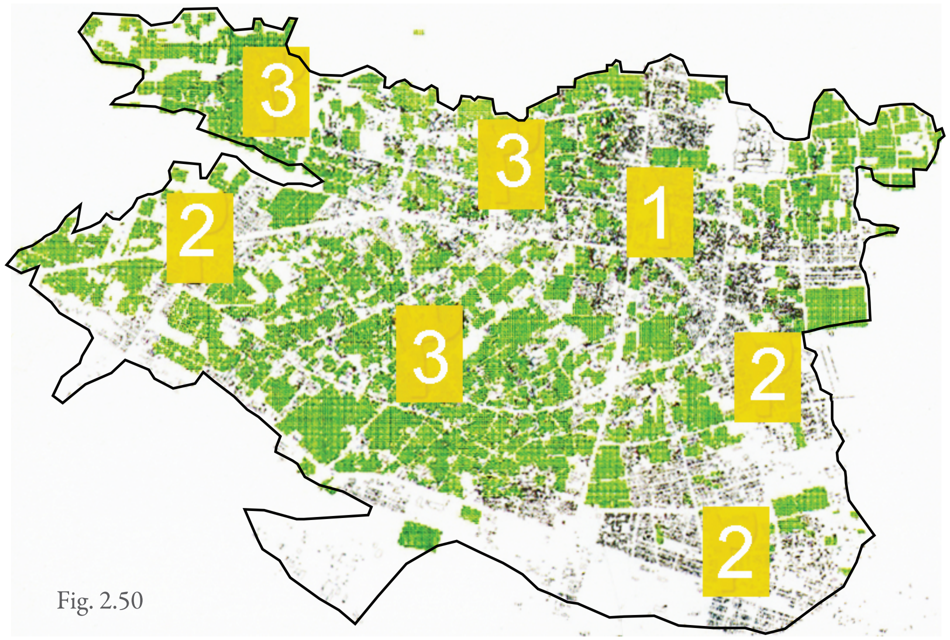


Fig. 2.50

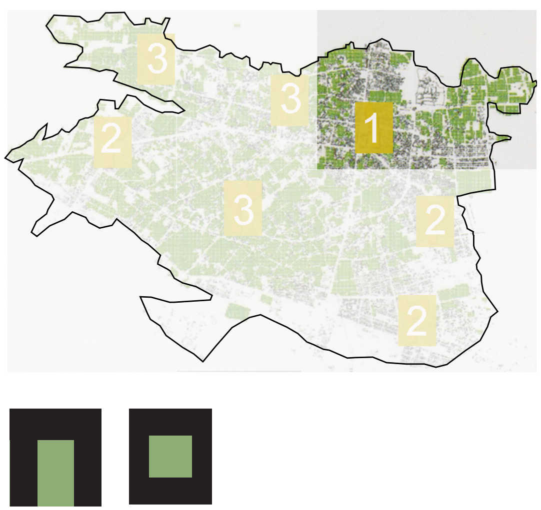


Fig. 2.51

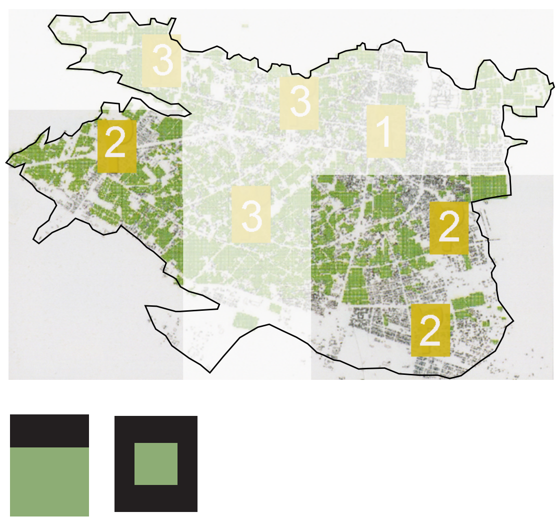


Fig. 2.52

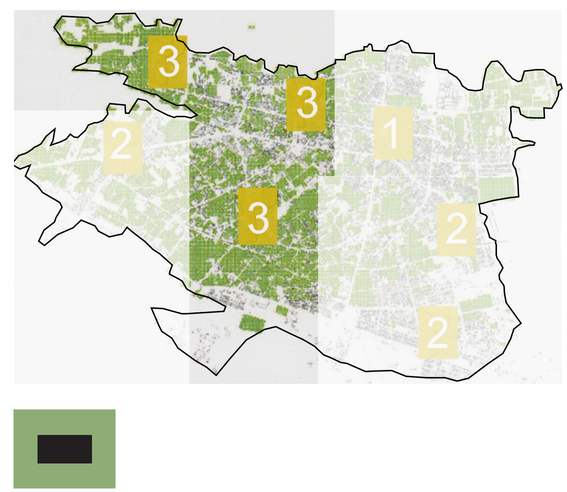


Fig. 2.53

Ashram's House, a typical traditional house in Zone 1.

FIG. 2.54. Ground floor plan of Ashram's House adjacent to Ameri's House.

FIG. 2.55. Ashram's House- Ground floor plan.

FIG. 2.56. Ashram's House- Sections.

FIG. 2.57. Ashram's House- View from the courtyard towards the Talar.

1. Talar (main hall)	5. Pool House
2. Courtyard	6. Hashti (entrance vestibule)
3. Reflecting Pool	7. Basement
4. wind Catcher	8. Garden

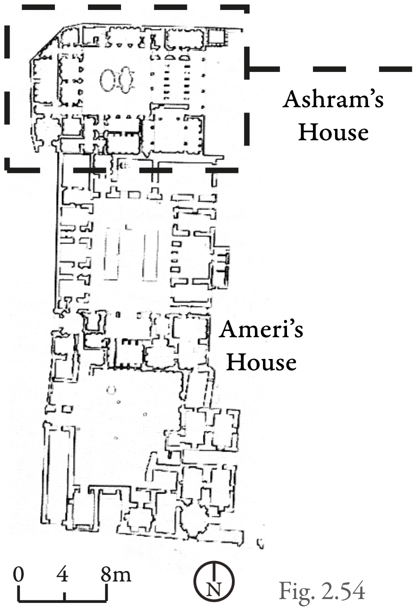


Fig. 2.54

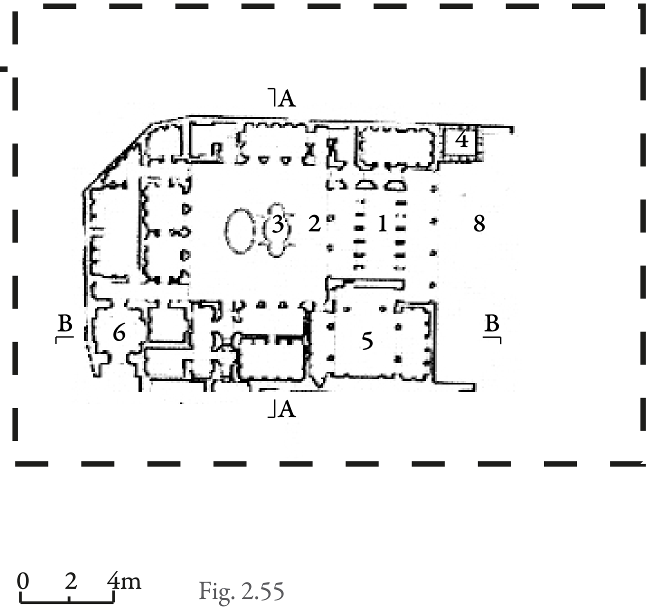


Fig. 2.55

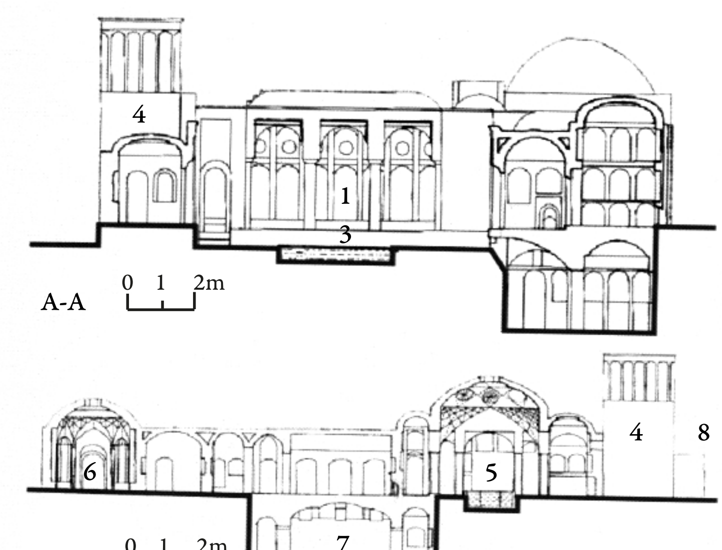


Fig. 2.56

Fig. 2.57

Dr. Esmaili's House, a typical contemporary house in Zone 2.

FIG. 2.58. Dr. Esmaili's House- Ground floor plan.

FIG. 2.59. Dr. Esmaili's House-South east view.

FIG. 2.60. Dr. Esmaili's House- View to the backyard.

1. Entrance
2. Hall
3. Garden
4. Courtyard
5. Talar (main hall)
6. Bedroom
7. Kitchen
8. Service

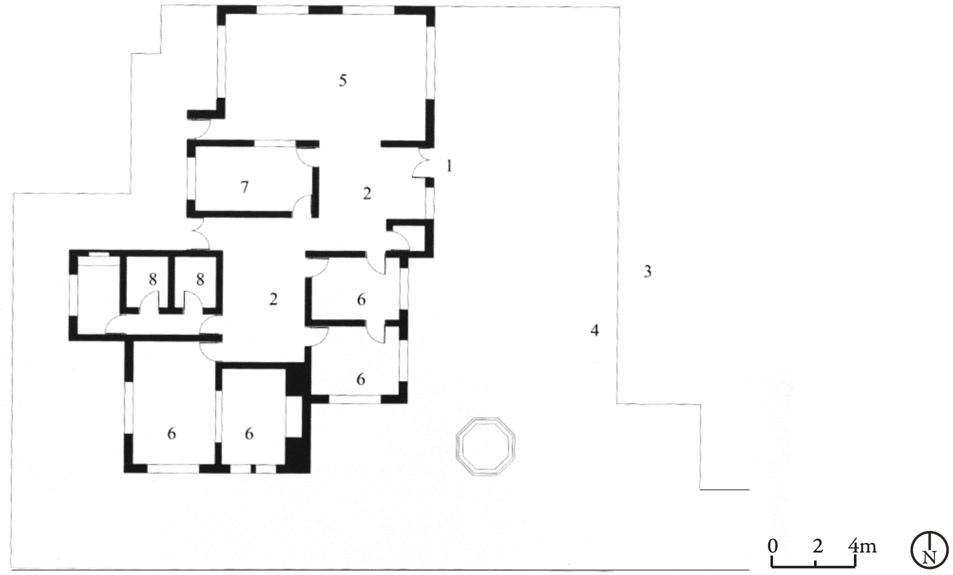


Fig. 2.58

Fig. 2.59

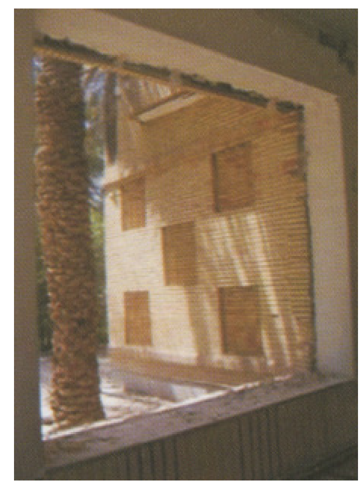
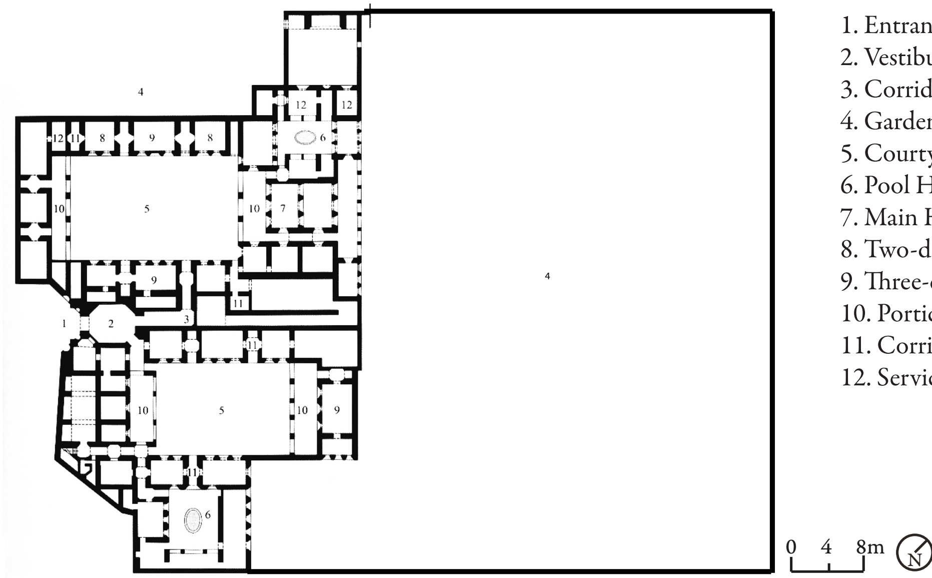


Fig. 2.60



1. Entrance
2. Vestibule
3. Corridor
4. Garden
5. Courtyard
6. Pool House
7. Main Hall
8. Two-door Room
9. Three-door Room
10. Portico
11. Corridor
12. Service

Ansari House, a typical garden house in Zone 3.

FIG. 2.61. Ansari House - Ground Floor Plan.

FIG. 2.62. Ansari House - 3D Model in Urban Context

FIG. 2.63. Ansari's House- North elevation.

FIG. 2.64. Ansari's House- View from enterance towards the courtyard.

Fig. 2.61

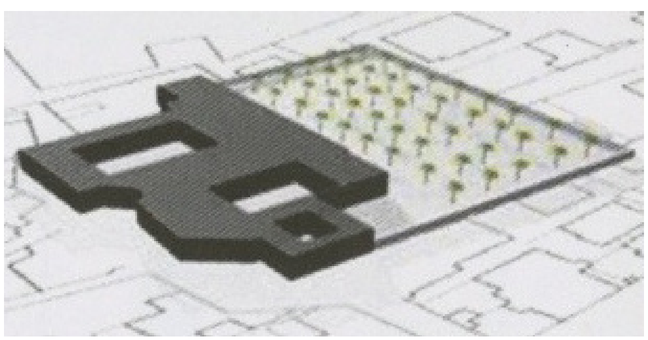


Fig. 2.62

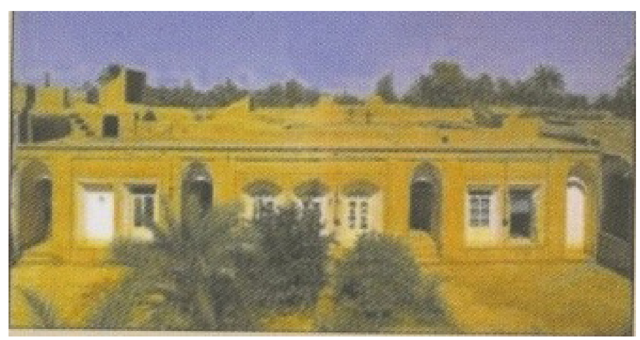


Fig. 2.63

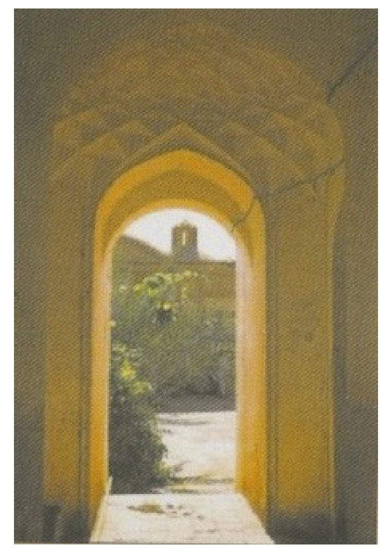


Fig. 2.64

2.6. Advantages of Bam's Vernacular Architecture

2.6.1. Sustainability

Through thousands of years of living in the difficult climatic conditions of the desert, inhabitants of the hot-arid climate have found the most suitable type of architecture and urban plan for this region. Traditional urban planning and vernacular architecture of desert areas are designed to take advantage of the surrounding living conditions to keep the heat away and cool the interior space of the buildings. They adapt and cooperate with the surrounding conditions, using all elements of nature, including the sun, wind, earth, and water to their advantage. Traditional residences of Bam are sustainable in terms of resources and income as well. Traditional garden houses provided income and resources through dates and citrus products of the garden, as well as meat and dairy products from the farm animals.

According to Nader Ardalan, a founding member of the Aga Khan Award for Architecture, and the author of the book The Sense of Unity[28], Bam's architecture is considered ideal for its context. Ardalan's description of good architecture is as follows:

> "good architecture should reflect a holistic appreciation of reality. Reality has a hierarchy of awareness levels within which there exists both outer and inner dimensions. The outer (ecological) dimension relates to a finite world of limited energy-income from the sun, of fixed energy reserves. The inner (cultural) dimension relates to human kind, who have an infinite, hidden reserve of energy, the spirit, that can often transcend the limited context of this phenomenal world."[29]

The following sections describe the elements and features that make the vernacular architecture and urban plan of Bam ideal for its environmental, social, and geographic context.

---

28 Ardalan, Sense of Unity.

29 Ardalan, Contemporary Architects, 1987, p. 44.

2.6.1.1. Urban Layout

The vernacular and traditional urban plan of every city demonstrates the sociological organization and cultural habits and behavior of its inhabitants, as well as how the city stands as a whole in its surrounding context and environment. The kinship pattern of traditional societies and the strong emphasis on the family unit create an important sociological reinforcement for the organization and use of space. Growth of families and their interest in living close to one another increases the urban density over time. The harsh environmental conditions of the desert also encourages a dense urban fabric. Through an urban plan with minimized exterior open space for public circulation and maximized interior private spaces, interaction with the hot, sandy desert is minimized. The narrow winding streets (Fig. 2.65) and typical courtyard residential typologies in the streetscape of Morocco (Fig. 2.67), Kerman (Fig. 2.68), Bam, and other traditional Islamic cities demonstrate the introverted culture of Islamic societies, creating a strong separation between the public and private realms. The winding narrow streets, surrounded by tall residential walls (Fig. 2.66), are designed to allow the sand-less wind to meander through the residential streets cooled by the shade of surrounding walls. The conjunction of shade and breeze creates a very pleasant space in the desert climate. The vernacular cities of the hot-aid climate are so environmentally well-designed that they create an oasis of shade, water, and vegetation in the heat of the desert.

FIG. 2.65. Streets of Jandagh's Citadel, shaded by structural arches and tall walls of surrounding residences.

FIG. 2.66. Traditional narrow Streets of Jandagh, a village in the hot-arid climate of Iran, shaded by the surrounding tall residential walls.

FIG. 2.67. Aerial view of Morocco, a typical Islamic city because of dense urban fabric with narrow winding streets, courtyards, and organic urban growth pattern.

Fig. 2.65

Fig. 2.66

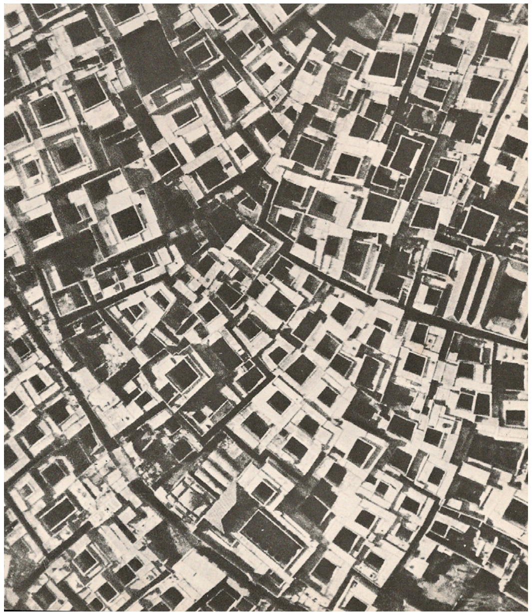


Fig. 2.67

FIG. 2.68. Aerial photograph of outskirts of Kerman, Iran.

FIG. 2.69. Sketch from the courtyard of a traditional house in Kashan.

FIG. 2.70. View of a residential courtyard and reflecting pool.

2.6.1.2. Architectural Features

Courtyard

Traditional buildings in hot-arid climates are based on courtyard typology due to cultural and environmental reasons. In a typical courtyard house, all windows open towards the courtyard (Fig. 2.69) with minimum or no openings towards the street. This creates an enclosed introverted space that is suitable for the conservative Islamic culture and protects the inhabitants from the harsh climate of the desert. The courtyard is used as means of circulation inside the house, creates a pleasant outdoor gathering space for the inhabitants, assists in cooling the house through the garden and the reflecting pool (Fig. 2.70), and provides shading created by the surrounding walls.[30]

Traditionally, different rooms around the courtyard were used in different seasons of the year. Spaces located to the north of the courtyard were used in winter and the spaces on the south side of the courtyard were used during summer to take advantage of shaded areas during the hot seasons and to use sun-lit areas during cold seasons.

30 Ministry of Housing and Urban Development, Typology of Bam, 13

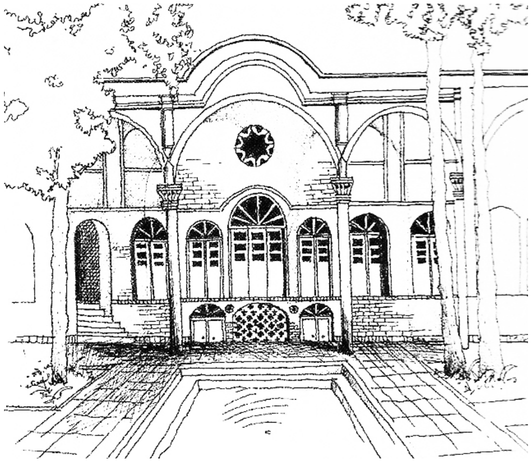


Fig. 2.69

Fig. 2.70

GARDEN

In many desert regions, such as Bam, the desert soil provides good conditions for particular agriculture. Plants that grow in desert climates, such as palm trees, are planted and used both as a source of income and as means of shading and cooling exterior spaces. The gardens are irrigated through Qanats (underground water channels) that bring the water from the mountains located to the west of the city. Access to water and fertile soil in Bam has created an oasis in the heart of the desert. The aerial image of Bam (Fig. 2.71) reveals its dry climate. As one looks closer at the urban fabric of this city, the green gardens seem to overtake the image of the desert (Fig. 2.72, Fig. 2.74). The modern city of Bam is a green oasis in the harsh climate of the desert with the earthen Citadel at its heart (Fig. 2.73). Green gardens and courtyards are used as public spaces to gather neighbors, family, and friends. It is interesting that the urban plan of Bam has no public parks. As the inhabitants use their gardens for public gatherings, there is no need for public green spaces outside of residences.

FIG. 2.71. Aerial view of Bam in its desert climate and with the Zagros Mountains located to the west of the city.

FIG. 2.72. Aerial view of the green city of Bam in its surrounding desert context.

Fig. 2.71

Fig. 2.72

FIG. 2.73. Bam Citadel at the foreground, the green citys of Bam in the middle, and the surrounding desert in the background.

FIG. 2.74. Aerial view of Bam covered with green Palm trees before the 2003 earthquake.

FIG. 2.75. A two layered garden in Bam.

Most traditional houses in Bam have two-layered gardens of palms and citrus trees (Fig. 2.75). In the two layered garden, rows of citrus trees are planted in between rows of palm trees. The difference in height of the trees creates optimal conditions for both trees. Date palms usually grow rapidly up to about 4 meters in height during the first year, after which their growth slows down. Citrus trees only grow up to 2.5 meters in total. The two layered garden allows the sunlight to penetrate through the branches of the Palms and reach the citrus trees. The evaporation of water beneath the palm trees also creates an ideal humid environment for the growth of the citrus trees.[31] Palm trees are so precious to the people of Bam that sometimes old palm trees are used for traditional sacrifices instead of animals such as sheep and cows.[32]

31 Ministry of Housing and Urban Development, Typology of Housing in Bam, 66.
32 Ministry of Housing and Urban Development, Typology of Housing in Bam, 44.

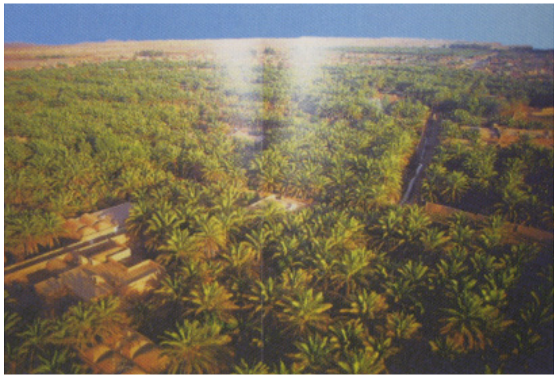


Fig. 2.74 (top left) Fig. 2.75 (bottom left)

Fig. 2.73

2.6.1.3. Natural Elements

Wind and Ventilation

The vernacular architecture of the desert takes maximum advantage of the prevailing cool and sand-less wind and blocks the unpleasant sandy wind. Wind catchers, vaulted roofs with openings on top, and the thoughtful location of openings in the building are the main elements of passive ventilation in traditional architecture of Bam and many other desert cities.

Bad-gir (wind catcher) is an architectural element designed for passive cooling through use of chanelling natural prevailing wind. Wind catchers are designed according to distinct wind patterns and climatic conditions of any specific location. The shape of the wind catcher, size, number and direction of openings, and height of the wind catcher is designed based on the direction and quality of various winds in the specific geographical location. The openings of the wind catcher face the prevailing cool wind, and its back blocks off the sandy desert wind. Fig. 2.78 demonstrates how the wind catchers cool interior spaces by drawing the cooling wind into the rooms, circulating it throughout various indoor spaces, and escaping through the courtyard. Unfortunately most wind catchers in Bam did not survive the earthquake in 2003 due to inadequate seismic resistance. However, windcatchers in other cities such as the ones in the town of Chupana (Fig. 2.76) in southern Iran and the ones in Boroojerdi residence (Fig. 2.77) in Kashan, central Iran, demonstrate the range of types of wind catchers. Fig. 2.66 on page 69 demonstrates a typical wind catcher that survivied the earthquake in Bam.

Vaulted roofs allow the warm interior air to rise to the top of the dome and escape from the small openings located at the top of the dome. Vaulted roofs are used in all building types including bazaars and residences. The ancient caravansarai and teahouse in Qom (Fig. 2.77, Fig. 2.78), Mematollah Vali Moselleum in Mahan (Fig. 2.82) and the bazaars and their surroundings buildings in Sirdjan and Isfahan (Fig. 2.81, Fig. 2.84) show the use of domes and vaults in a variety of building programs and cities throughout Iran. The Boroujerdi residence in the desert city of Kashan, Iran (Fig. 2.77), has some of the most sophisticated examples of wind catchers, skylights, and curved roofs.

FIG. 2.76. Windcatchers dominate the townscape of Chupana.

Fig. 2.76

FIG. 2.77. Boroujerdi residence, Kashan.

Fig. 2.77

FIG. 2.78. Windcatcher cross sections showing the temperatures of the external air, the Talar (ground floor living room), and the basement air. Air forced down through the tower travels through the basement and gets cooled and humidified before entering the courtyard. The cool air travelling back from the courtyard into the living spaces also reduces the heat and cools the occupants.

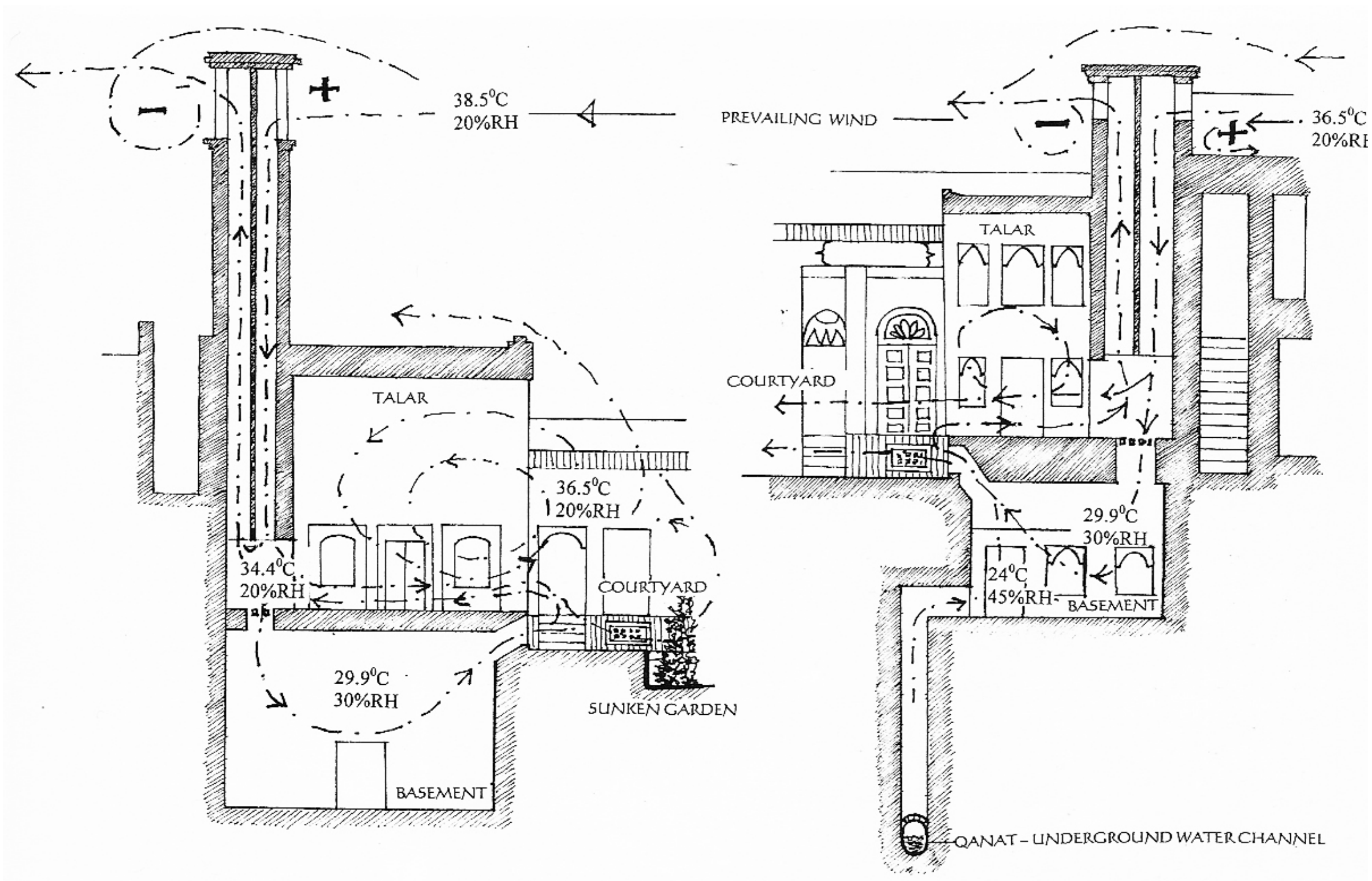


Fig. 2.78

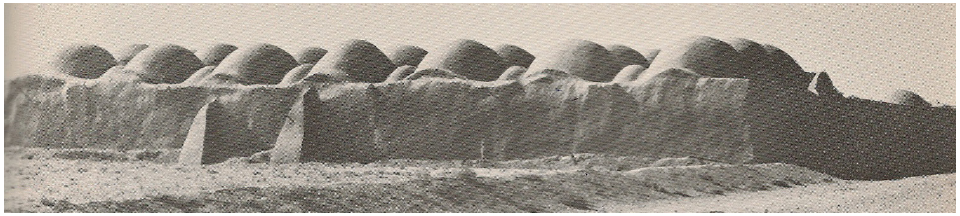


Fig. 2.79

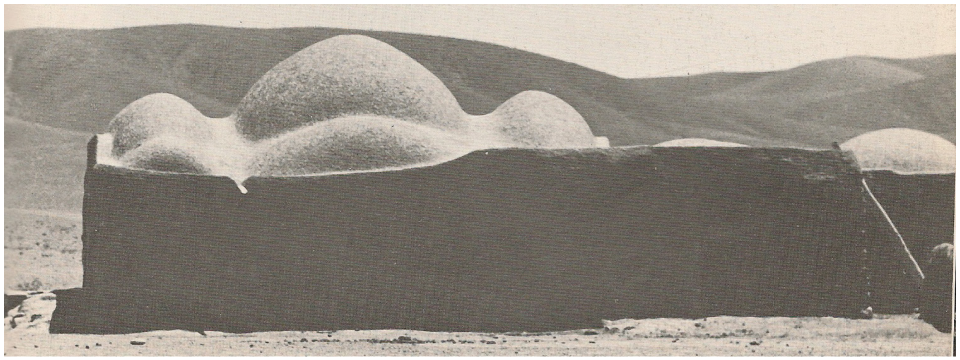


Fig. 2.80

FIG. 2.79. Sail vaults of a traditional Caravansarai in Qum, Iran.

FIG. 2.80. Sails vaults of an ancient Teahouse in Qum, Iran

FIG. 2.81. Aerial view of Bazaar in Sirdjan, Iran.

FIG. 2.82. Domed roof and ceiling vent at Nematollah Valli Moselleum in Mahan.

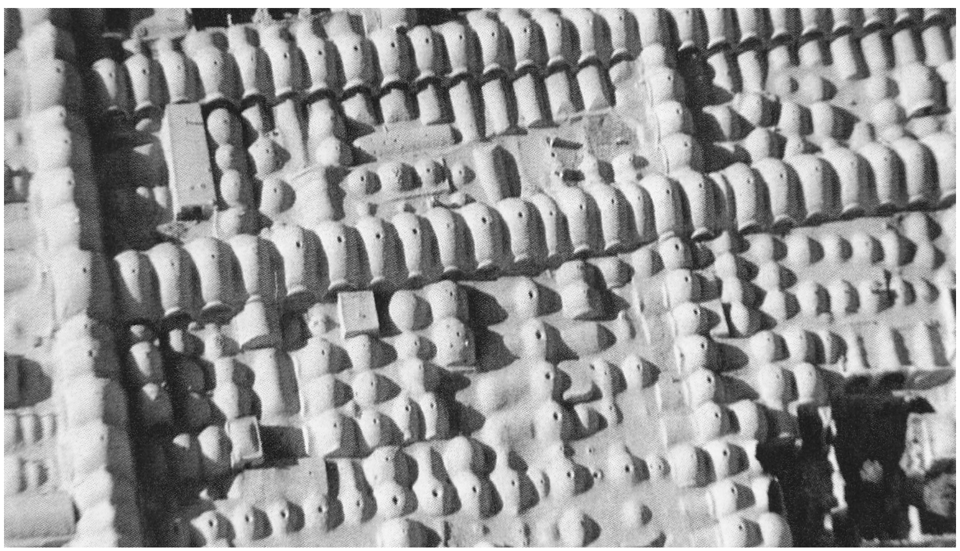


Fig. 2.81

Fig. 2.82

FIG. 2.83. Plans of poolhouses in Fatemi's House.

FIG. 2.84. Plans of poolhouses in Saadoddoleh's House.

WATER

Living in the hot and dry climate of the desert, water is a blessing. In traditional Persian architecture, water is used in conjunction with air to cool the space. There is typically a wind catcher located in a room called the pool house. Fig. 2.83 and Fig. 2.84 demonstrate two different arrangements of wind catchers in pool houses in traditional residences of Bam. The air traveling through the wind catcher passes over the reflecting pool located below the wind catcher. The air cooled by the water will then travel into other rooms cooling other interior spaces of the house and escape the house through the garden.

In traditional residences of Bam, there is usually a reflecting pool located at the center of the courtyard signifying its importance in the house. Traditionally the water in the reflecting pool was used for washing dishes and clothes. However today, the service function of the reflecting pool is eliminated, and it is only used as a passive cooling device to cool and humidify the courtyard. It also creates an aesthetically soothing environment in conjunction with the shade of the palms.

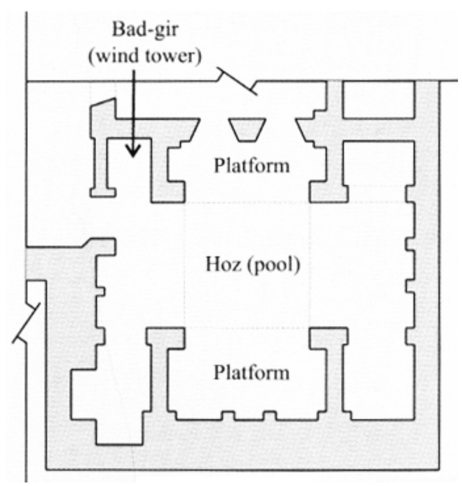


Fig. 2.83

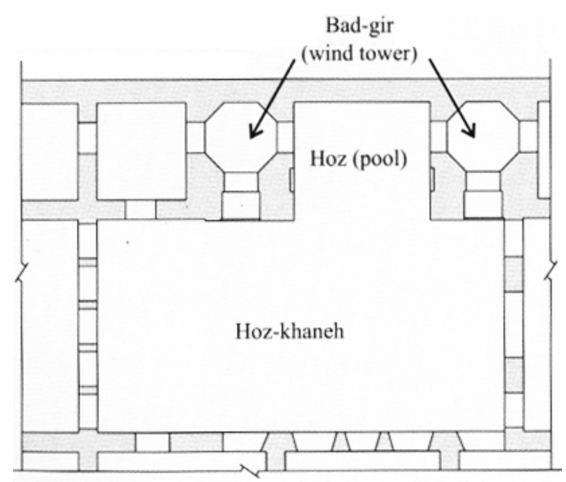


Fig. 2.84

The traditional architecture of Bam offers optimal use of the water by creating a well-planned circulation path for the water. Fig. 2.86 shows the cross section of the village of Khoranaq in the Central Iranian Plateau, noth of Yazd. The water enters the site through Qanats, and is stored in a drinking water cistern cooled and ventilated by wind catchers and a vent in the domed roof (Fig. 2.86). There is a staircase that provides access to a tap for drinking water from the cistern. The water from the cistern is directed to the baths and for use in washing kitchen ware and clothes without detergents (Fig. 2.87). The water then drops down a vertical chute to turn a water mill. The water is then used for washing clothes with detergents, and as drinking water for animals. The grey water is then used for watering the fields and gardens (Fig. 2.88).

FIG. 2.85. Cross section of the village of Khoranaq showing the path of the water through the village.

1. qanat (underground water tunnel)
2. drinking water cistern
3. wind catcher above water cistern
4. water tap for collection of drinking water
5. hammam (bath house)
6. washing kitchen ware and clothes without detergents
7. vertical chute
8. water mill
9. washing clothes with detergents
10. drinking water for the animals
11. watering the fields and gardens.

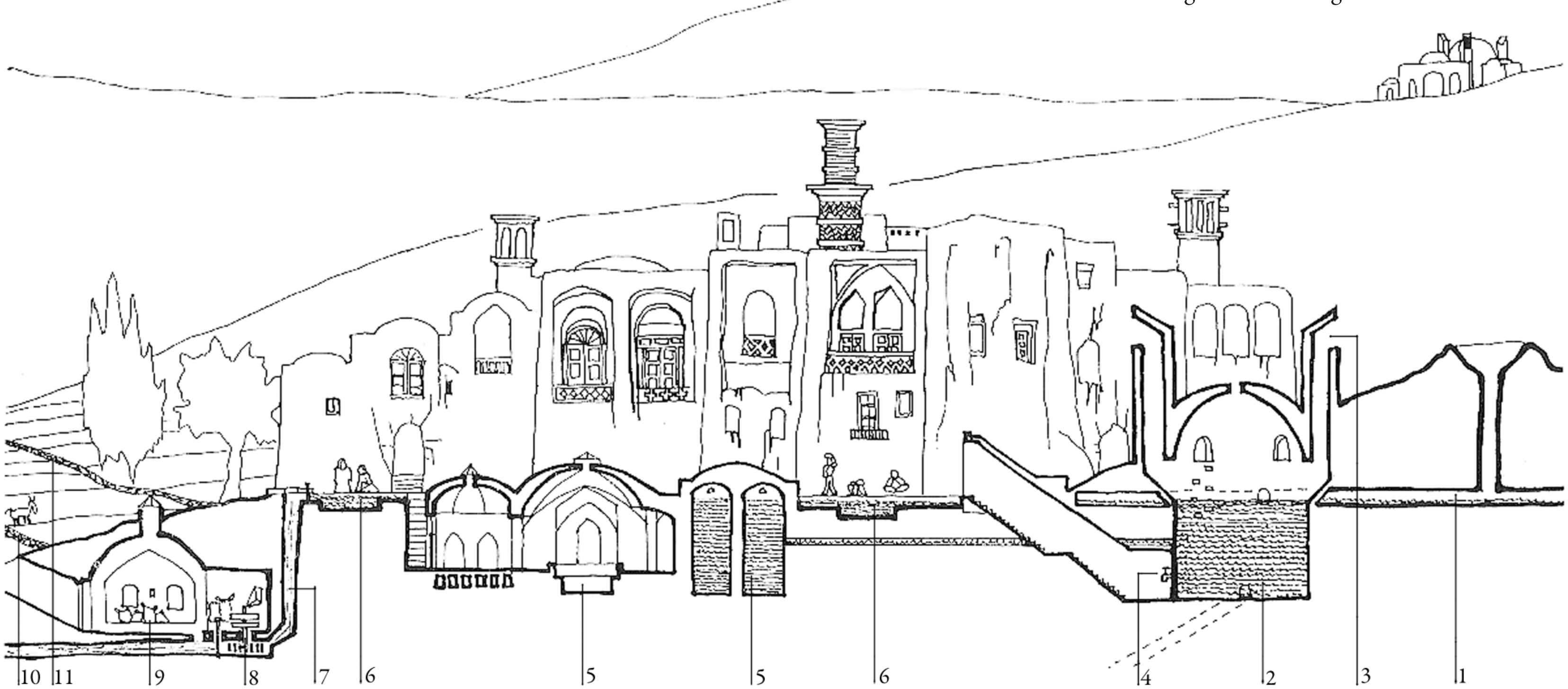


FIG. 2.86. A traditional water cistern with entrance to the staircase leading to underground cistern at the foreground, domed roof of the cistern and wind-catchers for ventilation at the background.

FIG. 2.87. Water channels at grade in Jandagh, Iran, transporting the water to a public laundry room.

FIG. 2.88. Above grade water channels in Jandagh, Iran, transporting the water from the qanats to agricultural lands.

Fig. 2.87

Fig. 2.88

Fig. 2.86

2.6.1.4. Reclaimed Material

The recycling and reuse of materials is well integrated into the culture and architecture of Bam and other desert cities. This is not only due to financial restrictions and lack of resources, but it has a much deeper root into the culture of living in the desert. Residents of the desert take advantage of all available materials and resources including earth, vegetation, and post consumer products. In Bam, palm leaves, shipping and soda containers, fabric, and other salvaged material was used to provide shelter for the homeless after the 2003 earthquake (Fig. 2.39 and Fig. 2.40 on page 53). In Jandagh, a small ancient desert village near Kerman, Iran, palm branches and salvaged material are used to cover holes in the roof (Fig. 2.89), and tailgates are used as residential doors (Fig. 2.90). Jandagh has a tradition of tearing up old-clothing and making hand-made carpets out of them (Fig. 2.91). Different colour clothes create a versatile colourful carpet striped in different cloth colours.

FIG. 2.89. Automobile tires, palm leaves, shovels, and wood panels used among many other items for covering openings in the roofs, Jandagh.

FIG. 2.90. Residential door made of Toyota truck rear doors, Jandagh.

FIG. 2.91. Carpet made of fabric of old clothing. Different strips of colour are made of different colours of clothing, Jandagh.

Fig. 2.89

Fig. 2.90

Fig. 2.91

2.7.1. Cultural Adaptability

Bam and most other desert cities in the developing world are located in Islamic countries, where the culture is very conservative. The architecture of these cities reflects the conservative culture of its residents, and provides most comfortable living conditions for an introverted society. The introverted culture is evident in the rigid separation of public and private spaces both at the scale of the residence and at the urban scale. As demonstrated earlier in Fig. 2.66 on page 69, all residential windows open towards the private garden in a traditional dwelling, and there are no openings towards the street. Where an opening is required between public and private spaces, direct view is prevented through change of direction or other visual obstacles along the circulation path. The entrance vestibule (Hashti) is a very good example of the redirection of a circulation path to prevent direct views into the private spaces of the residence (Fig. 2.92, Fig. 2.93). Hashtis are used at the main entrance of all traditional residences to provide a visual disconnection between the house and the street.

In traditional houses each room is provided with a distinct view depending on its program and use. Different rooms have window openings of different sizes according to their program and privacy requirements. Large interior public spaces such as the Talar (Main Hall), where guests are received, have large openings to provide a feeling of transparency towards the courtyard, while more private areas have smaller window sizes to maximize privacy. Fig. 2.94 shows a small windows located high on the wall of a bedroom in the village of Jandagh, and Fig. 2.95 on shows the large windows of the Talar of Boroujerdi house in Kashan opening to the courtyard.

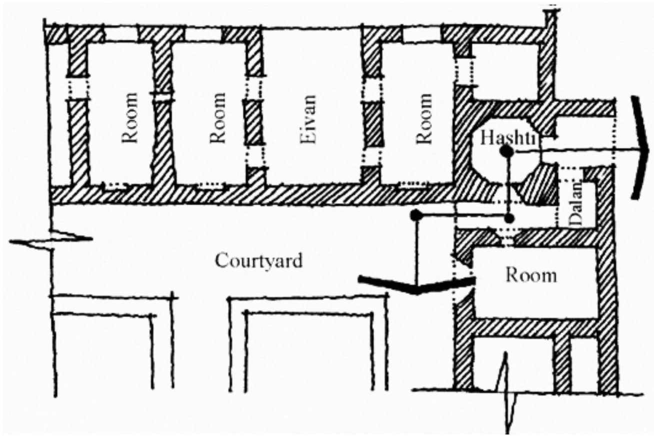


Fig. 2.92

FIG. 2.92. Entrance vestibule blocks the view into the courtyard by means of a turn in the entrance vestibule.

FIG. 2.93. Entrance Vestibule of a residence in Jandagh.

FIG. 2.94. Rays of light penetrating the small window openings and entering a private room in a residential building in Jandagh.

FIG. 2.95. View from the courtyard of Borjoojerdi house looking towards the windows of Talar. The windcatcher can be seen at the top and the reflecting pool at the bottom of the image.

Fig. 2.93

Fig. 2.94

Fig. 2.95

FIG. 2.96. Sedari (three-door) room in Tehrani's House, Yazd.

FIG. 2.97. Panjdari (five-door) room in Lariha's house.

2.7.1.1. Form and Space

The traditional Persian measuring unit of space is "Peymoon", a system based on human scale and proportions. The Peymoon system is based on opening sizes that suit the human proportions. It creates a three-dimensional system that refers to spaces by the number of openings. In this system a public room with three dors is called Se-Dari (three doors) (Fig. 2.96), and one with five doors is called Panj-Dari (Fig. 2.97). The word 'dar' translates to 'door' in farsi, and its suffix refers to the number of doors. Referring to the room by the number of its doors provides an easier understanding of the scale and quality of the space, as it signifies the importance of human proportions and comfort in Persian architecture.

Fig. 2.96

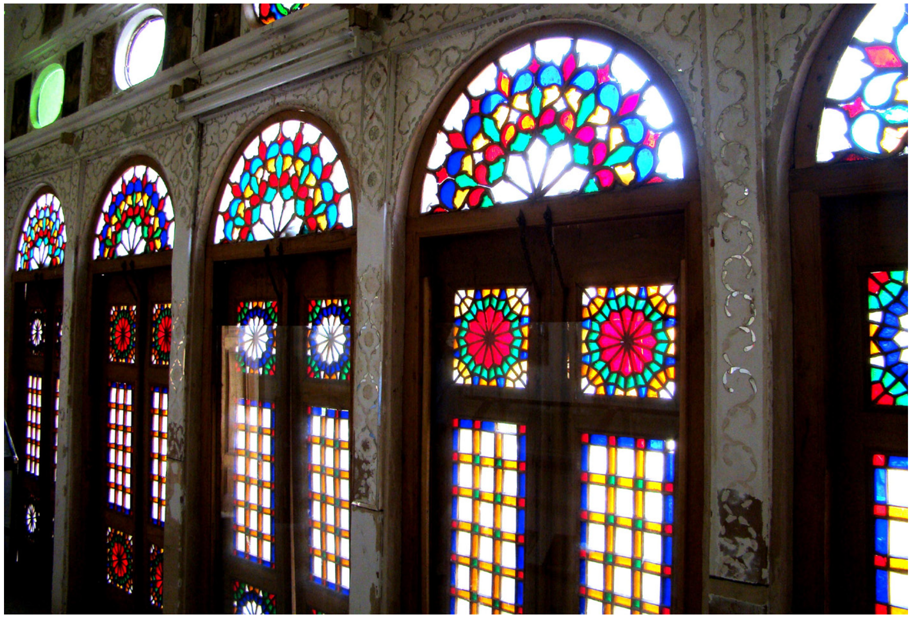


Fig. 2.97

In traditional Islamic architecture, the space is "cut out from the material forms around it and is defined by the inner surfaces of these forms."[33] It is the inner face of a vault, an arch, or a dome, or the walls of a garden that specify the quality of the space, not the material forms that occupy the space. The traditional architecture of Bam is very flexible in terms of program and use. In a traditional house, spaces are multifunctional and can be adapted or integrated to other functions. All rooms have flexible programs, with the Talar as the most flexible space because it can extend into its Eivans (porticos), as well as its side rooms or annexes, and can be used for various programs including sleeping, dining, and reception.

In a traditional house, open and semi-open spaces play an important role in the organization of the three functional space categories of living, circulation, and services. In most garden houses, the courtyard acts as the main circulation space. Semi-open spaces such as Talar provide access both to the open space of the courtyard and enclosed space of the private rooms. This creates a flexible separation of interior and exterior spaces, and creates the impression of courtyard penetrating into the house.

2.7.1.2. Spirituality and Architecture

Traditional Persian culture is deeply rooted in spirituality. Architecture reflects the spirituality though form, colour, interaction of architectural elements, and symbolism. The architecture of the desert tries to bring the serenity and holiness of the sky into the man's dwelling through the open space of the courtyard. With minimum openings to the outside, the house turns its back to the harsh climate of the deserts and opens its heart to the holy sky. It is as if the house owns a piece of the sky, which constantly replenishes the spirituality of the home from the heavens.

In symbolic terms, the courtyard is part of a microcosm that parallels the order of the universe. The four sides of the courtyard represent the four columns that carry the dome of the sky. The sky itself roofs the courtyard, and is reflected in the reflecting pool at the center of the courtyard. The pool becomes a reflective model for the dome of the heaven,

33 Ardalan and Bakhtiar, The Sense of Unity, xiii.

> Persian architecture is the ultimate example of an ideal world of form inspired by nature that allows transcendence to the higher stages of being through spatial experiences within the form.
>
> - Ardalan (The Sense of Unity, 16)

FIG. 2.98. Author's interpretation of Ardalan's Arc of Descent and Ascent of Seven Stages.

representing the existence of the holiness of the skies in the house.[34] This is not only an abstract symbolism. The combination of natural and architectural elements creates a strong spiritual space that can be sensed by all visitors who come from the unpleasant environment of the desert into the calming environment of a courtyard.

Persian architecture is intimately related to cosmology. Persians believe that man, architecture, and the cosmos are all works of 'sacred art' and are governed by divine principles.[35] Influenced by Islam, Persian architecture symbolizes "unity within unity" as well as "multiplicity within unity", demonstrating harmonious cycles with no beginning or end.[36] The philosophy of Persian architecture is about transcendence into unity through nature and its influence on forms. According to Nader Ardalan, in order to transcend from microcosm to macrocosm, one must take influence from the world of nature, transform his/her experience into the world of form, move to the world of spiritual perception and then to the world of imagination, transcend into the world beyond form, join the divine nature and ultimately the divine essence.[37] The author's interpretation of Ardalan's Seven Stages of Arc of Descent and Ascent (Fig. 2.98) demonstrates the path from the world of nature to the divine essense. What is essential to realize is that the second stage of transcendence to microcosm is the world of forms; it is this world connected to the world of man and nature, and to the world of spiritual perception that assists man's evolution to the higher stages of being. For optimum performance, the world of forms must maintain its constant connection with the world of nature and the world of spiritual perception. Typical forms in Persian architecture recall patterns in nature, achieving harmony with nature by simulating its forms.[38]

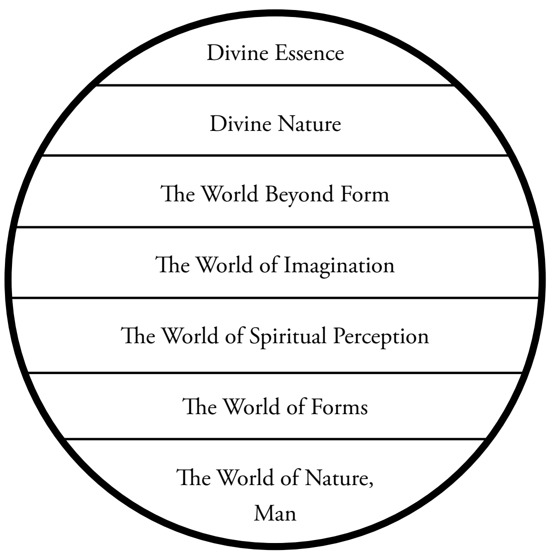


Fig. 2.98

34 Hassan Fathy, Architecture for the Poor, 56.
35 Ibid, xii.
36 Ibid, 6.
37 Author's interpretation of The Arc of Descent and Ascent of Seven Stages, from Ardalan, the Sense of Unity, 7.
38 Ardalan and Bakhtiar, The Sense of Unity, 16.

2.7.1.3. Architecture and Senses

Persian architecture captivates one by involving all of one's senses. A play of light, colour, view, texture, and scent of earthly material that embodies a spiritual fulfillment transcends one into the higher states of realization.

Light is the most dominant feature in Persian architecture.[39] Not only a physical element in Persian architecture, light also has a symbolic meaning of divine intellect and Being. Ardalan sees light as "a spiritual presence, which pierces the heaviness of matter and transforms it into a noble form worthy to be the dwelling place of the soul of man, whose substance is also rooted in the world of light."[40] The geographic location of Iran with its intense sun and the crystalline air of the high plateau region provides great opportunities for thoughtfully and vividly lit spaces. Different rooms in a traditional house are lit differently according to their program. Spaces such as the Hoz Khaaneh (pool-house) have minimum or no access to natural light, private spaces have small openings, and public spaces such as the Talar and the guest rooms have maximum access to natural light. Despite the amount of natural light allowed into the space, all openings, whether small or large, are designed carefully to capture the light in its most effective fashion. Fig. 2.94 on page 84 shows the play of light from a small window in a bedroom. The window is located high on the wall to prevent view into the private space of the bedroom, but allows rays of light to enter through the lattice of the window. Fig. 2.99 shows the powerful play of light in a stairway leading from the courtyard to the rooftop of a traditional home near Jandagh. Play of light on the texture of earthen walls gives a powerful depth to the space, and creates an ascending feel to the staircase.

FIG. 2.99. Light penetrating an opening above an ancient adobe staircase connecting a residential couryard to the rooftop.

FIG. 2.100. Colourful door, and colourful hand-crafted rugs of a residential house in Jandagh.

FIG. 2.101. Detailed flower carvings and hand-made door-knock on an ancient green door in Jandagh.

Fig. 2.99

39 Ibid, xiii.
40 Ibid, xiii.

Fig. 2.100 (top) Fig. 2.100 (bottom)

Colour is another significant element in the architecture of Persia. Influenced by the vivid nature of this country, all Persian arts including miniatures, carpets, and tiled buildings carry expressive use of colour. Colours are always selected with attention to both the symbolic meaning of the colour and its effect on the human soul. Traditional use of colour aims at "evoking a reminiscence of the celestial reality of things rather than imitating the natural colours of objects".[41] Traditional Islamic architecture of Iran uses a variety of colour combinations in the form of coloured tiles or coloured glass. Use of glass in Persian architecture dates back to 1 millenium B.C. in Choghazanbil Ziggurat. During Achaemenids Dynasty, 559-330 B.C.E., glass was used for its translucent quality. It was not only during the Safavids Dynasty, 1501 to 1736, that mirrors and glazing were decorated in various geometric shapes and painted in different colors.[42] Colored glazing can be considered one of the primary decorative features of traditional Persian architecture. Nasir Al-Molk Mosque in Shiraz was built in 1888 during the Qajar Dynasty. Use of colored glazing and detailed colorful interior decoration on the ceilings, along with colorful Persian rugs on the floor creates a very colorful and lively space (Fig. 2.103).

The architecture of the desert cities such as Bam mostly use monochromatic colour systems, as buildings are made of earth and the availability of resources is limited. Through use of a single colour system, the relationship of colour and geometry becomes a one to one ratio. Here the colours are no longer an infill for the geometric form, and there is full opportunity for the quality, character, and beauty of individual colours to be realized.[43] Through use of a single material such as earth, the inherent nobility and richness of the material can be observed at the surface level.[44] Sometimes single colour interiors are decorated with coloured glass panels. This creates beautiful interior spaces lit by multi coloured light shining through the glazings. Tabatabai's House in Kashan (Fig. 2.102) is a very good example of coloured glazing with single colour interior walls. Colour is also used for furnishing, fixtures, doors (Fig. 2.100), windows, and carpets (Fig. 2.100) to liven mono-colour interior spaces.

41 Ibid, xiv.
42 Joshan, Color and Form in Persian Architecture, www.saeedjoshan.com/?p=1681, accessed on 28 February 2011.
43 Ibid, 53.
44 Ibid, 33.

FIG. 2.103. Nasir Al-Molk mosque uses colored glazing with colorful interior decorations on the ceiling. (left)

FIG. 2.102. Tabatabai's home in Kashan uses coloured glass with single colour wall interiors.

Fig. 2.102

2.8. Disadvantages of Bam's Vernacular Architecture

2.8.1. Fragile Structures against External Forces

Traditional buildings of Bam are mostly made of adobe and cob, two vernacular earth construction techniques that employ unreinforced earth as the load bearing structure. Un-reinforced earth construction is least resistant to seismic tremors, which resulted in destruction of most of the buildings in Bam in the earthquake in 2003.

Adobe bricks are produced by putting the appropriate soil, clay, and straw mixture into the mold where the mix is worked lightly by hand and then quickly removed to dry under the sun.[45] The bricks are then stacked on top of one another with a layer of mud mortar to act as adhesive. Fig. 2.105 shows the garden walls of a 100 year old Hanna Factory in Bam, built of adobe bricks and covered with straw-mud coating.

Cob varies the adobe mixture by adding as much straw as a mud mixture can accept before it fails to bind. The subsoil containing clay is mixed with straw and water brought to a suitable consistency by kneading or treading. The lumps of earth or cob are placed in horizontal layers to form a mass wall. Fig. 2.106 shows a cob wall in Jandagh, Iran. Fig. 2.104 is a typical scene in today's ancient desert cities of Iran. It shows traditional walls of adobe and cob, patched with fired brickwork.

45 Paulina Wojciechowska, Building with Earth: A Guide to Flexible Form Earthbag Construction (City: Chelsea Green Publishing, year), 7.

FIG. 2.105. Wall of the Hanna Factory surviving from end of Qajar dynasty-beginning of Pahlavi.

FIG. 2.106. Wall texture of a typical exterior wall in Jandagh.

FIG. 2.104. Garden wall of a residence in Jandagh made of various earth construction techniques such as earth covered adobe and baked brick.

Fig. 2.105

Fig. 2.106

Fig. 2.104

2.9. Contemporary Architecture of Bam

Earth architecture has been substantially replaced by buildings of concrete and steel in the contemporary architecture of hot-arid climates. Fig. 2.107 and Fig. 2.108 show two typical modern concrete and steel structures built in Bam after the earthquake of 2003. The climatically ignorant, mere copying of Western architecture has become an epidemic in the developing countries. The elimination of earth architecture by substituting steel and concrete buildings is more evident in seismically active areas such as Bam, where the collapse of earth architecture has caused significant destruction and fatalities.

2.10. Advantages of Bam's Contemporary Architecture

2.10.1. Possibility of Stronger Structures

During the past few decades, authorities of the building sector have enforced various strategies to strengthen earth architecture against seismic tremors. The main principal of seismic-resistant earth construction is reinforcing the earth to allow ductility in case of tremors. In most countries, the seismic resistant building code suggests use of earth architecture such as brick in combination with steel to increase tensile strength. Reinforced earthen buildings create resilient structures that are able to withstand seismic stresses. Fig. 2.110 to Fig. 2.112 demonstrate some reinforcing techniques approved by the building codes in Iran and most other seismic-prone hot-arid regions. These techniques include confining masonry with concrete and steel rebars (Fig. 2.109), bed joint reinforcement (Fig. 2.110), reinforced grout cavity (Fig. 2.111), and reinforced hollow unit masonry (Fig. 2.112).

FIG. 2.108. Masonry ceilings and concrete columns and joists in a contemporary two-storey house in Bam.

FIG. 2.107. Steel structure to reinforce masonry in a contemporary building.

Fig. 2.108 (top) Fig. 2.107 (bottom)

FIG. 2.109. Two variations of confined masonry.

FIG. 2.110. Two variations of bed joint reinforcement.

FIG. 2.111. Reinforced grout cavity masonry construction.

FIG. 2.112. Reinforced hollow unit masonry.

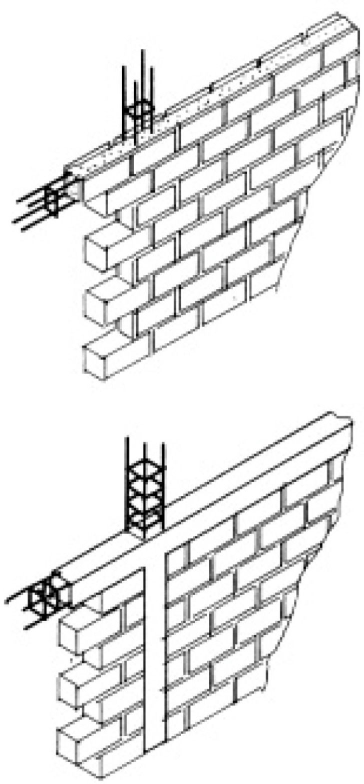


Fig. 2.109

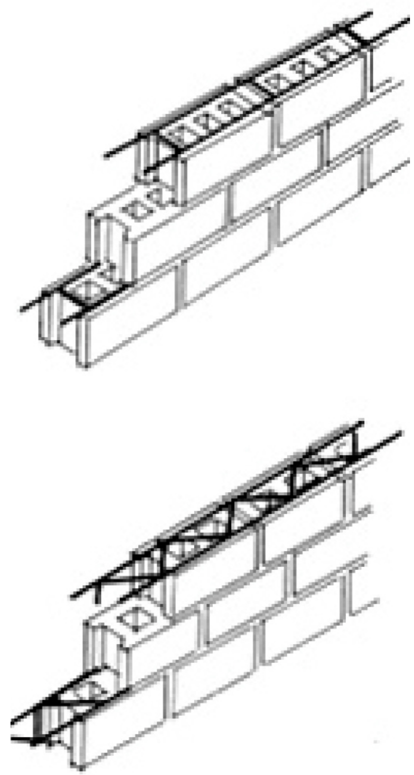


Fig. 2.110

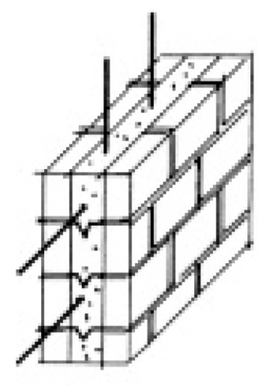


Fig. 2.111

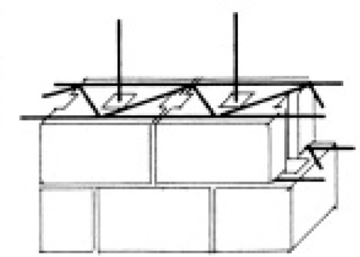


Fig. 2.110

Bam's 2003 earthquake damage and destruction map (Fig. 2.111) demonstrates that the historical center of Bam suffered the most damage. Most buildings in the historical center were traditional buildings of unreinforced earth. What is very interesting is that buildings in the modern neighborhoods of Bam were damaged to the same extent. These buildings were made of steel and concrete, and were expected to resist seismic forces much better than traditional earthen buildings. However, damage studies demonstrate that these buildings suffered the same extent as the traditional buildings. In many cases the ancient buildings survived, while the modern buildings failed catastrophically under the same extent of external force.

One might assume that the high destruction rate of the modern neighborhoods can be due to the high-rise construction. However, this is not the case in Bam, as the modern buildings are only slightly taller than the traditional buildings. The modern residential buildings are typically three to four storeys in height where as the traditional buildings are one to two storeys high. The primary cause of such high rate of destruction in modern buildings is the inadequate and inappropriate structural detailing, in spite of the potential strength of the materials used. Unfortunately this is the case in most developing cities, including Bam. The inappropriate structural detailing in the developing world is primarily due to using untrained construction workers, insufficient use of rebars and other structural reinforcing material due to budget restrictions, lack of supervision during construction, and irresponsibility of the authorities in issuing permits to buildings that are not structurally sound.

FIG. 2.113. Level of destruction in different areas of Bam demonstrates that the historical district and the modern district of Bam both have the highest destruction rate.

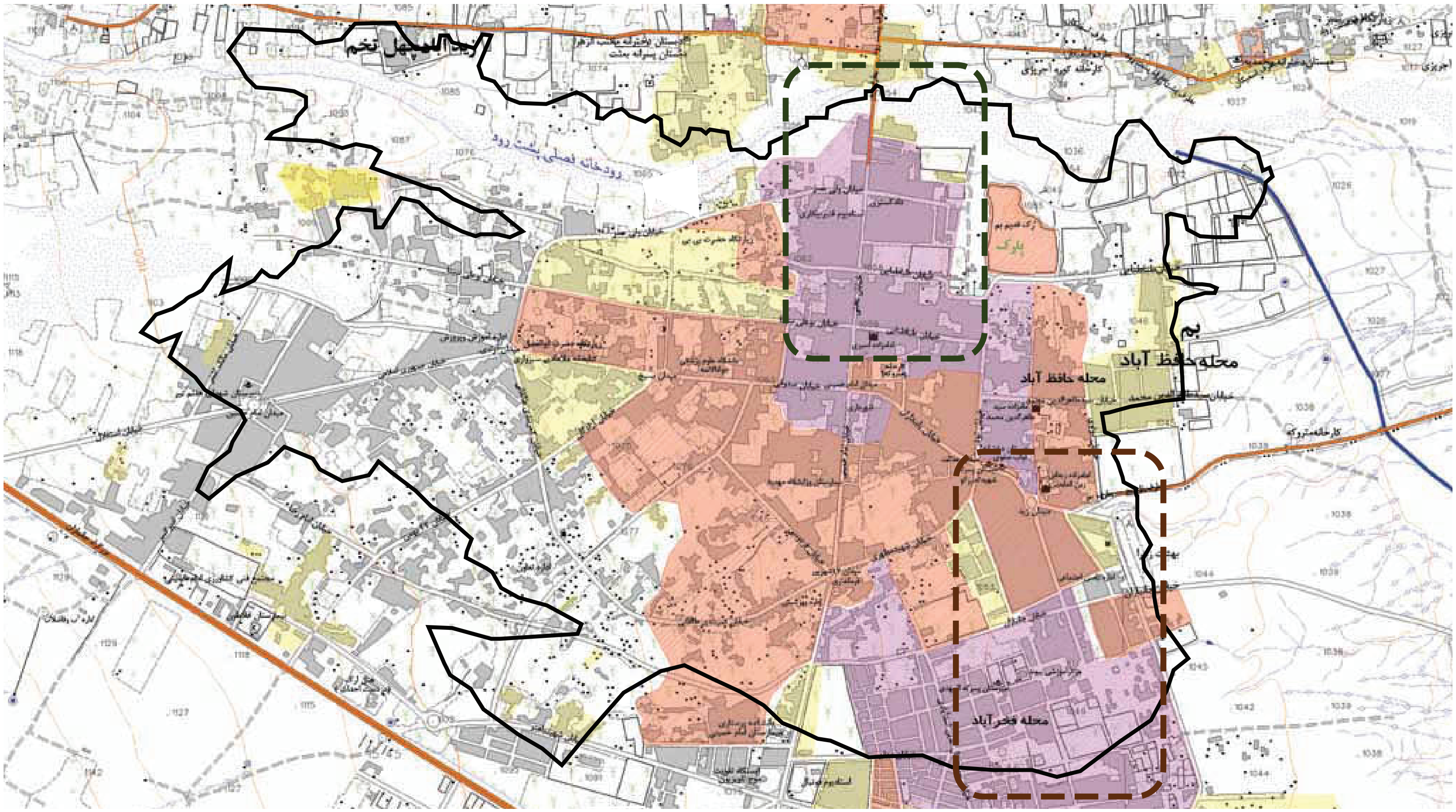


Fig. 2.113

2.11. Disadvantages of Bam's Contemporary Architecture

2.11.1. Climatic Inappropriateness

2.11.1.1. Ignorance in Urban Planning

Contemporary urban planning in many developing cities is adopted from modern Western cities. Wide, vehicle-friendly avenues (Fig. 2.114, Fig. 2.115) have replaced the traditional pedestrian-friendly narrow streets. Due to the large width of streets, surrounding walls cannot shade the streets and the cooling wind cannot meander through the alleys to cool the spaces.

Traditional desert cities such as Bam and Jandagh have a strong culture of social interaction and communal gatherings. As the streets widen and residences become sparser, human interaction between residences becomes more difficult. As the use of private motor-vehicles for transportation increases, informal social interactions fade out, weakening the social and cultural strengths of the traditional community. The modernization of the urban plan in traditional cities such as Bam results in negative effects on social and cultural aspects of life as well as negative impacts on environmental and comfort aspects.

Fig. 2.114

Fig. 2.115

FIG. 2.114. A wide contemporary street in Jandagh under the sun in an ancient neighborhood with windcatchers in the background.

FIG. 2.115. A residential street in Jandagh, with an ancient wall on one side and a contemporary wall on the other.

2.11.1.2. Ignorance in Architecture

Unlike the traditional architecture of Bam, this city's modern architecture is ignorant of its surrounding natural context. The contemporary architecture does not take advantage of the prevailing cool wind of the north and west, and does not block the sandy hot wind of south and southeast. There are openings in all sides of the building, allowing undesired wind and sunlight to enter the building. There are no passive cooling elements such as the wind catchers or vented domed roofs. The lack of consideration of surrounding natural context creates buildings that do not perform in coherence with their surrounding context. Instead of taking advantage of natural elements, these buildings block all natural conditions and require mechanical systems to create comfortable living spaces. This increases energy use and creates buildings that are in conflict with their environmental context. Fig. 2.116 shows some of the typical contemporary multi-storeys apartments built in Bam after the earthquake. What is evident is that all of these buildings are mere copying of the buildings in Tehran, which are formerly inspired by Western architecture, and are not suitable for the hot-arid climate of Iran.

FIG. 2.116. Typical contemporary apartment buildings in Bam.

Fig. 2.116

2.11.2. Cultural Inappropriateness

2.11.2.1. Loss of Identity and Spirituality

Replacing traditional architecture with contemporary non-regional architecture threatens the identity of historical cities such as Bam. Contemporary architecture uses interior and exterior forms and finishes, space layouts and program organizations that are foreign to the culture and social context of the place. Through using these foreign forms and elements, the character and identity of the city is blurred and gradually diminished.

The contemporary architecture of Bam eliminates all spiritual aspects commonly found in the traditional architecture of this city. In contemporary architecture, the house does not reflect the cosmos, but is just a space to contain our living requirements and services. The house within the city does not represent unity within unity, but is just a unit within a larger scope of neighbourhoods and the city. The spiritual play of light, colour, form, and texture is also eliminated in the contemporary architecture. It is as if the link between the world of form and the two worlds of nature and spiritual perception has been lost. According to Ardalan, this lost connection prevents man from transcending to higher stages of evolution.[46] The contemporary architecture creates a superficial space without any of the spiritual qualities of traditional architecture. Contemporary houses are designed as an extension of a two dimensional plan into a three dimensional space. This is very different from the traditional Persian module (Peymoon), where the dimensions and proportions were adopted from human scales to create three-dimensional spaces familiar to human perception. The ignorance towards human scale and comfort, space identity and links to sprituality creates spaces that are not familiar and comfortable for the users.

46 Ardalan and Bakhtiar, The Sense of Unity, xii.

2.11.2.2. Ignorance of the Conservative Culture

The predominant typologies for contemporary housing in Bam are the central hall, villa, and freestanding house types. Contemporary architecture minimizes the separation of public and private spaces, an essential quality of the architecture of Islamic societies. Unlike the traditional architecture in which each room had distinct window size and location according to its program and privacy requirements, all rooms in contemporary buildings have the same sized windows with equal access to view and light. Contemporary architecture allows for larger window openings. This is a great feature for ostentatious societies, but does not work well for conservative societies. In introverted Islamic societies, such as Bam, where a strong visual separation is required, residential windows are blocked with dark blinds and curtains preventing view and inevitably natural light from entering the rooms. In contemporary buildings, windows face the street, allowing undesired views from the public streets.

The growth of the population has resulted in multi-storey apartment buildings. This eliminates the possibility of private courtyards, and results in building the residences closer together. As the population grows, the number of multi-storey apartments increases and the window openings become closer together, resulting in more undesired views from the exterior into the private spaces of the house and creating more uncomfortable spaces to reside in.

The scale of the house has been reduced in contemporary architecture, and the house itself is no more used as the means of public gathering of the neighbors. Public gathering spaces of Talar, courtyard, Se-dari and Panj-dari have been minimized to a simple small living room. Eliminating gathering spaces such as courtyards in private dwellings diminishes the social culture of the residents over time, and creates a less social environment. Fig. 2.117 shows a few typical contemporary apartment buildings in Bam constructed after the earthquake of 2003.

3. Pilot Project

3.1. Pilot Project Design

3.1.1. History of Rahavard Mehr Va Danesh Institute

The pilot project proposes construction of a day-care institute for 112 orphans of the 2003 Bam earthquake. Rahavard Mehr Va Danesh Institute is a not-profit and non-governmental organization founded by Ali and Sarah Divsalar through financial donations from the private sector. This Institute is known throughout Bam and in some other cities such as Tehran, where funding is raised. The author first heard about this Institute through fundraisers who collected donations for the children after the 2003 earthquake. During a visit to the Institute in 2008, the Author decided to propose a solution to improve the children's living conditions at the Institute.

Ali and Sarah Divsalar moved to Bam in 2003 immediately after the earthquake to make a documentary film of the post disaster conditions. Noticing the number of orphaned children and the high risk of kidnapping, Sarah started adopting the orphans and taking care of them in their private tent. As the news of them adopting the orphans spread, more traumatized children came to them asking for support. Three months after the earthquake, Ali and Sarah were taking care of over 300 children in about 30 tents among the ruins of the city.

To improve the children's living conditions, they rented six temporary shelters made of shipping containers. These units provided better living conditions than the tents, but the space was limited to thirty children. Another group of volunteers soon joined Ali and Sarah to assist them in supporting and taking care of the children. However, due to administration conflicts with the second party, Sarah and Ali soon transferred all the administrative responsibilities to the joined party and moved back to their hometown, Tehran. The children had such a great influence on Ali and Sarah that that they could not live their normal lives without the orphans any more. They moved back to Bam, determined to stay there and improve the orphans' lives. They founded Rahavard Mehr Va

Danesh Institute, incorporating a program with the purposes of education, nurturing, and providing psychological support for the traumatized children.

Sarah and Ali gradually transferred the children from temporary shelters to a more permanent residence, and found guardians and foster parents for most orphans. In 2008, when the author visited Bam, Ali and Sarah were living in a four-bedroom house, administering 112 children. Most of these children have an elderly family member as a foster parent. Sarah and Ali believe that it is essential that the children have the emotional support of a family. However, most of the foster parents are in post-disaster trauma, many are drug users, and most have financial difficulties and can not support their foster children. Rahavard Mehr Va Danesh supports the children during the day, providing them food, education, and recreation, and requests the foster parents to provide them night accommodations.

Rahavard Mehr Va Danesh Institute has been planning to move to a larger space for the past few years, but has not been able to do so due to financial difficulties. The Pilot Project by the author proposes construction of a new building for this Institute. This thesis offers low-cost and easy to build construction techniques so the project is affordable and students and other members of the community can be involved in the construction process.

The good reputation of Rahavard Mehr Va Danesh Institute throughout Bam and other cities facilitates broadcasting the project for fundraising and construction. It also provides ideal conditions for the pilot project, as there are many similarities between the conditions of this Institute and the conditions of post-disaster cities. Some of these similarities include wide range of users in terms of age, physical, and psychological state, change of user requirements over time, budget and resource restrictions, availability of labour, and traumatic psychological condition of users. The similarities between Rahavard Mehr Va Danesh and a typical post-disaster city provides the opportunity for a proposal that is adaptable both at an architectural scale and an urban scale in any post-disaster condition.

FIG. 3.01. Proposed design incorporates the benefits of vernacular architecture and contemporary architecture.

	Vernacular Architecture	Contemporary Architecture	Proposed Design
Affordable	✓	X	✓
Flexible	✓	X	✓
Sustainable	✓	X	✓
Local materials	✓	X	✓
Local skills	✓	X	✓
Culturally appropriate	✓	X	✓
Modern technology	X	✓	✓
Resilient Structure	X	✓	✓

Fig. 3.01

3.2. Design Theory

3.2.1. Combination of Traditional and Contemporary Architecture

What is evident today in Bam is the awkward and inappropriate combination of vernacular architecture and contemporary architecture. As discussed earlier, Bam's vernacular architecture has many benefits in terms of cultural, social, and environmental adaptability, but with the disadvantage of weak structural systems in terms of seismic resistance. Contemporary architecture is ignorant of cultural, social, and environmental factors, but is capable of providing sound structural systems and high-tech sustainable solutions if budget allows. This thesis recognizes the need for architecture that simultaneously incorporates the climatically responsive vernacular architecture and the structurally resistant contemporary architecture, and proposes a design strategy that incorporates the advantages of both vernacular and contemporary architecture (Fig. 3.01).

This thesis agrees with Hassan Fathy, the pioneering contemporary Egyptian architect who called for a return to understanding traditional and vernacular approaches, that "it is only by tradition, by respecting and building on the work of earlier generations, that each new generation may make some positive progress towards the solution of the problem".[1] Tradition is the result of thousands of years of experience, and must be used and treasured, but not all elements of tradition are beneficial for the contemporary time. Tradition must be analyzed and updated to adapt to any specific period of time.

It is as important to be original in architecture as it is important to follow precedents. Ardalan argues that to represent originality is the ability of the artist to see his identification with the primary purpose, to follow laws laid down by tradition and to avoid all nonfunctional aspects. This gives originality true aspects of both permanence and change. Following traditional archetypes provides a link to the primary cause, creating permanence, while creating a new synthesis of material, techniques, and functions through creative imagination provides change.[2]

1 Hassan Fathy, Architecture for the Poor, p 24.

2 Ardalan and Bakhtiar, The Sense of Unity, 10.

This thesis proposes alterations in construction techniques of traditional architecture and incorporates modern techniques that are more stable and resilient. This creates 'change', while the 'permanence' is visible through maintaining cultural and environmental friendly elements of traditional architecture such as the courtyards, wind catchers, and reflecting pools.

Hassan Fathy is a relevant precedent for incorporating traditional architecture in modern buildings. He re-established the use of traditional architecture as opposed to western building design in his design of the city of New Gourna. In this project, Fathy encouraged ancient and vernacular design methods and materials. He proposed a design depending on natural ventilation, orientation and local materials, traditional construction methods and energy conservation techniques. Fig. 3.02and Fig. 3.03 show elements of vernacular Egyptian architecture such as domes and vaulted ceilings in the design of New Gourna. Fathy's architecture is against the use of western techniques and materials that are not environmentally friendly or easy to construct for unskilled workers. The design of New Gourna was not just an architectural experiment, but also a development of a town on a cultural, and social level following the regional traditions.

In spite of all the positive architectural aspects, unfortunately New Gourna was not a successful project upon completion. Reasons of failure for this project included lack of understanding of users' culture and expectations, and selection of inappropriate traditional elements of architecture. This thesis adopts Fathy's key concepts of climatically and culturally appropriate architecture, and the adaptation of vernacular architecture in a contemporary state. It also realizes the causes of failure and attempts to prevent or resolve these issues in establishing a typology for the Bam Pilot Project. This thesis proposes educational strategies in addition to architectural strategies to prepare the public for contemporary architecture that is rooted in the traditional architecture. It involves the users throughout the design and construction process, to assure their contentment with the project.

FIG. 3.02. Open space in New Gourna, Egypt.

FIG. 3.03. Dome and ventilation openings, New Gourna, Egypt.

Fig. 3.02 (top) Fig. 3.03 (bottom)

To decide which features of vernacular and which features of contemporary architecture must be incorporated in the proposed architecture, this thesis considers the advantages and disadvantages of both contemporary and vernacular architecture and selects the most appropriate elements from both styles.

3.2.2. Regionalist Architecture

This thesis uses regionalist architecture governed by the unique climatic characteristics of the specific geographical location, altered to meet modern aesthetics and structural standards. Regional architecture signifies uniqueness of architecture in a particular locality.[3] Regional architecture does not reject modernism, but rejects Internationalism. Modernism's demands, including respect for inherent qualities of building material, structural expressiveness, and functional justifications of forms, does not contradict with regional architectural style.[4] Regionalist architecture is reflected in the traditional architecture Bam, which is incorporated in the proposed design for the Bam Pilot Project.

3.2.3. Regionalism and Sustainability as Global Trends

For years, the International Style of construction in glass without consideration of surrounding climatic context was the architectural trend in the developed countries. Today scientists have realized that this style is not environmentally suitable, and are suggesting strategies towards a more sustainable architecture. With advanced research in global warming and resource usage, architects are encouraged to use natural resources to reduce the carbon footprint and consumption of non-renewable energy in buildings. Developed countries, such as Canada and the United States, have undertaken great efforts in educating the public and promoting environmental friendly living strategies. These efforts are most evident in present architectural trends in these countries. LEED™ (Leadership in Energy Efficient Design) is a prominent program encouraging sustainable design.

3 Architectural Regionalism, p 57. article: regionalism and nationalism in architecture, by Harwell Hamilton Harris published in Texas quarterly 1 (February 1958): 115-24.

4 Architectural Regionalism, p 107. essay: regionalism within modernism, by Suha Ozkan- published in regionalism in architecture, Robert Powell, editor, (Singapore: Concept Media, 1985), 8-15.

The use of reclaimed and recycled material, the use of natural resources such as solar and wind power, use of rainwater and gray water for irrigation, and use of passive heating and cooling with proper building orientation as well as the use of vegetation are some of the architectural design strategies encouraged today in the developed countries. It is very interesting that the traditional architecture of Bam incorporates all these aspects. Unfortunately the majority of the population in the developing countries is not aware of these benefits, and is trying to replace the traditional architecture with International or Western architecture. This is while the West is seeking sustainable elements present in vernacular architecture of the East.

The number of traditional buildings in Bam is being constantly reduced, as they are being torn down and replaced by multi-storey contemporary buildings. If the process of destruction of vernacular architecture proceeds at the speed it does today, soon the sustainable vernacular architecture of the East will be diminished. It will not take long until people realize the values of what they have destroyed, as the new structures provide much less comfort than the old traditional buildings. In many cases the inhabitants refused to live in the hot and unbearable living conditions of prefabricated metal shelters and even the concrete permenant buildings. They abandoned these buildings, used them for sheltering their animals, and built vernacular earthen buildings for themselves to reside in.[5] Vernacular architecture of Bam is of great architectural and historical significance and must be saved from destruction.

"Good regionalist architecture is 90% cultural practice and 10% style."

-Barbara Allen

5 Khalili, Nader. Ceramic Houses and Earth Architecture, p.18.

3.2.4. Architect-User Relationship

To assure the success of any architectural project, the architect must fully understand the users' expectations and culture. The architect-client relationship is especially crucial in projects that are innovative and out of the ordinary. If the users approve the innovative ideas, they can become a strong force in broadcasting the idea and in facilitating the design and construction process. However, if they disapprove the idea, their resentment can be detrimental to the project as a whole.

Hassan Fathy offered revolutionary architecture for housing the poor in developing countries . He believed that "without the participation of the architect, the buildings will be ugly, inappropriate, and, or expensive. Without the cooperation of the people, the project will be sterile, unloved, and untended."[6] He emphasized close interaction of the architect and the user, but the failure of New Gourna demonstrated that he did not succeed in creating the proper user-architect relationship in New Gourna. The people of Gourna were opposed to the project as a whole, as well as its architectural language and construction process. They did not want to move from their hometown to a new city. Fathy's design incorporated domes as the main roof form for all buildings, including residences. People of Gourna perceived domes only appropriate for burial spaces, temples and mausoleums, not for roofing residences. Residents of Gourna resented working to build their houses as they expected their homes to be delivered as a finished product. They also did not consider mud brick as progressive and did not believe it to be a sound engineering material.[7] Fathy failed in understanding the users' cultural and architectural expectations as well as their anticipated level of involvement in the construction process. Even though he selected an appropriate architectural style, his failure to understand the users' expectations resulted in the failure of the project as a whole. For the purpose of the Pilot Project, it is essential that the users be involved throughout the entire design and construction process to assure that their expectations are met.

6 Fathy, Architecture for the Poor, xiii.

7 Ibid, 187-192.

3.2.5. Aided Self Help

This thesis proposes aided self-help as the main construction strategy. Through this strategy, equipment and material will be provided to the financially depressed, who will offer their labour time for free in order to improve their living conditions.[8]

The following conditions must be satisfied in order to have a successful system of aided self-help.[9] Material provided must be low in cost in order for the users to be able to purchase them, or for the external parties to be willing to donate them. Only common, local materials should be provided for ease of access after project completion. Construction techniques must require minimum skills in order for unskilled users and volunteers to be able to construct the project. Construction materials must be easily accessible, and construction techniques must be easy to follow to allow for adoption of construction techniques in future opportunities. The first self help residence was built by Habitat for Humanity in 1976 by Millard and Linda Fuller. Following this project, many other foundations started involving volunteers and using self help strategies for constructing homes for low-income families.[10]

Construction through aided self-help becomes a communal activity that impacts the community at a deeper level. Self-help construction has easier applicability in societies that have a strong sense of community. Bam is the ideal city for a pilot project through self-help, as it is a traditional city that values communal activities. Low income residents of Bam are mostly unemployed and are willing to offer their time for incentives such as building homes or learning new skills that increase their chance of employment in the future.

> "Good architecture comes from good architects. Great architecture has to come from a client."
>
> -Thom Mayne

8 Ibid, 116.

9 Fathy, Architecture for the Poor, 118.

10 Habitat for Humanity Website, Accessed 20 September, 2011, http://www.habitat.ca.

3.3. Affordable Seismic Resistant Architecture

3.3.1. Earthbags

Architect Nader Khalili, founder of Cal-Earth Institute (California Institute of Earth Art and Architecture), invented Earthbag construction, a new strategy for construction of earth architecture. Earthbags are textile bags or tubes filled with earth, tamped to a very solid mass, used to construct foundations, walls, and domes. The bags act as forms that allow ramming or tamping the earth to create thick earthen walls, symmetrical arches, vaults, or domes covered by plaster.[11]

Earthbags construction is one of the two main construction techniques used for the construction of the pilot project. Earthbag construction is ideal for Bam because this city is located in the Persian Plateau, where soil is the most commonly available resource and residents have the culture of altering and reusing fabric. Bam is also known for its wheat and barley production, usually packaged in jute bags, ideal for earthbag construction. Earthbag buildings are low in material cost, but intensive in labour. It is ideal for Bam because there is a large number of unemployed residents who are willing to volunteer for construction.

When built properly, earthbag walls are extremely strong and can last hundreds of years.[12] Earthbag structures have been structurally tested and proved to withstand seismic tremors. Between 1993 and 1995, three of the experimental earthbag structures at Cal-Earth passed structural tests approved by the International Conference of Building Officials (ICBO), leading to building permits for the Hesperia Museum and Nature Centre in California in March 1996, followed by a school initially designed by Nader Khalili and Iliona Outram in Nevada in the same year. Later tests performed by ICBO approved earthbag building techniques for all types of buildings, from residential to commercial.[13]

11 Wojciechowska, Building with Earth,12.

12 Wojciechowska, Building with Earth, 43.

13 Ibid,14.

Compressive strength of un-plastered earthbag walls meets or exceeds the vertical compressive strength of conventional stud-frame housing technology.[14] The use of bags as containers allows the builder to utilize a wide range of soils, from un-stabilized earth or sand directly from the site, to soils with high clay content, or even gravel. Using this technique, costly materials such as cement and steel can largely be avoided.

One of the first projects that used this technique was Baninjar Refugee Camp (Fig. 3.06) in Khuzestan, Iran. This project included fifteen homes for the refugees of the Persian Gulf in 1995. Eco Dome (Fig. 3.07, Fig. 3.08) is another project made of earthbags and barbed wire by Cal-Earth Institute. Fig. 3.09 shows Eco dome under construction and Fig. 3.10 shows the finished clad building.

Ideal forms for building earthbag structures are domes and vaults in the order mentioned. This is due to structural strength of these forms and the possibility of using one construction method for the walls and the roof. Domes and vaults can be layed out in a variety of ways to create unique shapes or urban layouts. Fig. 3.04 and Fig. 3.05 demonstrate two different master plans for laying out earthbag building. In Fig. 3.04, the units are half-dome shaped, and are aligned to a central spinal wall, creating opportunites for two back to back neighborhoods. Hobbit House by Paulina (Fig. 3.11) follows this layout. Fig. 3.05 demonstrates a courtyard-based layout, in which the buildings gather around a central courtyard, creating a more center-oriented layout. Layout and form of the buildings create the spatial character of the building and neighborhoods, and must be designed according to the identity and program of the place. The form of the building is also crucial. The earthbag building can be a simple dome or vault, or can be an organic form, such as the Emergency Domes by Cal-Earth Institute (Fig. 3.12). This building has offered a unique organic free form to the vault, creating a much more modern appearance.

14 Callaghan Daigle, "Earthbag Housing: Structural Behaviour and Applicability in Developing Countries," (master's thesis, Queen's University, Canada, 2008), ii.

FIG. 3.04. Typical layout of units along a central spinal wall.

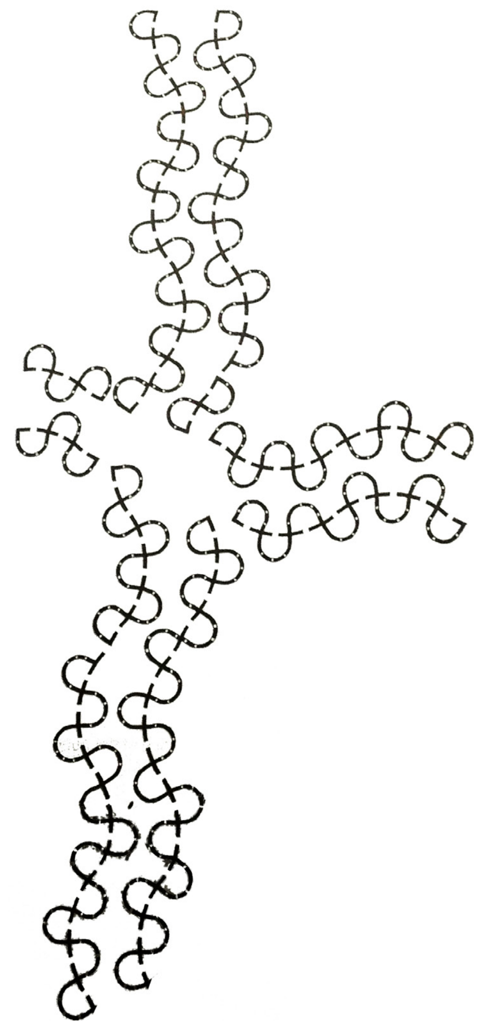


Fig. 3.04

FIG. 3.05. master plan of Eco-Village with shelters clustering around a courtyard.

FIG. 3.06. Beninjar Refugee Camp, Iran, by Nader Khalili.

FIG. 3.07. Eco Dome, interior vaults.

FIG. 3.08. Eco Dome, dome with skylight.

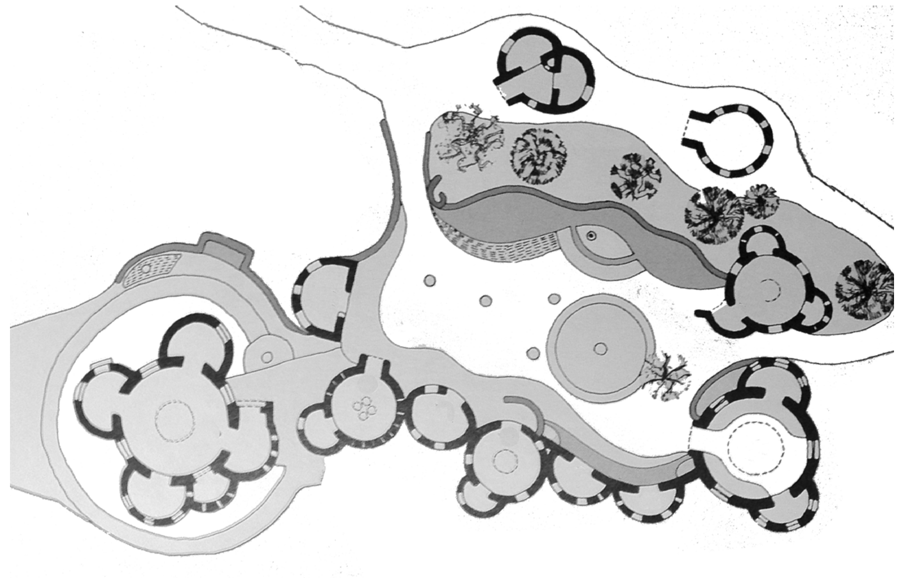


Fig. 3.05

Fig. 3.06

Fig. 3.07

Fig. 3.08

FIG. 3.09. Eco Dome during construction.

FIG. 3.10. Eco Dome after completion of exterior rendering.

FIG. 3.11. Hobbit House, Warsaw, Poland, by Paulina and Jerema.

FIG. 3.12. Emergency Domes by Cal-Earth Institute.

Fig. 3.09

Fig. 3.10

Fig. 3.11

Fig. 3.12

FIG. 3.13. Procedure of filling up earthbags.

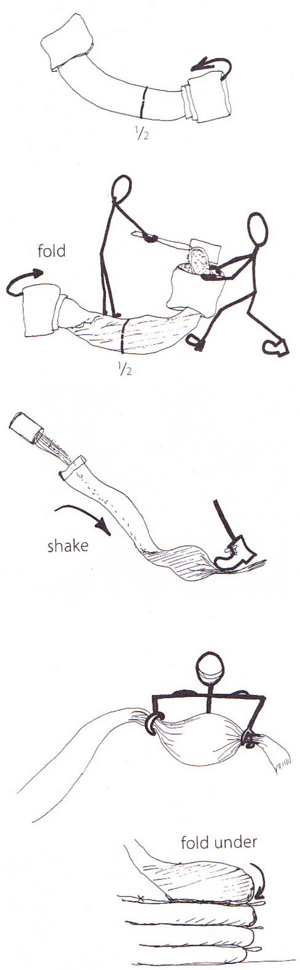


Fig. 3.13

3.3.1. Earthbag Construction

The construction of an earthbag structure is very simple and requires minimum materials and skills. Almost all one needs for constructing a building in this technique is earth and bags. There is no need to lift heavy loads as the earth on site can be used to fill the bags. Bags or tubes used in the earthbag technique can be made of any cloth that is strong enough to resist tamping; even old clothes can be cut up and altered to hold earth.[15] The bags are only temporary forms, and will not effect the durability of the structure if earth is tamped properly.

To begin the construction, the site must be cleared and flattened. A string or chain can be used to inscribe a round base for the dome. The bags are located on the perimeter of the base and filled up with earth. Fig. 3.13 demonstrates the procedure for filling up the earthbags. Usually the bags are filled from both sides with one person holding the bag and the other filling it up. The edges of the bag can be folded if long bags are used. The filled bags are then tamped and folded under at the edges. Fig. 3.16, Fig. 3.15, and Fig. 3.17 show images of an earthbag building during construction.

The earthbag building can be built sunken into the ground to reduce contact with the surrounding hot air and maximize contact with the cool earth. The earth that is dug out can be used for filling the bags. The surrounding ground acts as a buttress and the Earth's mass acts as thermal insulation against the hot desert climate. For earthquake areas, Nader Khalili uses sand to isolate the foundation slab from the base of the structure, allowing the building to 'float' during the earthquake 'like an upside down tea cup' to reduce the risk of breakage in the walls. Fig. 3.14 demonstrates a typical wall section for an earthbag building in earthquake-prone hot-arid areas. The barbed wire and sand isolation at the base of the building allow resilience and structural strength. In the hot-arid climate of the desert, drainage, water proofing, and insulation are not required.

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15 Ibid,19.

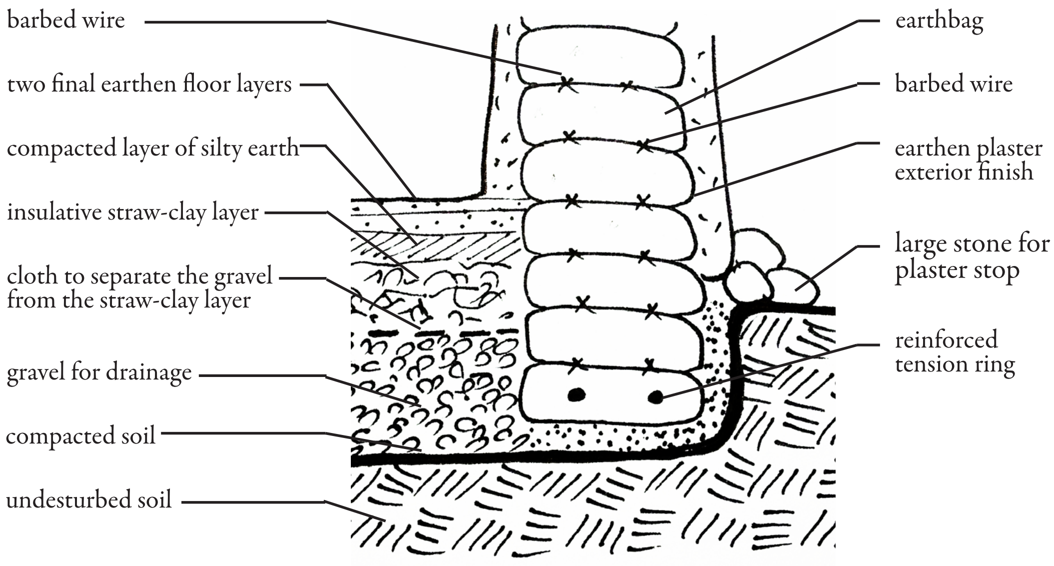


Fig. 3.14

FIG. 3.14. Wall section of an earthquake resistant earthbag building in the hot-arid climate.

FIG. 3.15. A Cal-Earth earthbag filled with earth with one row on barbed wire on top.

FIG. 3.16. Filling up the earthbags: one person holds the bag, while the other fills it up with soil.

FIG. 3.17. Ducts, tubes, and wooden forms can be used for making door and window openings.

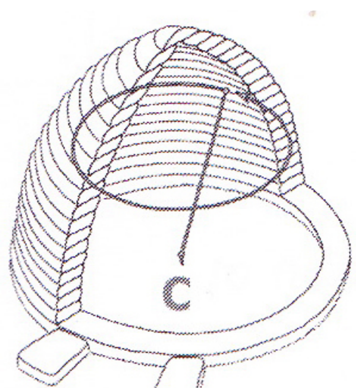
Fig. 3.15

Fig. 3.16

Fig. 3.17

FIG. 3.18. Center compass is connected to the center of the dome at one end, and determines the edge of the bag at every row.

FIG. 3.19. Height compass is connected to the side of the dome and determines the height of each row of sandbags.



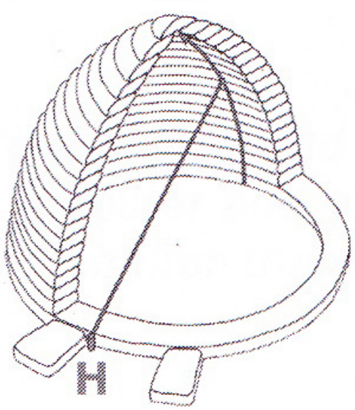


Fig. 3.18 (top) Fig. 3.19 (bottom)

Two simple compasses are used to construct the dome. The first is a Center Compass, connected the center of the dome at one end, determining the edge of the bag at every row (Fig. 3.18). The other compass is the Height Compass (Fig. 3.19), connected to the side of the dome, determining the height of each row of sandbags. The compass can be made of chains or other non-stretchy cable or rope.

The earth used to fill the bags must be moist enough to allow compaction. Bags can be filled with a shovel, tin can, bucket, or any other container that the worker can lift. Each bag must be filled as much as possible and the tamping should not start until the whole row is filled. Tamping should continue until no movement of the earth is felt in the bags. It is essential that each row be tamped flat for stability. Bags filled and tamped by different workers will look different as the strength and technique of workers vary. Therefore it is essential that one person or team builds an entire row of earth bags to minimize inconsistency in one course. Attention must be paid to stagger the joints on successive courses, similar to masonry construction. For dome construction, it is beneficial to have one long bag per course rather than a large number of short bags. This is even more important for the foundation, where the bags or tubes should be as long as possible to minimize breaks and maximize structural stability. After filling each bag, the ends of the bag must be folded over and tucked underneath the bag to close the opening. After each row of bag is filled with earth and tamped, two strands of four-point barbed wire must be placed on top of every row of earth bags as keying for the next row (Fig. 3.15). As this thesis proposes all ages be involved in the construction process, it is important that adults be responsible for more difficult or dangerous tasks such as placement of barbed wires.

Span width and number of openings in an earthbag dome is limited due to structural stability of the dome. In general, square openings are not suggested for domes, but suggested for straight walls. Arch openings are suggested for domes. To construct arched openings, objects such as buckets, barrels, or constructed wooden forms can be used as forms. (Fig. 3.17) shows how wooden forms and circular ducts are used as forms for creating door and window openings in the Eco House.

The roof of an earthbag building can be made of any material including brick, adobe, wood, or steel frame. It can be any shape, such as dome, vault, flat, or pitched. It can also have various functions such as water catchment or green roof.[16] However, the ideal is to build the roof using the same material as the walls. For dome structures, courses of earth bag used for constructing the walls will be gradually placed more towards the inside to shape the dome of the building.

Domes have two areas of maximum pressure, the base of the dome and the top of the dome, where there is a lot of pressure if the dome is open on top. The base of the dome must be buttressed by architectural buttressing or constructing the building sunk into the ground, buttressed by earth. A continuous tension ring must be used at the base of the dome to absorb the downward horizontal forces that would otherwise cause the base of the walls to splay out and collapse. In seismic regions, this ring must be stabilized with continuous reinforcements surrounded by concrete, cement-stabilized rammed earth, metal or some other resilient material. The stabilization of the base of the dome is the most expensive part of constructing an earthbag structure. Compression rings, used to strengthen the dome against upward and inward pressures are to be used if the dome is open on top. The compression ring must also be continuous, made of concrete, metal, wood, or other material providing sufficient and continuous reinforcement. Only a small amount of concrete is required for the compression ring, which could also be substituted with wood to eliminate the negative effects of concrete.

16 Ibid, 65.

FIG. 3.20. Earthship, Brighton, England.

FIG. 3.21. Interior view of a rammed car tire building revealing the shape of car tires.

Fig. 3.20 (top) Fig. 3.21 (bottom)

3.3.2. Rammed Automobile Tires

The rammed automobile tire technique is similar to the earthbags technique but uses recycled automobile tires as permanent forms instead of bags. Soil-filled tires are stacked like giant bricks to form foundations and walls. Concrete may be used to fill the voids between tires.[17] This type of construction is earthquake resistant,[18] and since it does not rely on any specific type of earth, it is adaptable for any location and any soil type.

Michael Reynolds, the creator of Earthship concept and the founder of Earthship Biotecture has built many car tire buildings all around the world including Africa, Norway, Texas, California, Montana, Canada, and Jamaica.

The province of Kerman is well known for its automobile and tire industry. With modernization, growth of urban areas, and increase in use of motor vehicles, disposal of automobile tires has become an issue in many countries including Iran. Recycling and reclaiming facilities are not available in financially restricted cities such as Bam, and any action towards reusing the tires is beneficial to the environment and economy of Bam.

17 Ibid, 39.
18 Meinhold. Inhabitat, "Earthquake Resistant Tire Earthships for Haiti Disaster Relief", accessed on 11 November 2011.

Earthships construction has been used for disaster relief due to its easy construction and low cost. Earthship Biotecture has constructed many post-disaster permanent buildings using this technique. Almost all of these buildings are sustainable and provide their own food and sanitation.

The Haiti Earthship Project was built in four days with the help of forty Haitians from the tent camps. The age of the volunteers ranged from 4 to 50 years old. Fig. 3.23 and Fig. 3.23 show images of Haiti Earthship under construction and upon completion.The Haiti Eco Living Project adopts the same construction technique, but also considers its expansion to larger scales. This project houses 32 people in eight groups of four. The 32-occupancy units can be grouped together to create housing for 256 people in a 240 foot diameter. The main feature of this project is ease of replication and expansion of the project into larger scales.[19]

FIG. 3.22. Haiti Earthship Project under construction.

FIG. 3.23. Haiti Earthship Projec completed.

19 Earthship.com, disaster relief, accessed on 26 September, 2011.

Fig. 3.22

Fig. 3.23

FIG. 3.24. Pounding earth into an automobile tire.

Fig. 3.24

3.3.1. Rammed Automobile Tire Construction

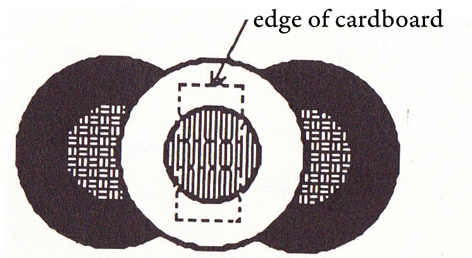
To start the construction of a rammed car tire building, loose topsoil must be removed to prevent settling under the weight of the structure. Undisturbed soil must be leveled before laying out the tires. Earth can be dampened to ease pounding. Pounding is usually done in teams of two people; one who shovels and one who pounds the earth in the tires (Fig. 3.24). Each tire takes approximately 5-15 minutes to pound[20], and takes about three or four wheelbarrows of dirt. A pounded tire weighs around 300 pounds[21], therefore all tires should be pounded in place. An unpounded tire is 7 – 7 ½" in height. Earth is shoveled into the tire and pounded until the tire is swelled to about 9 – 9 ½" in height.[22] Tires are located in a staggered manner, similar to the layout of masonry units. A layer of cardboard can be placed inside each tire to close the opening at the bottom of the tire. The cardboard is only a temporary form, as the earth is pounded it will not require a form any more. The cardboard will not be removed, but it will not serve a purpose after the earth is rammed inside the tire. Fig. 3.25 demonstrates the location of the cardboard and the staggering of a tires.

It is extremely important that each tire is swelled evenly throughout the tire and the entire row. A level must be used for each tire and at the connection of tires to ensure the level throughout a course. Larger tires, such as #15 and #16 are usually used for the first course, #15 is used throughout the body of the wall, and #14 is used for the top course.[23]

20 Michael Reynolds, Earthship: How to Build Your Own, Vol. 1, (City: Solar Survival Architecture, 1990, 83.
21 Reynolds, Earthship Vol. 1, 83.
22 Ibid, 85.
23 Ibid, 90.

FIG. 3.25. A piece of cardboard can be placed at the bottom of the tire to prevent the soil from pouring out into the gaps between tires. The tires are staggered to maximise structural strength.

FIG. 3.26. Wood connection blocks such as L-shaped Connection Blocks can be used to fill up gaps between tires.



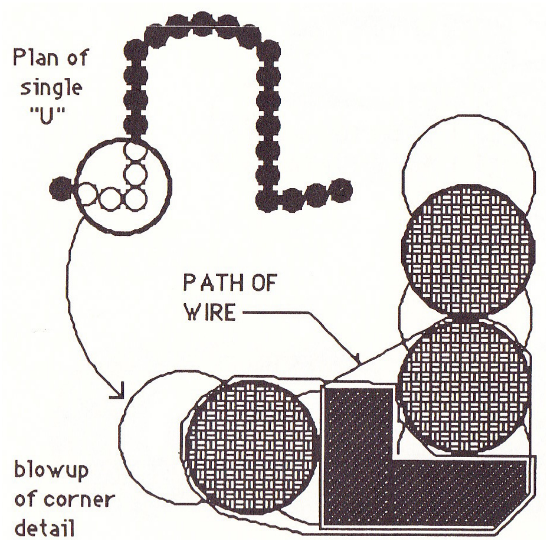


Fig. 3.25 (top) Fig. 3.26 (bottom)

At parts where half tires are required, such as at the corners or edges of windows and doors, wooden blocks can be constructed and used. There are four different types of blocking, all of which can be constructed of pieces of lumber and plywood scraps. The blocks include spacer blocks, end blocks, L connection blocks, and Y connection blocks.[24] Fig. 3.26 shows how an L-shaped wooden block can fill the gaps at the corners of a building. All blocking should be coated with two coats of wood preservative and wrapped in two layers of 6 mm plastic.

The roof structure is fastened to the tire wall using anchor bolts set in concrete. Bolts are located at every other tire on the top course. To set the bolts, some earth must be removed from the selected tires. The concrete mix is poured into the void. The concrete mix should be a stiff mix of three-part sand, one-part cement. A ½" diameter, 8" long anchor bolt is then placed in the center of each concrete filled tire in such a way that they stick 2" above the top of the tire.[25] After the concrete has dried, top plates are located and bolted to the concrete using the anchor bolts projecting out of the tires. Number and type of headers, top plates, and posts can vary depending on the available material. It is ideal to use two layers of 2x12 pressure treated dimension lumber, or two layers of rough sawn 2x12s coated with wood preservative as headers, and 6x6x8' long posts on top of the plates. Fig. 3.28 show how headers are connected to the tires using anchor bolts, and posts are connected to the headers using toenails. Palm hard wood could also be used for posts if dimension lumber is not available. ½" rebars are used to connect the posts to the headers.[26]

24 Ibid, 95.
25 Ibid, 100.
26 Ibid, 101.

The spaces between the beams and blocking are filled with empty aluminum pop cans set in a cement mortar (Fig. 3.25) to reduce the amount of cement mortar and create a lighter structure. The cement mortar mixture should be three-parts course sand to one-part Portland cement. All cans should be laid with the mouth facing towards the inside of the room. The mouths will act as a metal lath to hold the plaster. To anchor the cement work to the woodwork, nails are driven in the wood where the cans and cement will make contact. A 1 ½" bed of mortar is poured on the blocking, followed by crimped cans located about ¾" apart from one another.[27] More layers of mortar and cans are placed until the gap between the beams and blockings are closed. Fig. 2.29 shows a rammed car tire building during construction of the roof. The spaces between the wooden posts are filled with cans and mortar, and the exterior wall is made of rammed car tires with mortar infill. Roof decking can be made of any material. Traditionally thatching of palm leaves or adobe blocks are placed over palm hardwood beams. If wood decking is available, it is ideal to use wood decking before covering it with earth and thatching.

FIG. 3.28. Headers are connected to the tires using anchor bolts, and posts are connected to the headers using toenails.

FIG. 3.29. Empty crippled aluminum cans are placed in the mortar between the beams

FIG. 3.27. A rammed car tire building during roof construction. The space between the posts is filled with pop cans and mortar. The exterior wall is constructed of staggered rammed car tires and mortar infill.

27 Ibid, 111

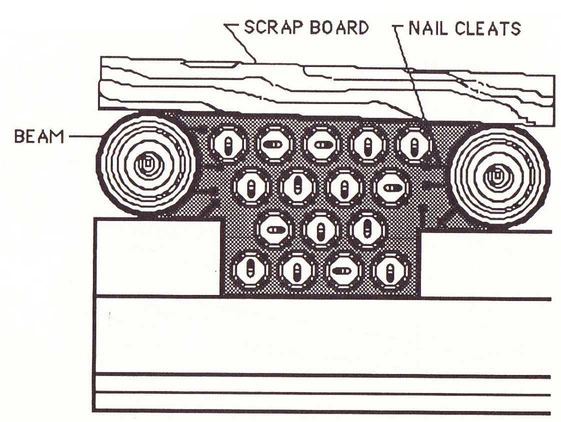


Fig. 3.28

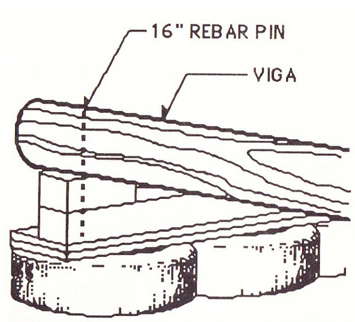


Fig.3.31

Fig. 3.27

Fig. 3.30 demonstrates the secton of a typical rammed car tire wall. In a rammed car tire building, the tire walls are load bearing and should have minimum openings due to the heavy weight of the structure. Fig. 3.31 demonstrates a typical U-shape rammed car-tire floor plan. This layout is the most commonly used floor plan by Earthship Biotecture. The three sides of the U are constructed of structural rammed cartires, and the fourth side is open to a glazed corridor. In this layout, the span should be no lrger than 9m by 6m.[28]

FIG. 3.30. Typicall section of a rammed car tire wall.

FIG. 3.31. Floor plan of a typical three-room dwelling unit by Michael Raynolds.

28 Raynolds, 88.

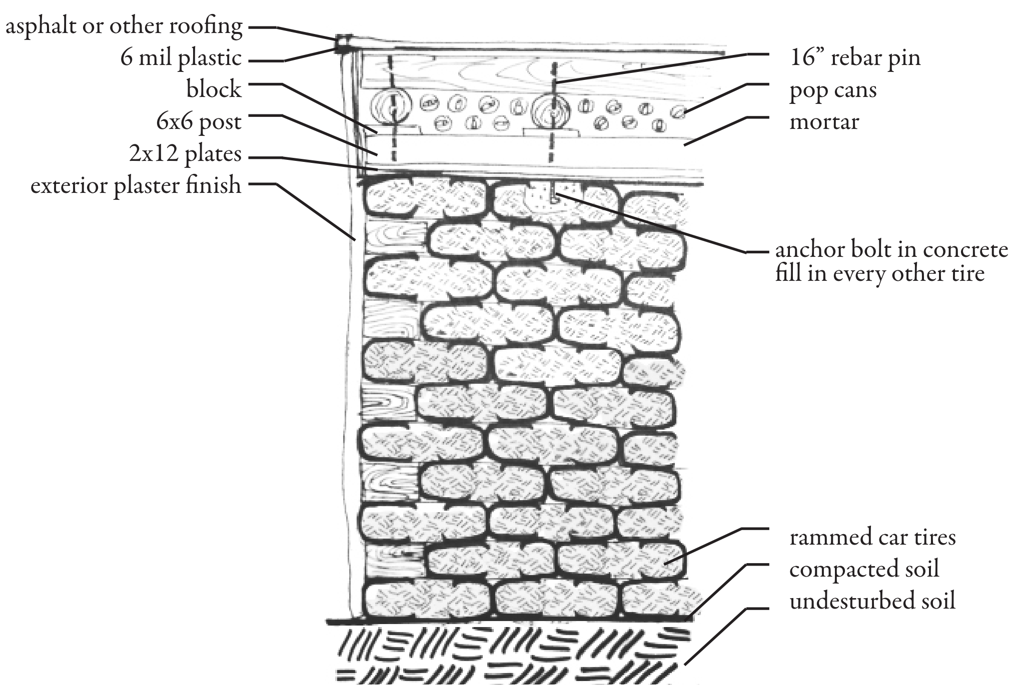


Fig. 3.30

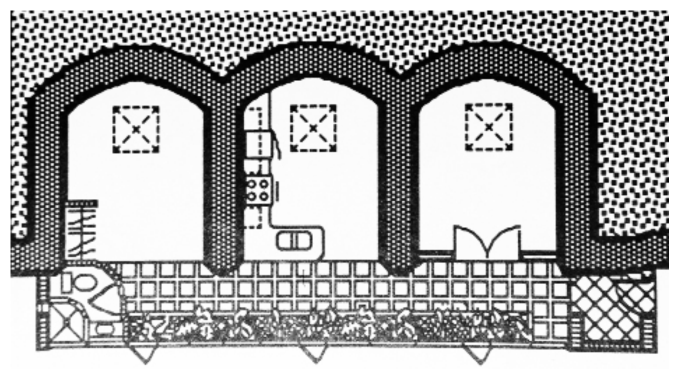


Fig. 3.31

FIG. 3.32. Paper Log House, a post-disaster shelter for survivors of Kobe earthquake in 1995, made of beer crates foundation, paper tube walls, and tent roof.

3.3.3. Construction Technique and Space Categories

For the Bam Pilot Project, earthbag and rammed car tire construction techniques will be employed based on design criteria and spatial requirements for every space. The selection criteria include size, program, and spatial quality. Rammed car tires use wood frame ceilings, allowing for larger spans. Therefore buildings that require larger indoor spaces such as classrooms and multi-purpose indoor spaces are constructed out of rammed car tires. Earthbags have dome or vault shaped ceilings to maximize stability against seismic tremors. Therefore they have a limited span, and are used for construction of smaller spaces such as residential units.

3.3.4. Reclaimed and Donated Materials

In post-disaster situations as well as for financially deprived areas, available resources must be used for construction. In the case of Bam, earth, textile bags and automobile tires are the most affordable and accessible material for construction. However, construction of a house requires more than these three items; rebars, screws, cement, glazing, windows and doors are also required. Where use of reclaimed and recycled material is not possible, this thesis suggests employing donated materials or small construction loans for the purchase of materials.

A good example of adaptation of donated materials is Shigeru Ban‘s Paper Log Houses built to shelter the suvivors of Kobe earthquake in 1995 (Fig. 3.32). The foundation of the Log House is made of donated beer crates filled with sandbags. The walls are made from 106mm diameter, 4mm thick paper tubes, and the roof is made of tent material. Waterproof sponge tape backed with adhesive is sandwiched between the paper tubes of the walls to act as insulation.[29]

Fig. 3.32

29 Works-Paper Tube Structures- Paper Log Houses, Kobe, Japan, Accessed 27 September, 2011, http://www.shigerubanarchitects.com/SBA_WORKS/SBA_PAPER/SBA_PAPER_6/SBA_paper_6.html.

Some of the potential industries to provide reclaimed material for construction of seismic-resistant buildings in the province of Kerman are Kerman Cable Co., producers of cables and wires, Kerman Carton Co., producers of boxes, cardboards, and cartons, Kerman Cement Co., Kerman Motor Co, a well-known automobile factory, and Kerman Tire and Rubber (previously known as Barez).These companies are possible sources of donated material such as automobile tires, cardboards, cables, and wires, with the incentive of publicity as sponsors of this project.

3.3.5. Permits and Regulation

It is difficult in most countries in the world to attain building permit for buildings using uncommon construction techniques such as earthbags or rammed automobile tires. For many projects, where permit attaining is difficult, or for post-disaster conditions, many projects have started construction without attaining a construction permit. This is not recommended, but sometimes inevitable. Nader Khalili, the founder of the earthbag construction technique and Cal-Earth Institute, constructed a few earthbag buildings in Bam using this procedure after the earthquake in 2003. The buildings were built without permit and were visited by government authorities after construction. These buildings were not granted a permit due to their unusual construction techniques, but were also not required to be demolished, which is unusual for buildings that are constructed without a `permit. Recent structural and environmental tests on earthbags and rammed car tires have increased the number of countries that provide construction permits for these construction methods. Iran has not included these construction techniques in its building code to date, but the officials have become more enthusiastic towards these innovative techniques.

FIG. 3.33. Haiti Earthship Project, Port-Au-Prince, Haiti.

Fig. 2.38

3.3.6. Budget

This thesis suggests a proposal for financially restricted families, aiming for a design and construction with the minimum cost possible. It proposes volunteers and unskilled locals for construction, and takes advantage of recycled and reclaimed materials donated by the local industry, minimizing the cost of material and labor.

One of the main features of the proposed design is its applicability to any budget. The basic structure for the proposed design requires minimum cost as it uses local resources and donated materials and labour. Any extra allowance can be spent on finishes or modern technology. Better quality doors and windows, larger panels of glazing, solar panels, and composting toilets are some of the features that could be added if budget allows.

Precedents of earthbag and car tire construction provide a good sense of the low budget required for construction of the proposed Pilot Project. Each of the fiteen homes in Baninjar Refugee Camp (Fig. 3.06 on page 115) with an area of 14.6 square meters cost about USD$625 to be constructed out of earthbags.

Haiti Earthship Project (Fig. 3.33) is a more high-tech precedent made of rammed car tires. This project is constructed of a 12' diameter pounded car tire circle at its foundation, followed by seven courses of pounded tires to construct the walls. Some parts of the wall including the top layer is an earthen wall filled with bottles. The roof is a double layered steel bird cage plastered and filled with cardboard for insulation. This project includes some modern technology such as water harvesting system, solar panel for electricity production, and small gardens for food production. The total cost of this project was $4,000. The construction included 40 Haitians, instructed by 4 members of Earthship Biotecture, working for four days to construct the house.[30]

30 Earthship Biotecture, " Haiti Disaster Relief", accessed on 21 June 2011.

3.4. Public Education

Immediate surveys after the earthquake in 2003 demonstrate that 80% of the locals and officials of Bam believed it is extremely important for the reconstruction of buildings in Bam to resemble Bam's traditional architecture.[31] As the developers reconstruct the city in the contemporary style, the public gradually forgets the significance of vernacular architecture. Due to lack of public education about the importance of traditional architecture, today most residents of Bam believe that contemporary Western architecture is the most appropriate style for Bam and should replace the traditional architecture of this city.

Hassan Fathy's design of New Gourna is a good example of the results of lack of public education. In this project, Fathy appropriately adopted vernacular architecture and regional material for construction, but locals did not understand the reasoning behind his choices. They rejected the traditional architecture and building technology based on the misconception that traditional techniques are obsolete and structurally weak. To prevent the same issue from occurring in Bam, the public must be educated about the advantages and disadvantages of both vernacular and contemporary architecture.

This thesis adopts various educational techniques such as workshops for students, newspaper and magazine articles, as well as digital media to communicate with a wide range of audience. The goal is to raise awareness in earthquake prone areas about the values of vernacular architecture, its potential for technical and structural upgrades in order to resist earthquakes, and to prepare these areas for possible future seismic catastrophes.

31 Typology and Design Guide for Housing in Bam, 75.

FIG. 3.34. Students of Rahavard Mehr va Danesh drawing their imaginary spaces.

FIG. 3.35. Javad's drawing of his dream space shows a dome roof supported with thick walls.

FIG. 3.36. Alireza's drawing of his imaginary space shows courtyards with palm trees, citrus trees, and reflecting pools.

3.4.1. Student Workshops

The first educational step was a workshop conducted at the Rahavard Mehr Va Danesh Institute in 2009.[32] Students were selected as the first target group for the educational program due to their high learning potential and their significance in the future of the city. Through educating the younger generation, the community becomes educated from the base, and will have a more aware general public in the years to come.

Through this workshop, the students were taught the basics of understanding space and architecture. They practiced the basics of architecture through drawing their house, school, and an imaginary dream space. In addition to practicing architecture, this experiment provided documentation on the students' memory of their house before destruction by the earthquake, the main architectural elements that influenced their

32 Khanbani, Student Workshop, 2009.

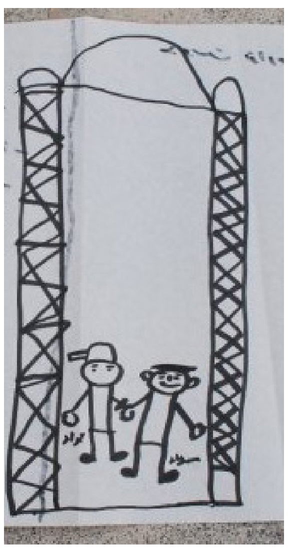


Fig. 3.36

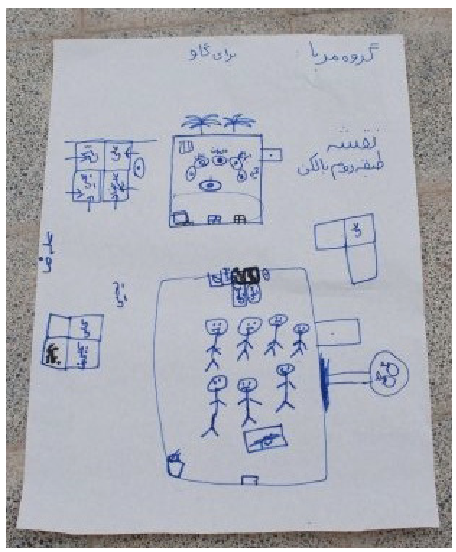


Fig. 3.35

Fig. 2.27

experience of space, and their imagination of their dream space its key elements. This study demonstrated that for the students, the vernacular architectural elements are associated with comfort and good memories before the earthquake. The drawing of the eight-year-old Javad shows the section of a dome roof supported by thick walls (Fig. 3.35). The drawing of the nine-year-old Alireza demonstrates the sigificance of courtyards, palm trees, and citrus trees in Alireza's mind (Fig. 2.30). In both Alireza and Javad's drawings, community and friendship play a sigficant role.

A field trip was then organized to collect rubble and scrap materials from the ruins of the quake (Fig. 3.31). The materials were brought to the school, where the students built various handicrafts and artifacts with them (Fig. 3.40, Fig. 3.32). Having grown up in the desert, with earth as the most available resource, it was a natural intuition of many students to use mud for building the handicraft and decorating it with salvaged items. Final artifacts and handicrafts included jewelry, pottery, furniture and household objects. Fig. 3.38 and Fig. 3.39 show a sculpture of a dog and a pencilcase made of earthquake rubble including concrete junks, animal fur, mud, and straw.

FIG. 3.37. Rubble and scrap materials collected from the ruins of the quake.

Fig. 3.37

FIG. 3.38. Pencil case made by a student out of straw and earth.

FIG. 3.39. Students' sculpture of a dog made of a piece of cement from the rubbles of the earthquake and some animal fur.

FIG. 3.40. Students and teachers of Rahavard Mehr Va Danesh making handcrafts out of the rubble collected from the earthquake-stricken areas.

FIG. 3.41. A teacher holding up a doll made of rubble by the students.

FIG. 3.42. An eight year old student making handcraft out of mud.

Fig. 3.40

Fig. 3.32

Fig. 3.38

Fig. 3.41

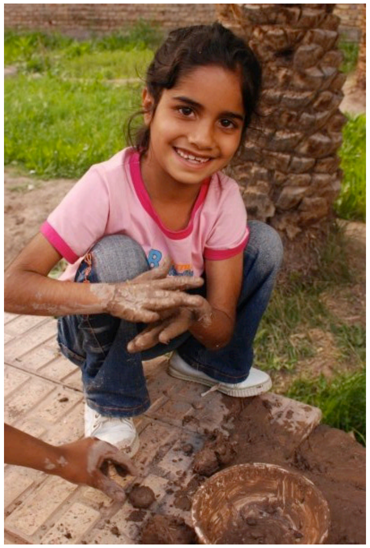


Fig. 3.39

3.4.2. Newspaper Articles

A series of articles were written and published by the author in Toronto's Shahrvand newspapers to raise public awareness of seismic hazard and mitigation (Appendix A.1.). The first article was published on the anniversary of Bam Earthquake in 2010. The article "Current Conditions of Bam" (Fig. 3.37)introduces Rahavard Mehr Va Danesh and describes their current conditions. This article received positive response by many readers who contacted the author and declared interest in supporting the Institute. The second article, "Earthquake Hazard Threatens Tehran" (Fig. 3.38), provides scientific facts on the current hazardous condition of Tehran, calling for public awareness and education in disaster prevention and mitigation for disaster prone areas.

FIG. 3.43. Article Current Conditions of Bam, published in Shahrvand Newspaper.

FIG. 3.44. Article Earthquake Hazard Threatens Tehran, published in Shahrvand Newspaper.

FIG. 3.45. Article Bam's Anniversary Removed from Iran's Official Calendar, published in Shahrvand Newspaper.

امروز در بم چه می‌گذرد؟

Fig. 3.37

زلزله تهران را تهدید میکند!

Fig. 3.38

سالروز زلزله بم از تقویم رسمی ایران حذف شد!

Fig. 3.39

FIG. 3.46. Article Earthquake Sakes Bam once more on the Anniversary of the Earthquake, published in Shahrvand Newspaper.

36 | شهروند

در سالگرد زمین لرزه بم
زلزله دوباره این شهر را لرزاند!

سارا خاکباز،
علی دیوسلا

شش روز پیش از سالگرد زلزله بم، در تاریخ ۲۰ دسامبر ۲۰۱۰، زمین لرزه ی ۶/۵ ریشتری شهرستان کرمان را دوباره لرزاند. مرکز این زمین لرزه در ۲۰ کیلومتری حسین آباد، و در ۱۰۰ کیلومتری بم بود. این زلزله ۱۱ کشته، بیش از ۱۰۰ زخمی، و خسارات بسیار در روستاهای چاه قنبر و ریگان بر جا گذشت. این زمین لرزه شهر بم را نیز لرزاند، اما خوشبختانه خسارتی به این شهر داغ دیده وارد نکرد. روستاهای آسیب دیده اکثرا روستاهای کم جمعیت بودند. به همین دلیل تعداد قربانیان نسبت به مقیاس زلزله بالا نیست، ولی به دلیل دشواری دسترسی به این

Fig. 3.40

Interestingly enough, a week after publication of "Earthquake Hazard Threatens Tehran", the author was informed that the anniversary of Bam's earthquake had been removed from Iran's national calendar. Dec 26 was registered as Disaster Awareness Day in Iran since the earthquake of Bam in 2003. Every year on this day seminars and educational programs took place to raise public awareness towards seismic prevention. However, the Disaster Awareness Day was removed from the official calendar of Iran for reasons unacceptable to scientists. The third article, "Bam's Anniversary Removed from Iran's Official Calendar" (Fig. 3.39), stresses the importance of national occasions for public awareness for hazard prevention and mitigation.

The city of Bam was once more shaken by seismic tremors a week before the seventh anniversary of the 2003 earthquake. The center of the tremor was in Chah Ghanbar, a small village about 100 kilometers away from Bam. The fourth article "Earthquake Shakes Bam once more on the Anniversary of the Earthquake." (Fig. 3.40) includes a brief summary of the disaster in Chah Ghanbar, as well as Ali Divsalar's personal experience at the disaster site a few hours after the tremor. This article portrayed the atmosphere of a post-disaster village.

The four mentioned articles are the first few of the article series aimed to raise public awareness for seismic hazard prevention and mitigation. Future articles will concentrate on analysis of the traditional architecture as well as the contemporary architecture of Iran, providing a thorough description of both. It is crucial that the public is educated about different fields involved in disaster management in order to make correct decisions to minimize damage and fatalities, as well as to select the appropriate type of architecture for post-disaster construction. The articles published in Toronto raise public awareness globally towards seismic hazard prevention and appropriate post disaster construction.

3.5. Design

3.5.1. Design Inspirations

The design of the Pilot Project is influenced by the form, spirit, and behavior of the desert and vernacular desert cities. The desert is ever changing; it changes constantly in accord with the wind and other natural elements. It is as if it dances to the music of nature; as nature changes its rhythm or tune, so does the desert. The desert is resilient, and therefore ever lasting. In order to be permanent, one needs to adapt to its changing environment over time. This applies to buildings as well. A permanent building must adapt to its surrounding environment rather than overtaking it. The more resilient and adaptive a building, the longer lasting it can be. Fig. 2.39, Fig. 2.40 and Fig. 3.49 show images of the Dasht-e Kavir Desert dunes in Iran, changing form as the wind moves the sand.

FIG. 3.47. The smooth surface of the sand dune, Dasht-e Kavir Desert, Iran.

FIG. 3.48. Ripples created on the sand dunes as a result of the wind, Dasht-e Kavir Desert, Iran.

FIG. 3.49. Scale of people and dunes at Dasht-e Kavir Desert, Iran.

Fig. 3.47

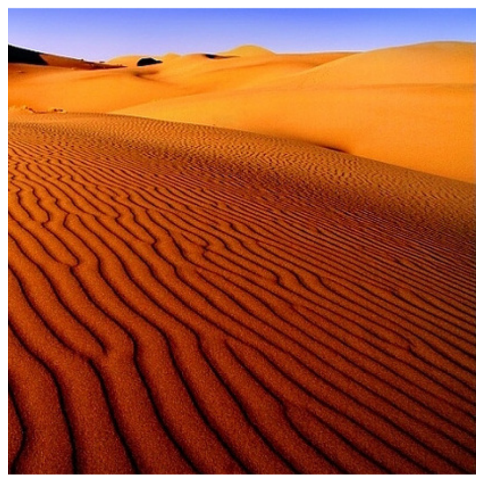


Fig. 2.40

Fig. 3.49

The design is also influenced by the shape and growth patterns of Iranian Islamic cities. As this is a proposal for self help in post-disaster conditions, it is crucial that the design incorporates a self-growing pattern. The design is derived from surrounding environmental, natural, and cultural conditions, creating a comfortable and flexible space.

3.5.2. Design Objectives

Based on the analysis of vernacular and contemporary architecture of Bam, the following is a summary of design objectives governing the design of the pilot project.

1. Adaptability of design guidelines both at the urban and architectural scale
2. Affordability
3. Flexibility
4. Meeting users' needs and expectations
5. Incorporating advantages of vernacular architecture:
   - Climate responsive
   - Sustainable
   - Use of local materials
   - Use of local skills
   - Cultural appropriate
6. Use of advantages of contemporary architecture
   - Adaptation of modern technology
   - Earthquake resistant structures

3.5.3. Architectural Features

Based on the environmental, social, and cultural study of Bam, the following architectural features should be incorporated in the design of the Pilot Project.

1. Thick earthen walls acting as thermal mass for passive heating and diurnal action to promote cooling.
2. Courtyards to circulate and cool the air and act as a private gathering space.
3. Roof vents located at the top of domed roofs to allow for the escape of hot air.
4. All openings should face north and west to take advantage of the prevailing cool wind.
5. Openings towards south and southeast should be avoided or minimized to block unfavourable and sandy winds.
6. Vegetation and other shading devices should be incorporated according to sun angles throughout the year to minimize penetration of the sun into interior spaces during summer and maximize its penetration during winter.
7. Palm and citrus orchards, irrigated by the Qanats, should be incorporated in the design to cool the space and provide a source of income.
8. The building should be resistant to seismic tremors.
9. The design should incorporate the following cultural and social aspects:
    - Separation of public and private spaces.
    - Variation of closed, semi- open, and open spaces, with subtle and ambiguous transitions between interior and exterior.
    - Flexible spaces in terms of program usage.
    - Incorporation of communal gathering spaces.
10. The appearance and aesthetics of the building should reflect both its historical influence as well as modern technology to incorporate both 'permanence' and 'change'. Incorporation of traditional architecture with modern technology preserves the ancient heritage of Bam, while it meets the modern users's expectations.

FIG. 3.50. Program requirements for the Pilot Project.

3.5.4. Program Requirements

During a meeting with the administrators of Rahavard Mehr Va Danesh, Ali and Sarah Divsalar discussed the facilities and spatial qualities required for this Institute with the author.[33] The requirements include classrooms and other educational spaces such as labs and workshops, administrative spaces, recreational spaces including a multipurpose room, theatre, dining hall, various outdoor spaces for activities of all ages, a residential suite for Ali and Sarah, and a minimum of three guest suites for visitors (Fig. 3.50).

Spaces and program requirements mentioned by Ali and Sarah are based on present requirements for 112 students currently enrolled at the Institute. They also mentioned their interest in expanding the Institute in the future. The proposed Pilot Project meets current requirements of the Institute, and provides opportunities for future expansion and growth. The proposed design has a natural, self-growing potential that is adaptable at the urban scale of the city as well as the architectural scale of the Institute.

33 Author's interview with Sara Divsalar on Dec 2010.

Recreational	Vocational	Educational	Administrative	Residential	Service
<-- public——					**private -->**
Dining hall	Workshops	Science lab	Accounting office	guest suites x 3	Kitchen
Multi-program area		Small class for 10 - 15 students x 6	Administration office	Ali and Sara's suite	Resting area for about 40 kids
Movie theater room		Large class for 30 students x 2	Education office		Washroom facilities
Exercise room			Conference room		Bathroom facilities
					Cow stable
					Bread baking

Fig. 3.50

3.6. Site

3.6.1. Site Selection

The selection of an appropriate site for building the pilot project is essential, as this project is a prototype for building many other similar projects globally. A site was selected by the author and approved by the administration of Rahavard Mehr Va Danesh Institute during the author's visit to Bam in 2009. Fig. 3.51 shows how the city of Bam is connected to neighboring cities through highways located to the south of the city. It also demonstrates the vehicular circulation routes throughout the city and to the proposed site for the Pilot Project. Fig. 3.52 shows the significant location of the pilot project, as it is located to in the oldest part of Bam, to the south of the seasonal Bam River and across the street from the ancient Bam Citadel.

The pilot project takes advantage of tourist traffic visiting the Citadel, creating public educational programs for the visitors, as well as a source of income through renting guest suites, selling homemade products and handicrafts. As the pilot project has an educational program, the location within the historic context of the city is very important. This specific site was also chosen because it is a typical residential site with a palm garden and an un-planted area. As demonstrated in Fig. 3.53, the site can be accessed from two sides: the main entrance is to the east, facing the Citadel and the secondary access is from north, facing the river.

FIG. 3.51. Vehicular access routes throughout Bam.

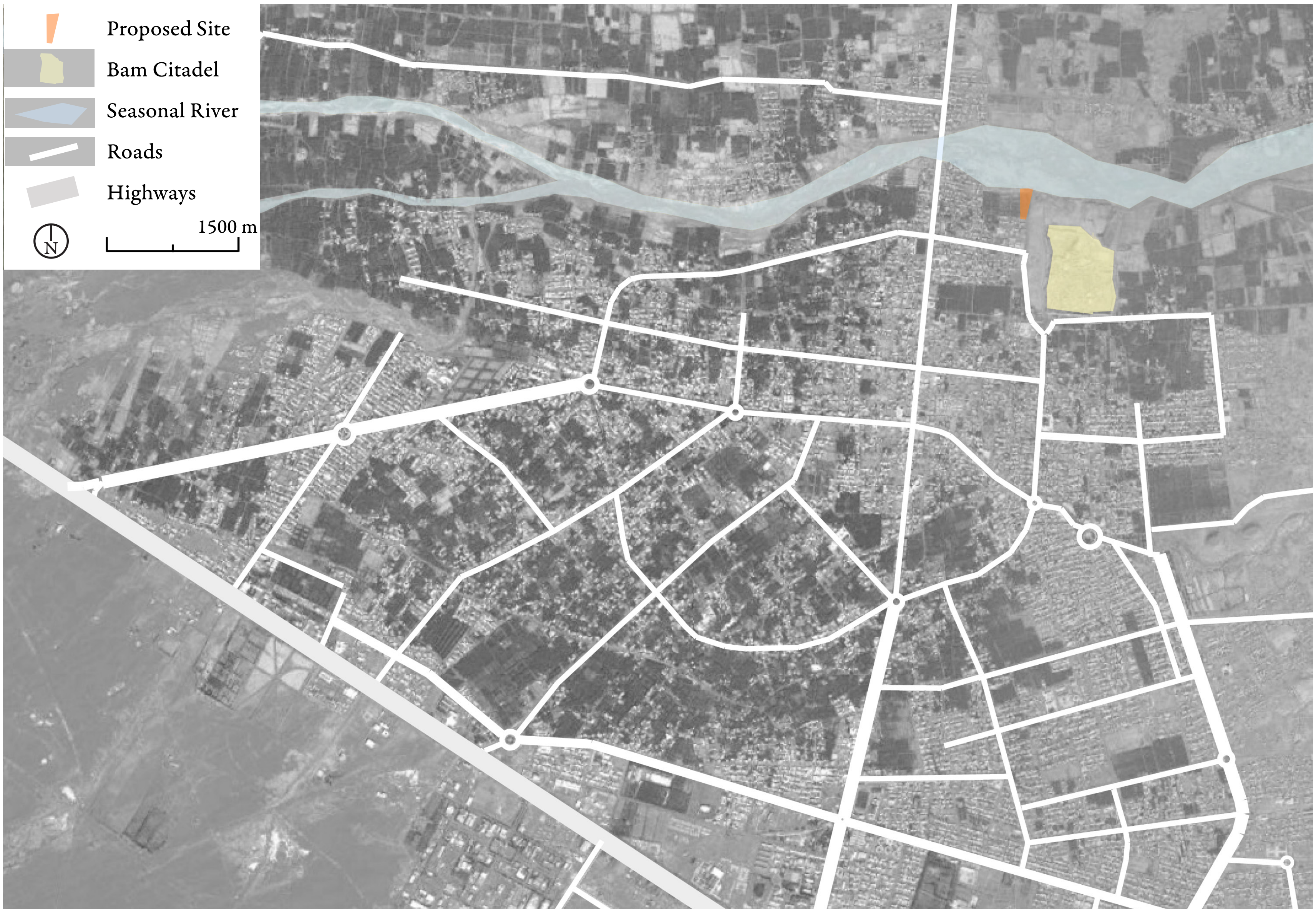


FIG. 3.52. Relationship between proposed site with the Citadel, river, and the city.

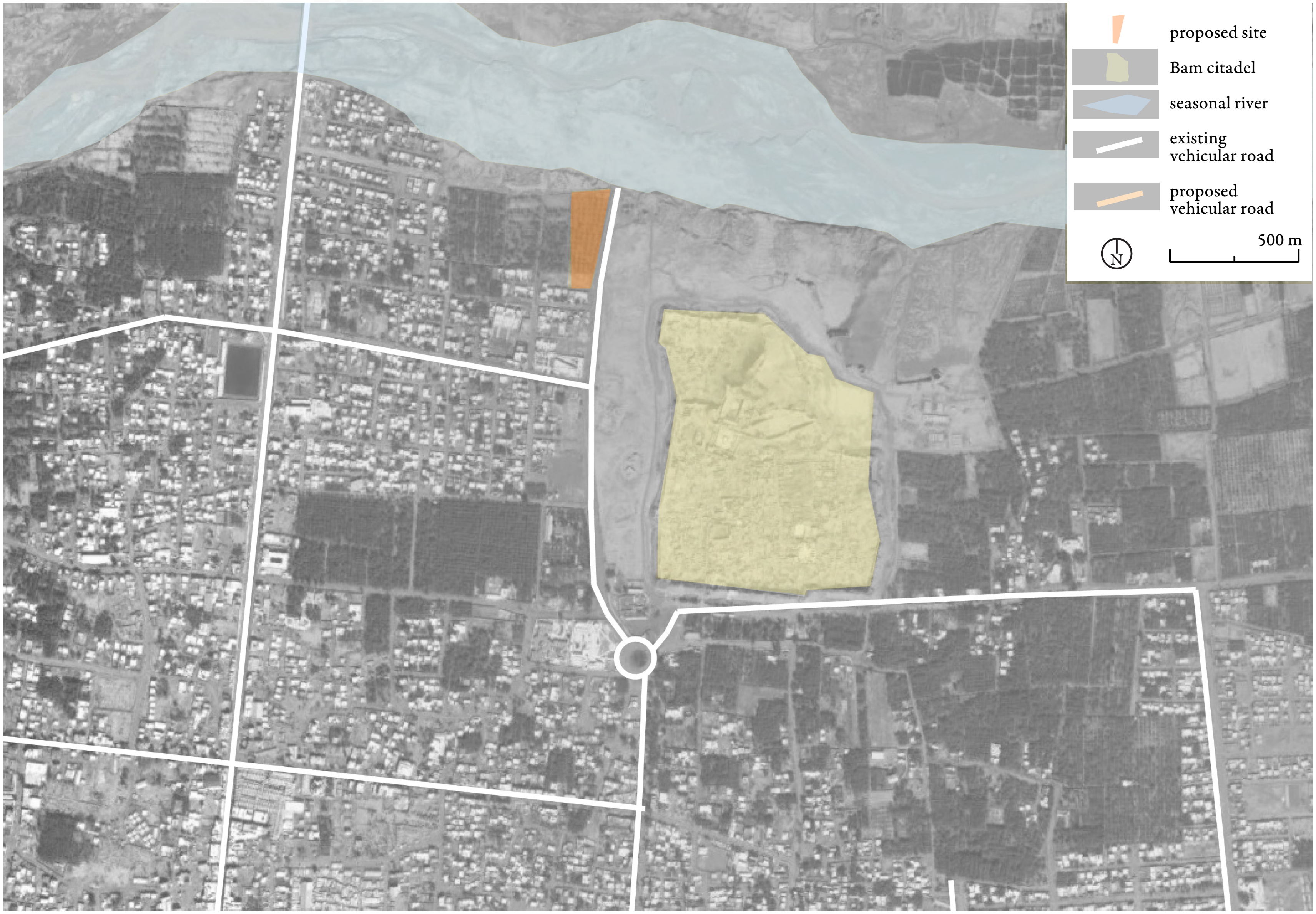


FIG. 3.53. The site is accessible from the north and east.

3.6.2. Site Plan and Layout

The site is divided into two sections: the planted palm date garden to the north and the unplanted and unbuilt area to the south of the site. Fig. 3.54 to Fig. 3.57 show views of the site and its surroundings from different locations on the site. Traditionally, only the unplanted area is used for building, and the garden is used for outdoor recreational programs. As this is a pilot project for post-disaster conditions, the proposed design occupies both the flat area of the site and the garden to demonstrate how the design can take place with existing obstacles and restrictions on site.

This thesis studies five different options of site occupation in a post-disaster condition, where urban planning is not available and occupants select the construction site without a master plan. These five patterns are only a few of many possibilities of growth for the site. The study was governed by the growth pattern of traditional Iranian Islamic cities. As Bam is a traditional city, its occupants tend to have a traditional culture and are expected to create a traditional neighborhood if no master plan is provided.

The pilot project is designed at an architectural scale including a combination of different buildings, and has the potential of being interpreted at the urban scale. Elements of a traditional residence are very similar to the elements of an urban plan in Iranian Islamic cities. There is a separation between public and private spaces both at the architectural and urban plan scales. There are public communal spaces at both scales; courtyard at residential scale, and Meydan (city square) at the urban scale. The five variations include information on growth of the design both at the urban scale and at an architectural scale (Fig. 3.58 to Fig. 3.65).

The creation of a typical Islamic city or of a typical residential site at the architectural scale starts by creation of the city walls and gates, or site boundary and site entrance (Fig. 3.58). Primary access roads of the city connect the gates and entrances at both residential and urban scales (Fig. 3.59), public spaces are located along the primary path. Public space includes the Meidan (city square) at the urban scale and the courtyard at the residential scale (Fig. 3.60). At the urban scale the most public and primary route is the commercial path of the bazaar (Fig. 3.61). Secondary access routes take off from the primary access route (Fig. 3.62) and are surrounded by semi-public spaces (Fig. 3.63). Tertiary routes are the most private circulation route (Fig. 3.64), surrounded by residential spaces (Fig. 3.65). The separation of public and private spaces exists in residential dwellings as well. In residences, the most public space of Talar (Main Hall) is located facing the public space of courtyard, and the more private rooms are located further from the main courtyard.

The design of the Pilot Project is composed of a variety of buildings spread throughout the garden with many semi-outdoor spaces, creating an ambiguous separation of indoor and outdoor as well as a flexible transition between man-made and natural elements. Buildings are designed to incorporate a large variety of open and semi-open spaces to increase the interaction with the garden. The circulation is very fluid between the buildings and in the open space of the garden, creating a smooth flow throughout the site. Even though the project is composed of many smaller buildings, the project seems to be a self-growing whole due to the smooth transitions between indoor and outdoor spaces.

FIG. 3.54. View from north-east corner of the site viewing the site to the right, street at the center and the Citadel to the left of the image.

FIG. 3.55. View towards the unplanted section of the site looking towards neighboring buildings to the south of the site.

Fig. 3.54 (top)

Fig. 3.55 (bottom)

FIG. 3.56. View towards the planted section of the site.

FIG. 3.57. View towards north looking at the southern edge of the Citadel to the right, the dried seasonal river at the center and the north-eastern edge of the site to the left.

Fig. 3.56 (top)

Fig. 3.57 (bottom)

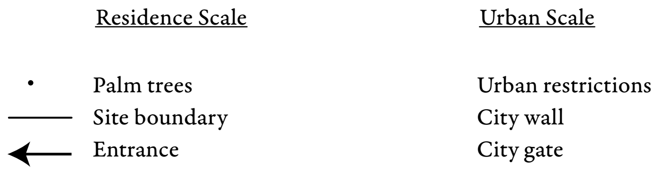


FIG. 3.58. Five possible variations of entrance to the site. Due to security reasons the site must be walled at its boundaries. Entrances are possible from two streets to the east and north of the site. Option 'a' is the best option as it provides the main entrance from the more public street towards the east of the site, and a back entrance from the northern side of the site. The main entrance leads to the unbuilt side of the site, where a large building can be constructed on the un-obsticled area.

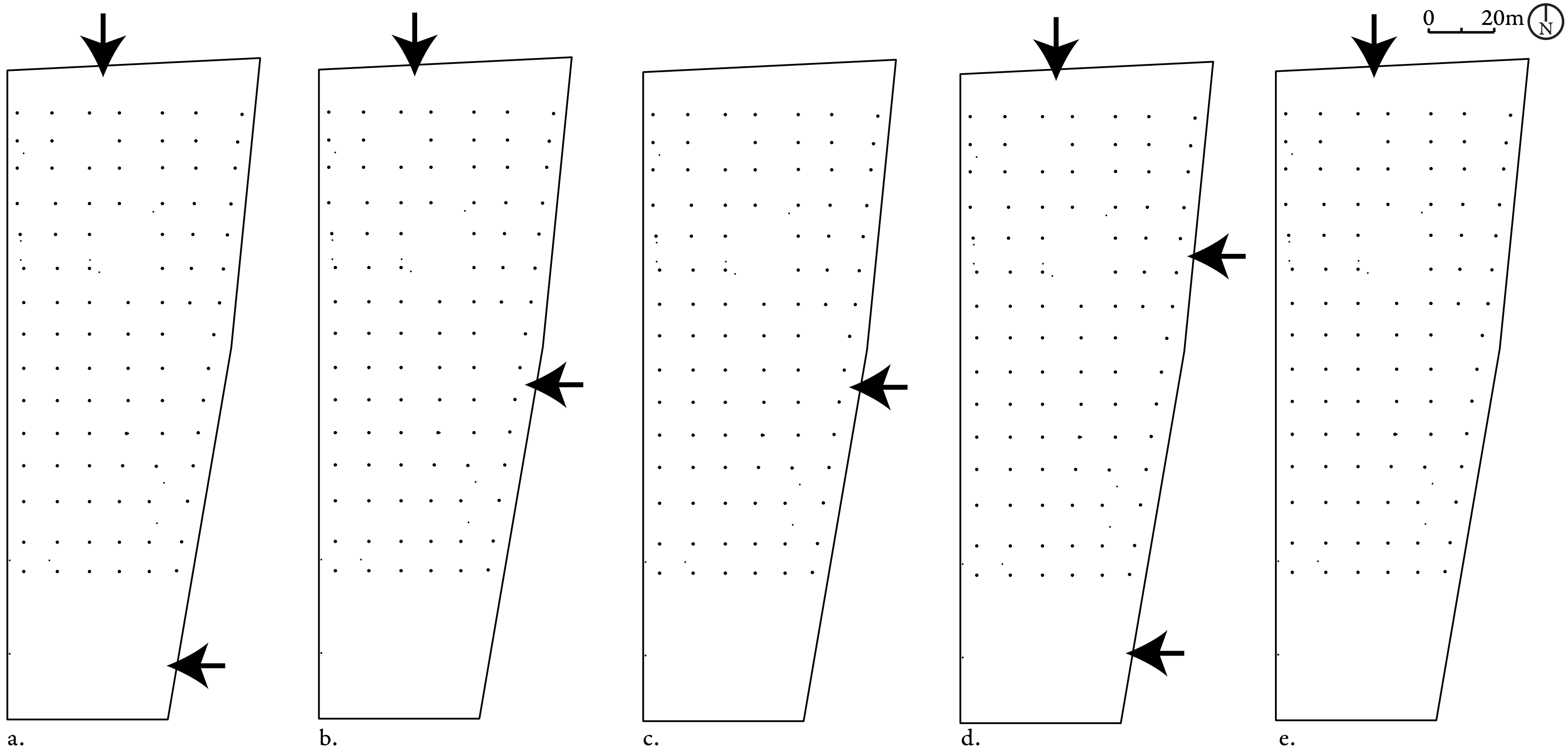


FIG. 3.59. Primary access routes connect the entrances to one another by a pathway through the site. This is the main circulation path and the most public access route throughout the site.

Residence Scale		Urban Scale
•	Palm trees	Urban restrictions
—	Site boundary	City wall
←	Entrance	City gate
▬	Primary access route	Bazaar's spine

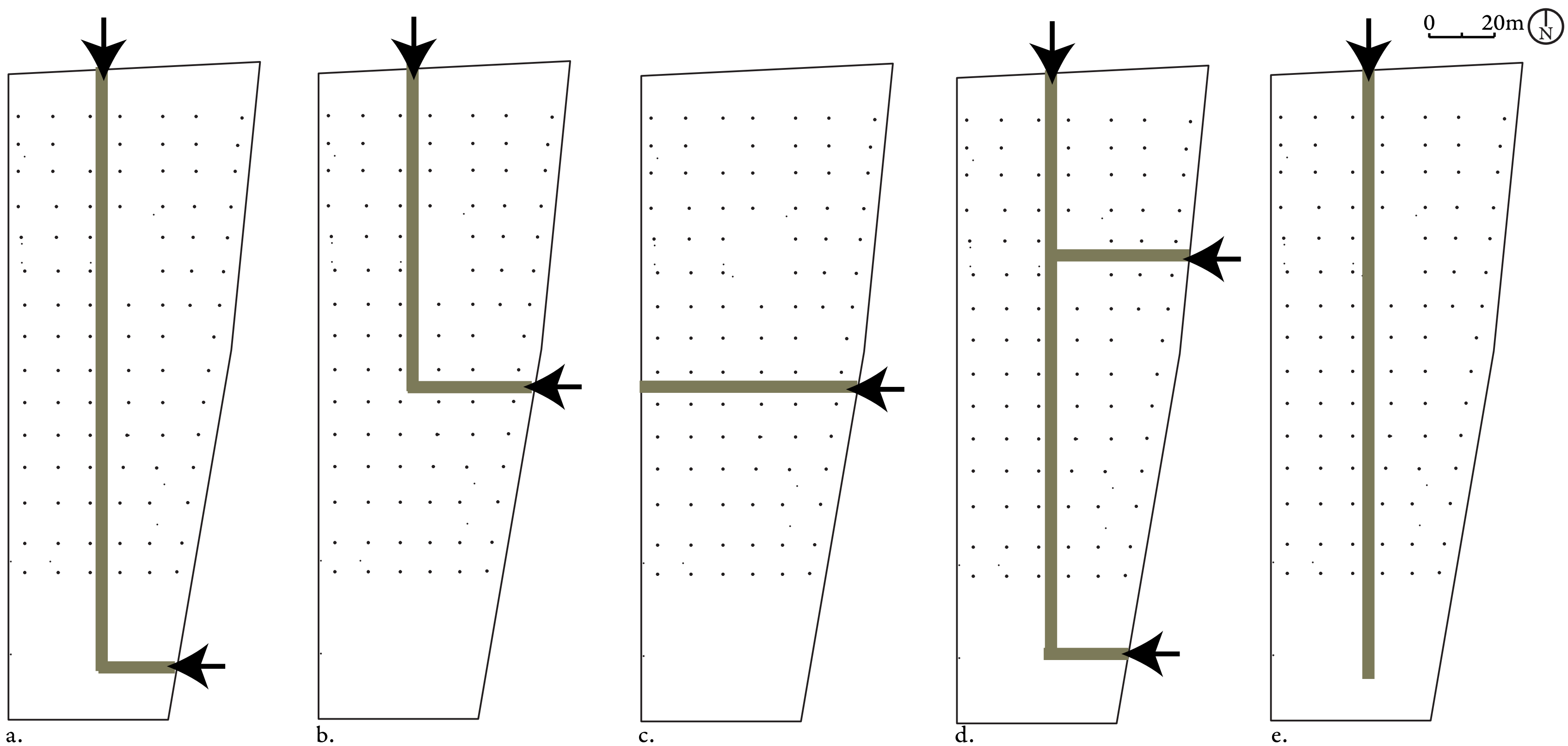


FIG. 3.60. Public center is created at the intersection of major routes or close to the center of main paths when intersections are not available. Options 'b' and 'd' create more public centers as the center is located at the intersection of two major paths.

Residence Scale	Urban Scale
Palm trees	Urban restrictions
Site boundary	City wall
Entrance	City gate
Primary access route	Bazaar's spine
Courtyard	City center (Citadel or Meidan)

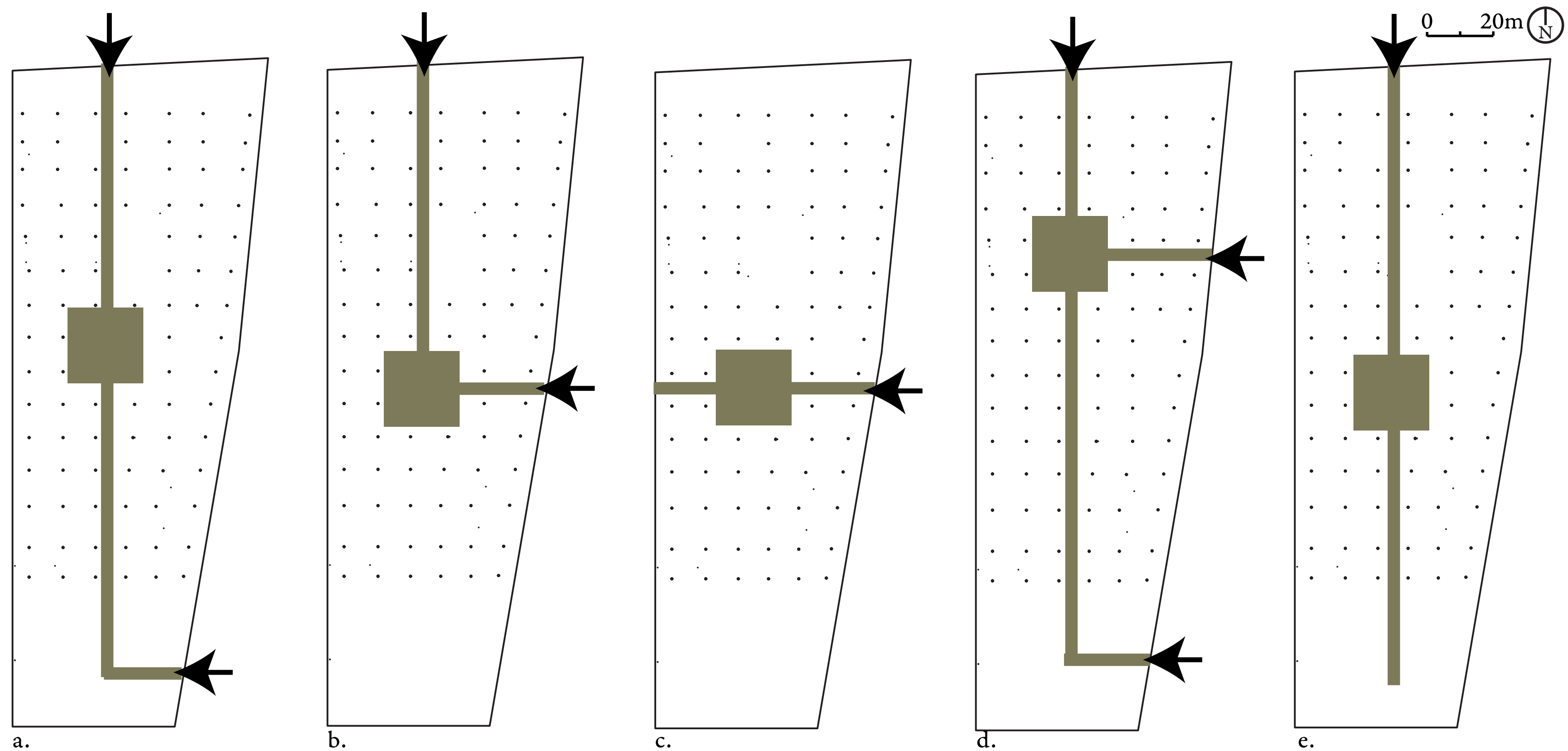
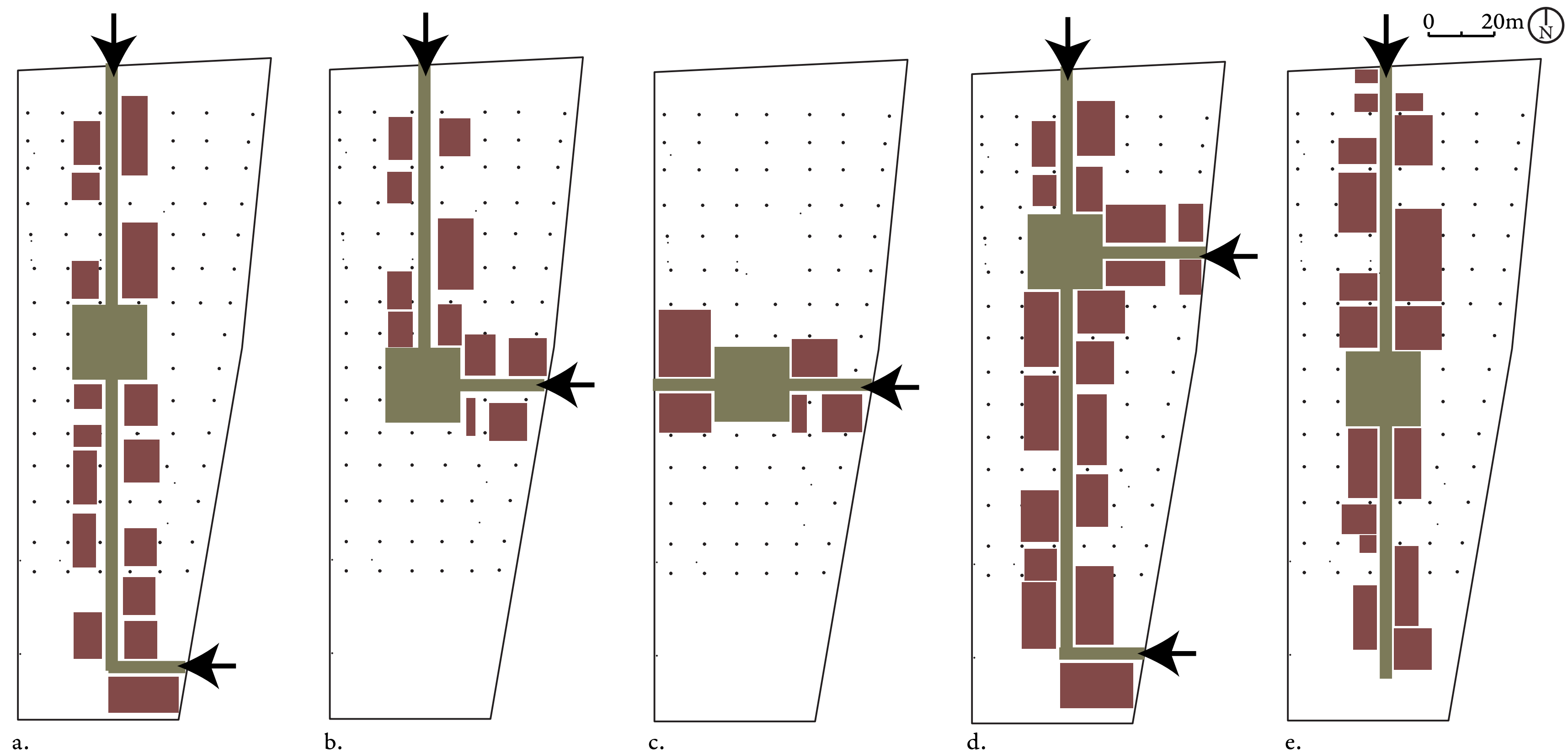


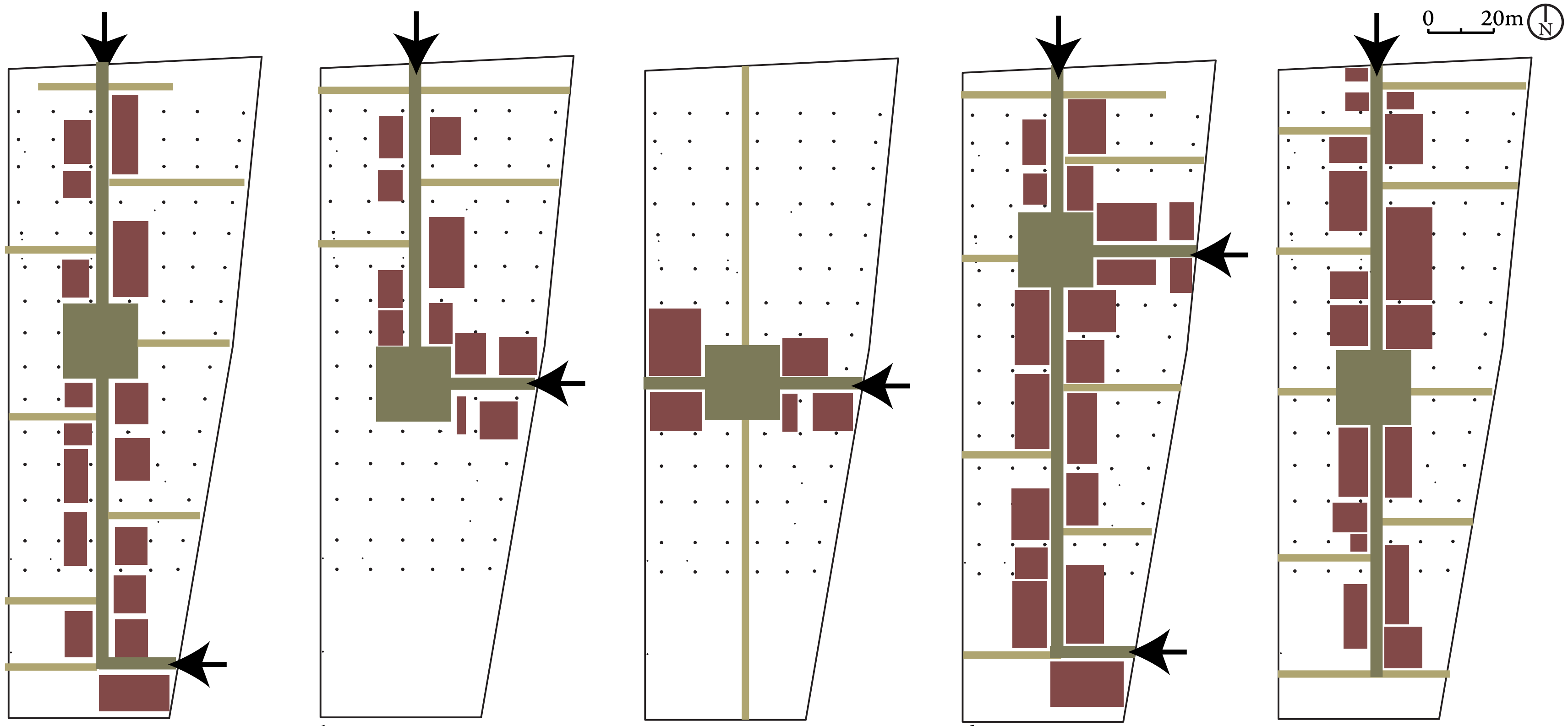
FIG. 3.61. Public buildings are built along primary routes. Options 'b' and 'c' are least favorable because they provide minimum public building space. Option 'd' provides maximum public space, but having two entrances on one side of the site is not optimal for this design. Option 'a' is the most appropriate of all, as it provides sufficient public space throughout the site.

Residence Scale	Urban Scale
Palm trees	Urban restrictions
Site boundary	City wall
Entrance	City gate
Primary access route	Bazaar's spine
Courtyard	City center (Citadel or Meidan)
Public spaces	Public spaces



Residence Scale	Urban Scale
Palm trees	Urban restrictions
Site boundary	City wall
Entrance	City gate
Primary access route	Bazaar's spine
Secondary access route	Bazaar's secondary routes to smaller shops
Courtyard	City center (Citadel or Meidan)
Public spaces (Recreational hall, dining hall)	Public spaces (Mosque, Bath, ...)

FIG. 3.62. Secondary access routes connect primary routes to adjacent areas. These routes are not as public as the primary access route. Options 'b' and 'c' are least favorable because they restrict the flow due to the shortness of primary access route. Options 'a', 'd', and 'e' all allow sufficient flow to both sides of the primary access route.



a. b. c. d. e.

FIG. 3.63. Semi-public spaces are built along secondary routes. options 'b' and 'c' are not favorable because the number of semi-public spaces are much more than public spaces. Options'a', 'd', and 'e' provide a good balance both in terms of number and location between public and private spaces.

<u>Residence Scale</u>

Palm trees
Site boundary
Entrance
Primary access route
Secondary access route
Tertiary access route
Courtyard

<u>Urban Scale</u>

Urban restrictions
City wall
City gate
Bazaar's spine
Bazaar's secondary routes to smaller shops
Residential streets
City center
(Citadel or Meidan)

Public spaces
(Recreational hall, dining hall)
Semi-private spaces
(Class rooms, workshops)

Public spaces
(Mosque, Bath, ...)
Semi-public spaces
(Warehouses and workshops)

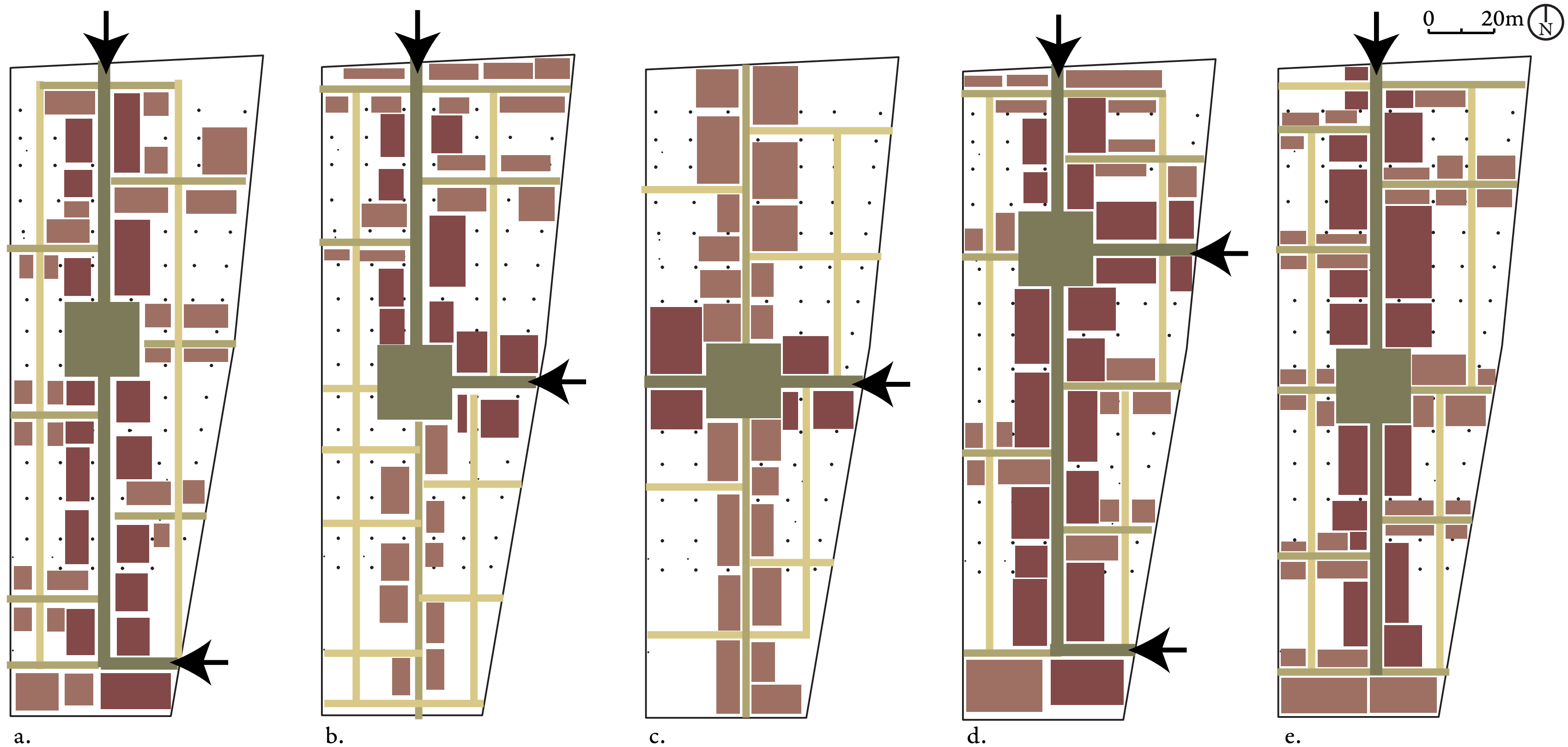
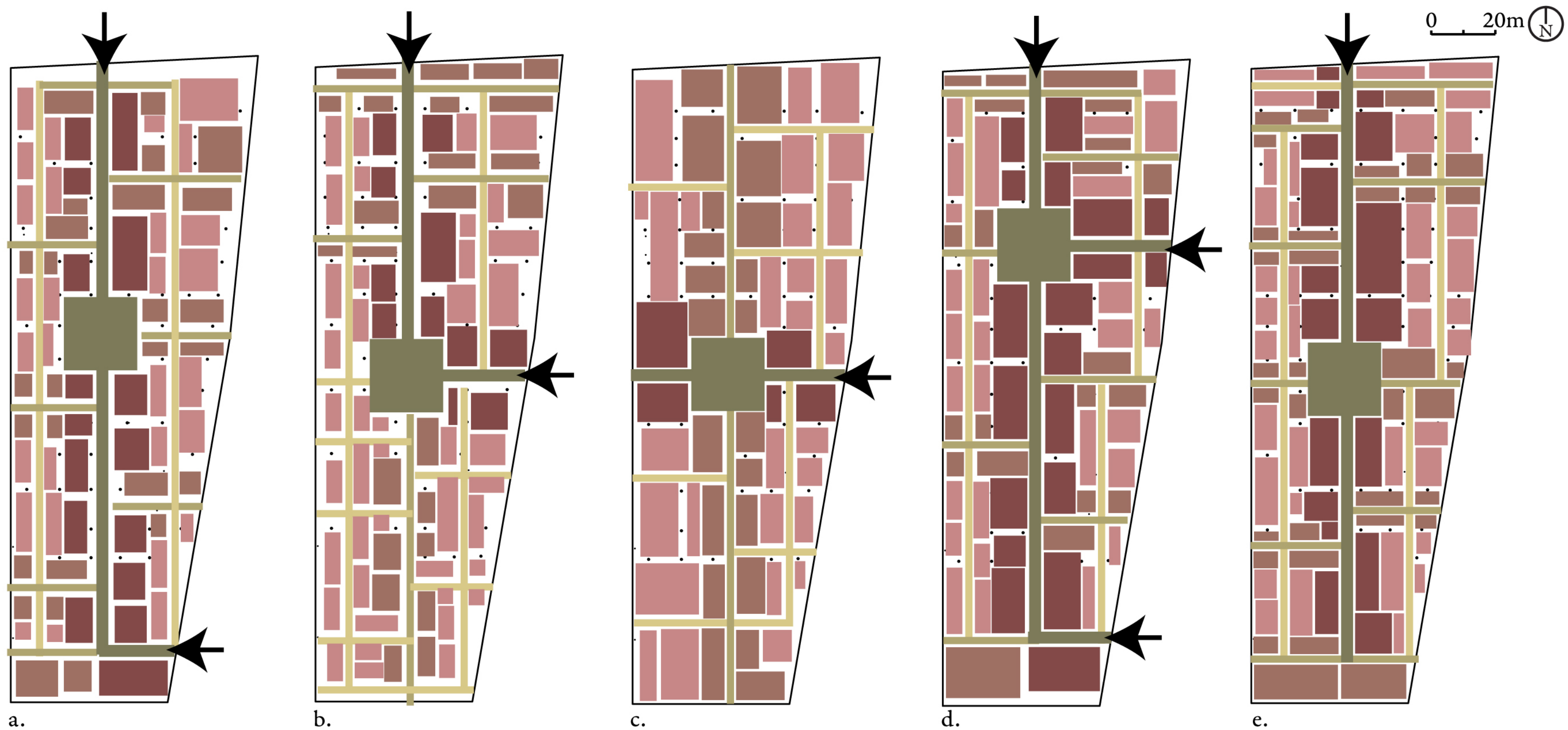


FIG. 3.64. Tertiary access routes provide access to more private areas. Options 'a', 'd', and 'e' provide a good distribution of all three access routes throughout the site.

FIG. 3.65. Residential areas are built along the tertiary access routes. Option ‘a’ is the most optimal design because it provides a better distribution of public, semi-public, and private spaces throughout the site.

Residence Scale	Urban Scale
Palm trees	Urban restrictions
Site boundary	City wall
Entrance	City gate
Primary access route	Bazar’s spine
Secondary access route	Bazaar’s secondary routes to smaller shops
Tertiary access route	Residential streets
Courtyard	City center (Citadel or Meidan)

Public spaces (Recreational hall, dining hall)	Public spaces (Mosque, Bath, ...)
Semi-private spaces (Class rooms, workshops)	Semi-public spaces (Warehouses and workshops)
Private spaces (Guest suites, administrators’ suite)	Private spaces Residential

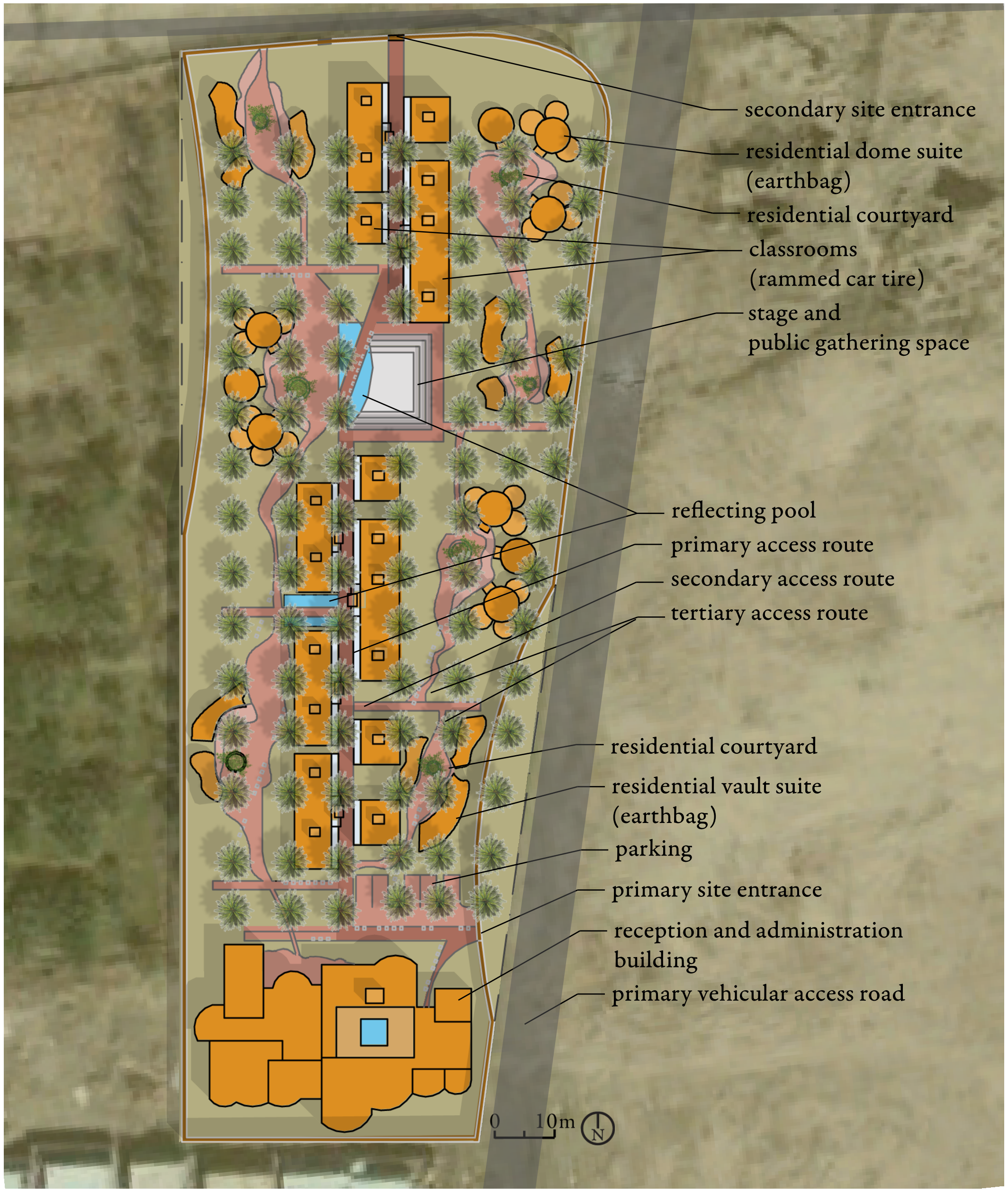


3.7. Building Layouts

The Pilot Project is designed based on Option A, as it provides better access and circulation throughout the site, as well as well distribution of public, semi-public and private spaces along the circulation paths, and a better flow in general. Fig. 3.66 is the interpretation of Option A in to a site plan for the Pilot Project. The site will be walled along all four sides of the site boundary due to security and privacy issues. Having walls around the site is a standard in almost all cities in Iran. Having tall walls and metal bars on the ground level windows was one of the main concerns of the administration of Rahavard Mehr Va Danesh Institute to ensure the security and safety of the students.

The primary vehicular entrance is from the east of the site, across the street from Bam Citadel. Parking is provided to the right of the entrance path and the Reception and Administration Building is located across the parking lot. The southern portion of the site is unplanted, and provides the opportunity for a larger building. The primary access route is the most public route, and is surrounded by the most public spaces on site. It is a north-south access route across the center of the site, passing through Corridor Type Buildings that will be primarily used as classrooms, workshops, display and retail spaces. The primary path represents the line of the Bazaar, acting as the spine of the city. Similar to the traditional Bazaars, such as Kerman's Bazaar (Fig. 2.68) and Bam's Bazaar (Fig. 2.47), the primary path takes a straight path central to the site, and leading to secondary and eventually tertiary paths.

FIG. 3.66. Proposed site plan.



The primary circulation path leads to a public stage, which acts as the most public center of the site, resembling the courtyard at residential scale and the Meidan at urban scale. Reflecting pools across the path and in the courtyard of the Reception and Administration Building cool the space and provide a more soothing spatial quality to outdoor spaces. The primary path ends at a secondary entrance on the northern edge of the site. Along the site, the primary path branches to secondary east-west secondary paths, that incorporate playgrounds and other semi-public spaces. These areas are very flexible and can occupy different locations along the secondary paths. The tertiary paths lead to small residential neighborhoods made of Dome and Vault typologies. The residences are gathered around a central neighborhood square to create a more friendly and cosy environment.

Since the Pilot Project can be incorporated both as an urban model and as an architectural model, the circulation axes can be used at both scales as well. If the proposed model is integrated at an architectural scale with one project complex within the site boundaries, the circulation paths will act as pedestrian walkways that allow access from one building to another, terminating at the site boundaries. However, if the proposed model is adopted at an urban scale for a variety of small dwellings within the larger context of the city, the circulation paths will act as vehicular roads that offer the possibility of expansion throughout the city over time. The Pilot Project is a proposal in the former model, therefore the paths are primarily on-site pedestrian walkways, except the East vehicular entrance.

Fig. 3.67 shows the view along the primary path, passing through the public gathering space of the stage. The path passes over the reflecting pool, which provides an architectural barrier between the path and the performance space. Dome and Vault Residential Typologies can be seen on the right of the image, and Corridor-type buildings can be seen on the left along the primary path. The short walls separating the public spaces from the residential neighborhoods can be seen on the right.

FIG. 3.67. Main public gathering space of the stage with the reflecting pool to the left. Classrooms along the primary access route are visible in the background to the left, and vaulted residences are can be seen in the background to the right of the view.

3.7.1. Type A: Courtyard Building Typology

FIG. 3.68. Locations of Courtyard Building Typolgy on the site.

Type A is the Courtyard Building Typology used for the Reception and Administration Building on the south end of the site (Fig. 3.68). This is the biggest building on site, and is the most permanent of all buildings on site. The Reception and Administration Building is constructed of rammed car tires. The wooden roof structure allows for large spans and flat roofs. As shown in the floor plan of this building (Fig. 3.69), the main entrance is through the entrance vestibule, inspired by the design of traditional Hashtis, to redirect the path of travel and block the view of the courtyard. The Reception Office is located on the vestibule to provide general information and registration for the visitors. This is where the information on public tours and accommodations will be offered to the visitors. A trellis to provide shade and create a welcoming entrance covers the vestibule (Fig. 3.70).

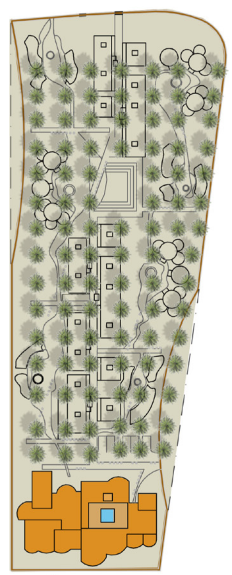


Fig. 3.68

FIG. 3.69. Courtyard Building- floor plan.

FIG. 3.70. Courtyard Building- isometric view.

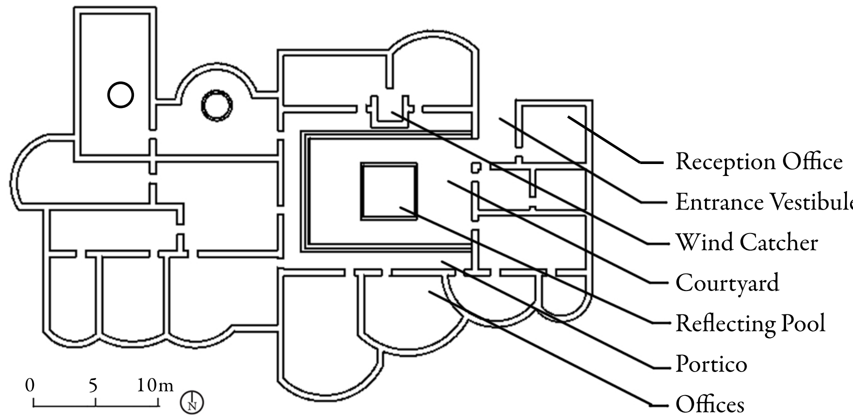


Fig. 3.69

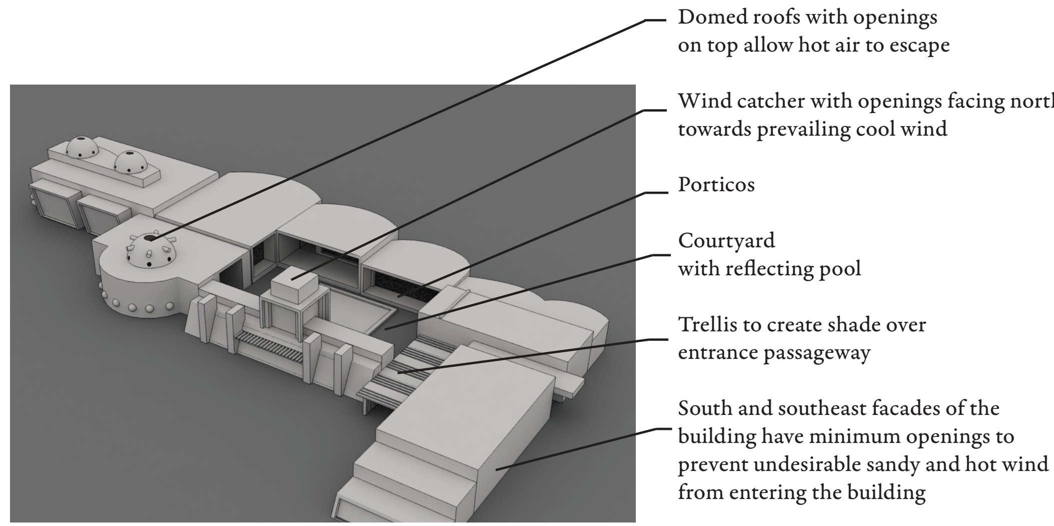
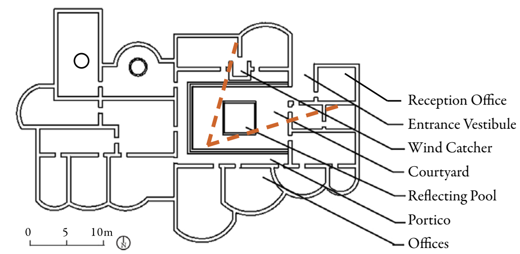


Fig. 3.70

The central courtyard of the Reception and Administration building has the typical elements of a traditional courtyard, and a modern minimal touch, celebrated by the joyful reflections of the colored window glazing, inspired by traditional Persian architecture. As shown in the rendered view of the courtyard (Fig. 3.71), the reflecting pool and the citrus tree at the center of the courtyard cool the space and create a spatially appealing gathering space. All rooms facing the courtyard have porticos with stairs all along the side of the portico. The stairs create a smooth transition between the indoor spaces and the courtyard, as well as creating sitting space to encourage gatherings. One of the rooms facing the courtyard can be used as a lobby, where group tours and visitors can gather. With the open access to the courtyard, the lobby will be a very entertaining and communal space.

The wind catcher has openings facing north, towards the prevailing cool wind. The cool air drawn down into the two rooms on the north side of the courtyard cools these spaces and is directed to the adjacent rooms. The air is then drawn into the courtyard, where it escapes the building. The wind catcher in the Pilot Project is not large enough to cool the entire building. The rooms on the western side of the building are cooled allowing the hot air to rise in the domed roof, and escape through the opening on top of the roof. Avoiding openings on the south and southeast sides of the building blocks the hot and sandy wind from entering the building, creating a cleaner and cooler living space.

FIG. 3.71. Courtyard of the reception building. The view shows the reflecting pool, a citrus tree, porticos and the back of the windcatcher.



3.7.2. Type B: Corridor Building Typology

FIG. 3.72. Location of Corridor building typology locations on site.

The Corridor Building Typology is used for the buildings along the primary access route (Fig. 3.72). These buildings have the potential of growing along the north-south access. Each building is accessed by a corridor, leading to various rooms that can be used as classrooms, workshops, or retail space to display and sell handicrafts and products made on site. As the floor plan shows (Fig. 3.73), there are three load-bearing sides to each unit within this building. The load-bearing walls are made of car-tires, and allow minimum openings due to the heavy weight of the walls. There is only one side of every unit that is not load-bearing and can be fully glazed to allow light and view into the interior spaces. The non-load-bearing side of every unit opens to the corridor with either floor-to-ceiling glazing, or half-walls depending on the privacy requirements of the specific program.

The corridor has glazed walls facing the primary path, creating a fluid separation between the indoor and outdoor programs. The glazed wall is slanted to provide a modern appearance. This typology is designed for a multi-functional program, and offers a variation of transparency levels between the primary path and the indoor spaces depending on the program. The rooms located behind the wind catcher have most privacy, as there is a solid wall separating these rooms from the public circulation path. These rooms can be used for classrooms that require more privacy. Classrooms that require less privacy can occupy the other rooms with partial glazing. All exterior glazing is provided with shading devices made of palm leaves to control view and sunlight access. The rooms that are used as workshops or retail spaces will occupy the rooms with minimum privacy from the primary path. The shades will remain open for these units to invite the visitors into the space.

Each classroom has an operable skylight that is designed according to sun angles at different times of the year to allow the winter sunlight into the classroom and to prevent summer sunlight access (Fig. 3.74). The skylights are facing south in order to take advantage of sunlight access during winter as thermal mass. The winter sun entering through the skylight heats the earthen floor slab during the day. This heat is released at night, keeping the building in a desirable temperature throughout the day. The winter

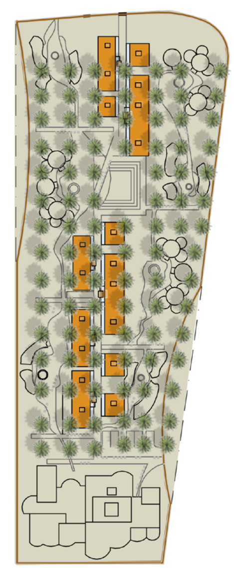


Fig. 3.72

FIG. 3.73. Classroom building- floor plan.

sunlight is desirable because Bam has cold winters. However, operable blinds are also provided on the skylights to allow control. There is a wind catcher located at the center of the building. The wind catcher faces the prevailing north wind, and directs the cool breeze into the corridor. The air circulates from the corridor into the classrooms, cooling the entire building. During summer, the operable skylights allow the hot air to escape and create negative pressure in order for more wind to enter the building through the wind catcher.

Fig. Fig. 3.76 shows the view across the primary path, showing the exterior view of one of a building with the Corridor Building Typology. The wind catcher facing north can be seen on the left of the image. The palm trees create shading over the primary circulation path, and the reflecting pool cools the space and creates a more desirable public space for gathering. The glazing along with operable shades made of palm leaves provide controllable transparency between the interior and exterior of the building.

Fig. 3.77 shows an inteior view of a classroom in the Corridor Building Typology. The skylights and the floor to ceiling glazing in the corridor allow natural light into the space. Hand-made blinds, the local handicraft of Bam, allow for control of light and view, and the interior earth-plaster finish provides a friendly and comfortable space.

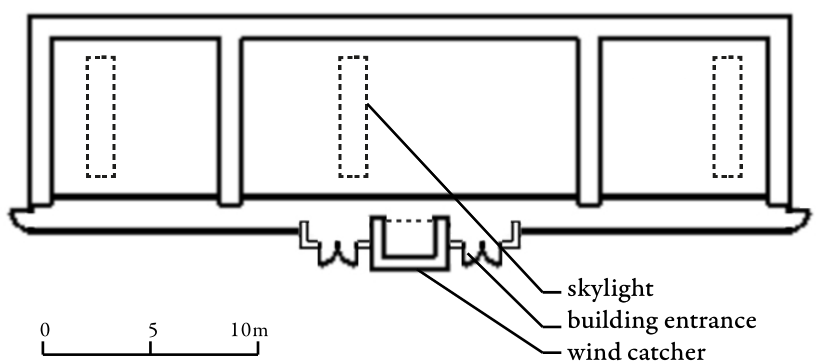


Fig. 3.73

FIG. 3.74. Classroom building- Sun and wind diagram.

FIG. 3.75. Classroom building- isometric view.

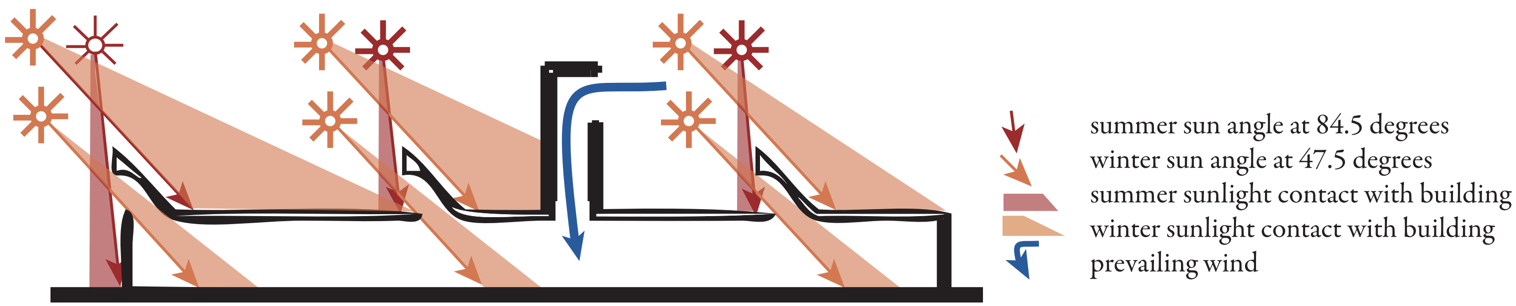


Fig. 3.74

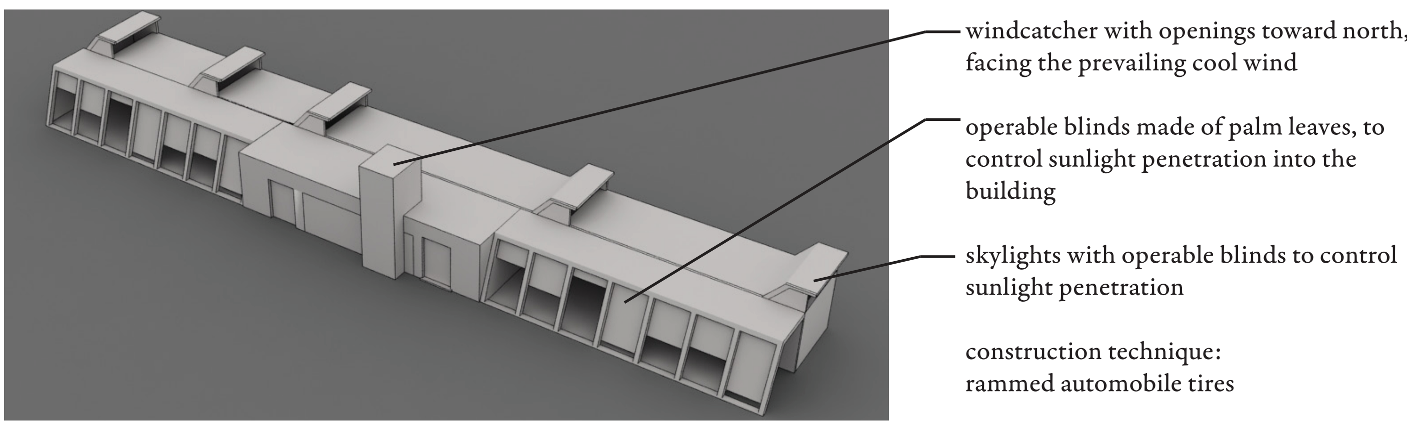


Fig. 3.75

FIG. 3.76. Primary access route with classroom buildings on one side and reflecting pool on the other. Classroom building has a north facing windcatcher, operable hand-made blinds, and sky-lights. Palm trees along the primary road shade the pathway during the day.

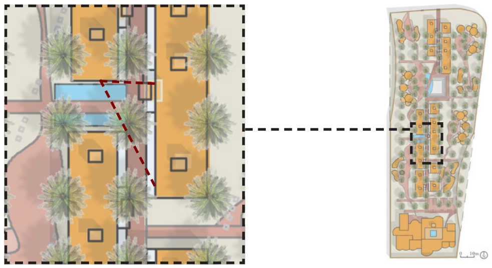


FIG. 3.77. Interior view of a typical classroom in the Corridor Building Typology.

FIG. 3.78. Location of Domed residences on the site.

FIG. 3.79. Location Vaulted residences on the site.

3.7.3. Type C: Domed Residential Building Typology

Domed Residential Building Typology is constructed of earthbags and is used for residences in the residential neighborhoods (Fig. 3.73). The Domed Residences are constructed with the possibility of expansion by joining multiple domes to the initial one (Fig. 3.80). There is an operable skylight on top of every dome to allow the hot air to escape. There is a variety of openings throughout the body of the dome for natural light and ventilation. The openings closer to the ground have colored glazing to provide privacy. Fig. 3.82 shows the view of a typical residential square with surrounding domed residences. The citrus plants at the center of the square along with the organic forms of the planter, domes, and the half-walls surrounding the neighborhood create a friendly communal residential neighborhood. The colored glazing brings a joyful touch to the monochrome earthen buildings, a strategy used in traditional Persian Islamic architecture.

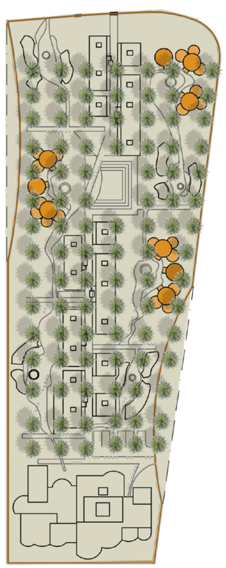


Fig. 3.73

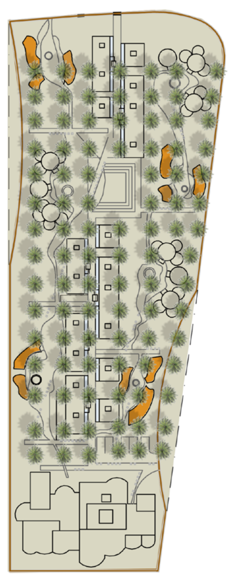


Fig. 3.77

3.7.4. Type D: Vaulted Residential Building Typology

Vaulted Residential Building Typology is also used for residences in the Pilot Project (Fig. 3.77). Similar to Domed Residences, the Vaulted Residential Buildings are also constructed of earthbags. These buildings have a more organic form, and have the possibility of expansion along the sides or the ends as shown in Fig. 3.83. These buildings also have colored and regular operable glazing throughout the vault to allow for ventilation and view (Fig. 3.84). Fig. 3.85 shows the interior view of a Vaulted Residence. The bed and the side bench are also made of earth and are covered with cushions to provide comfort. Colored glazing is used for windows that are lower in height in order to allow for natural light and to prevent view into the residence. Hand-made carpets and furniture made of local palm woods and leaves finish the interior of the space.

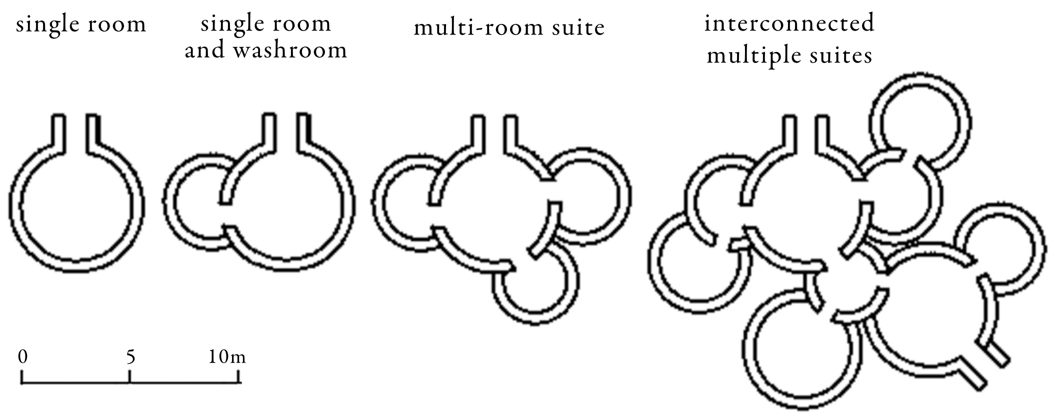


Fig. 3.80

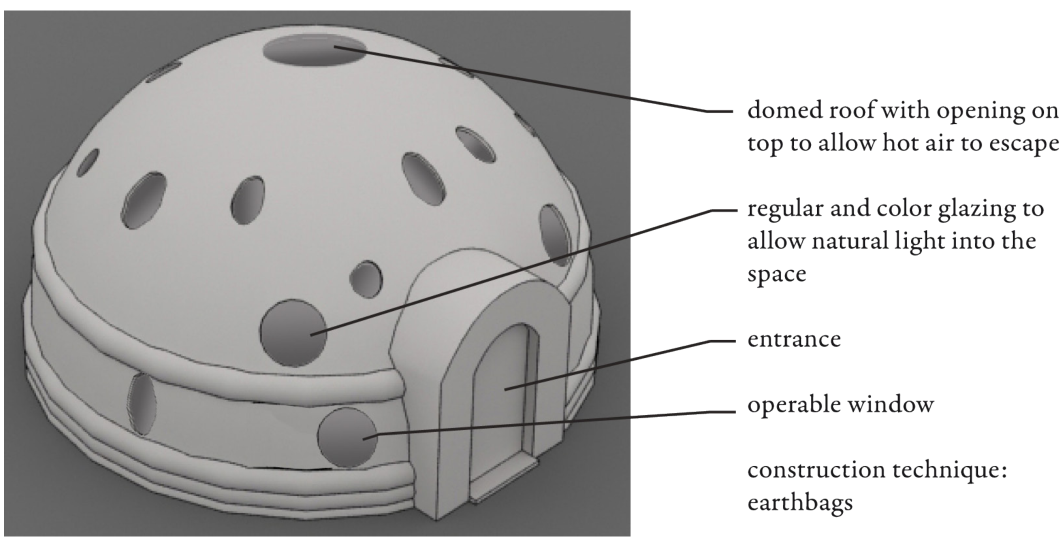


Fig. 3.81

FIG. 3.80. Domed residences- floor plan

FIG. 3.81. Domed residences- isometric view

FIG. 3.82. Residential courtyard for guest suites.

FIG. 3.83. Vaulted residences- floor plan.

FIG. 3.84. Vaulted residences- isometric view.

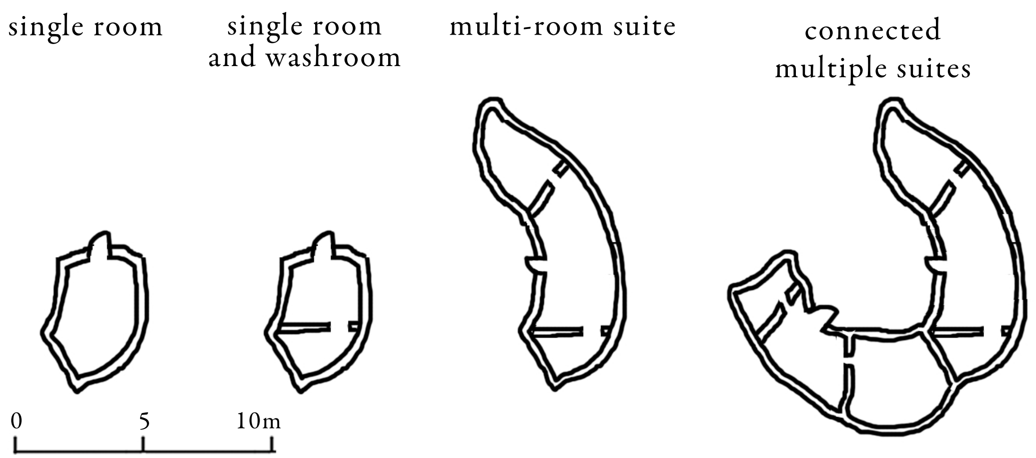


Fig. 3.83

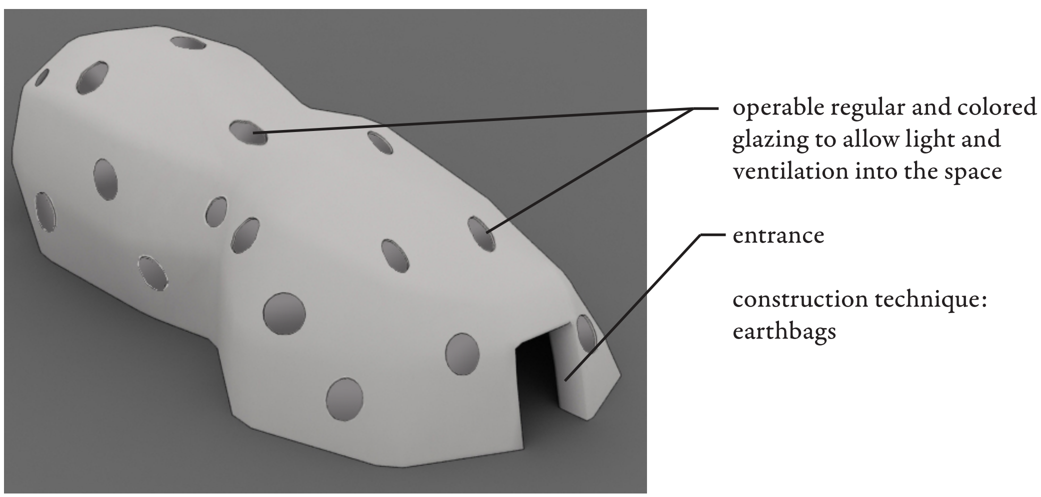


Fig. 3.84

FIG. 3.85. Interior view of a typical vaulted residence.

3.8. Self-Sustainability

3.8.1. On-site Income

As the project is very restricted on construction and maintenance budgets, traditional sources of income are incorporated for financial support. The palm trees are a source of income as Bam's dates have an international reputation. Workshops are provided for the students to learn various skills including pottery, handicrafts using palm leaves, carpentry, sewing, and carpet making. These workshops can be used for educational purposes as well as a source of income for the institution. A cow stable and a traditional wood oven bread bakery are incorporated in the design to provide the dairy products and bread for the daily meals of students as well as for sale to the public.

The visitor center attracts visitors and provides accommodations for the guests, provides educational tours of the buildings, and provides a source of income for the Institute. Earthship Biotecture is a successful precedent in renting accommodations in projects such as Phoenix Project.[34]

Students who assist in construction of the building can provide visitors with information on handmade, seismic proof, earthen buildings, spreading the knowledge and publicizing the self-help construction program. This not only benefits the publicity of the unique program at Rahavard Mehr Va Danesh Institute, but also educates the public about the possibility of adoption of this technique in other seismic prone areas. This project raises awareness of possible seismic hazards, and prepares the public for possible upcoming catastrophes. In case of future earthquakes in Bam or its neighboring cities, volunteers who assist in the construction of the pilot project can take a major role in leading reconstruction of damaged cities.

34 Earthship Biotecture, "Phoenix Earthship Nightly Rental", < http://earthship.net/Begin-Here/Phoenix-Earthship-Nightly-Rental-dp4>, accessed on 21 June 2011

Architectural elements that have proven appropriate for Bam's geographical and environmental context, such as the courtyard, the wind catcher, and the garden are incorporated to develop a sustainable building as well as to resemble Bam's vernacular architecture. Orientation of openings is designed in accordance with environmental conditions such as wind and sun. This project uses passive heating and cooling, and natural lighting strategies, and has the possibility of using active environmental strategies such as solar panels and composting toilets if budget allows. This project has the potential of becoming a self-sustaining entity, with the possibility of growth to the larger scales of a neighbourhood and even a city in the future.

3.8.2. Incorporation of Natural Elements

3.8.1. Wind and Sun

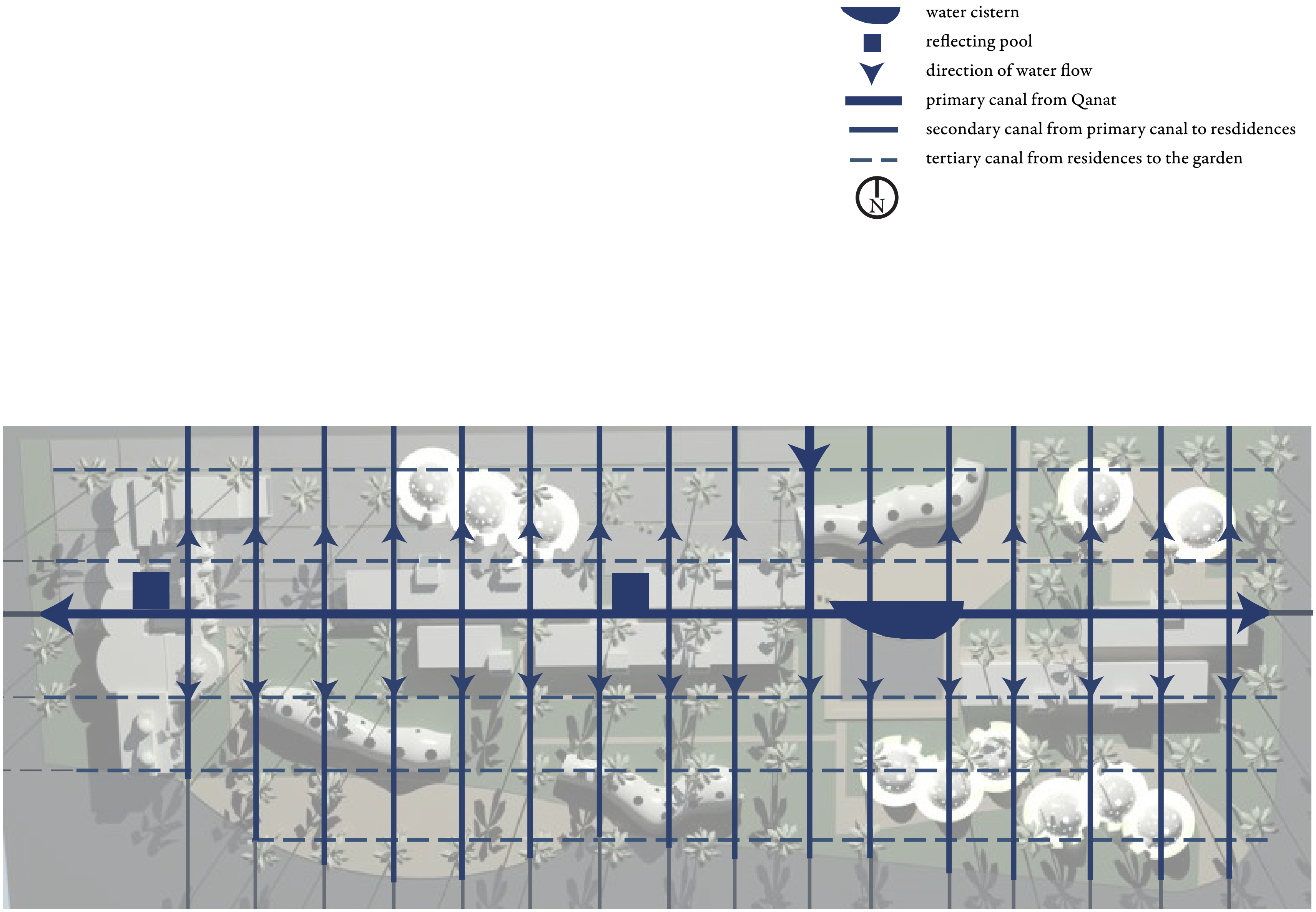
The Pilot Project incorporates natural elements, taking advantage of natural sources of energy and eliminating its negative impacts as much as possible. In Bam, the prevailing cooling wind blows from north and northwest, while the undesirable winds blow from south and southeast. This encourages the design to eliminate openings to east and south, which inevitably blocks the favorable natural lighting from south and east. The dilemma is to find a solution that blocks the unfavourable winds of south and southeast, but allows natural light access from these directions. The pilot project solves this issue through minimizing the openings and using skylights and windows with shading devices on south and southeast sides of buildings. This allows winter sunlight into the building and prevents summer sunlight from accessing the interior spaces.

3.8.2. Water

Water is incorporated in the design of the Pilot Project, as it is a very important factor in creation and maintenance of Bam. The traditional cities are naturally shaped along the path of water. Aligning the main path of water in the Pilot Project with the primary access route of the site symbolizes the significance of water in shaping the design, and provides a logical and appropriate circulation path for the water. The circulation of water for optimizing the use for different applications such as drinking, washing dishes, flushing the toilets, and aggregation of the palms is inspired from the traditional path of water circulation used in traditional Persian residences.

The water is supplied to the site of the Pilot Project through the Qanats that bring the water from the mountains to the west of the city. Water enters the site through underground water channels, and a part of it is collected in the reflecting pool located at the central gathering space of the public stage (Fig. 3.86). This is the main water element in the design, representing the traditional water cistern (Aab Anbar), and the reflecting pool in the courtyard of traditional residences. There are two other reflecting pools on the site, one in the courtyard of the reception building, and another along the primary pedestrian path at the spine of the site. The water travels through the site along the primary access route, branching to the secondary and tertiary water channels to feed the buildings on site. The water is used for various purposes including drinking, washing dishes and clothes, flushing the toilets and aggregating the gardens in an order influenced by the traditional water circulation and adaptable to modern water filtration technologies. The circulation of water from least polluting use to most polluting use optimizes the water usage, and eliminates the waste of water. The waste water is filtered and used for watering the garden as the end use.

FIG. 3.86. Water circulation diagram.



3.8.3. Vegetation

The pilot project takes advantage of its location in the date palm gardens of Bam. The project is designed according to the existing location of the palms, and the buildings are situated in between the trees in order to maintain all existing vegetation. The palms provide shading from the hot desert sun and break the desert wind, creating a more pleasant outdoor space in the garden. The buildings are located to take maximum advantage of the shade provided by the palms. The primary access route is a north-south route due to the available entrance points to the site. The palms along the primary path block the direct sunlight on the path and create natural shading over the pathway (Fig. 3.76).

Vegetation is also used to create different atmospheres throughout the project. Palm dates and citrus trees are the two most common and environmentally suitable trees for Bam. Along with providing a source of income and cooling the space, they create unique atmospheres in the project. Palm trees are taller and occupy less space at their base, while citrus trees are shorter and more accessible to human reach. The existing site only contains palm trees, but the proposed design suggests introduction of citrus trees in residential areas to produce a double-layered garden and create a cozier atmosphere for the residential areas. As mentioned earlier, double-layered gardens are typical for Bam, creating ideal conditions both for the growth of the trees and for creating a comfortable natural space.

Palm trees are used for various purposes in this project. They provide a source of food and income, the hardwood of the palm is used for construction of flat roofs, and its leaves are used for hand-made blinds for the windows. Bam is known for its handicrafts such as baskets and fans made out of palm leaves (Fig. 3.87, Fig. 3.88), a local tradition and skill supported and encouraged by this project.

FIG. 3.87. A local Bami making hand-made floor mats from dried palm leaves, a local handicraft.

FIG. 3.88. Hand-made baskets, fans, and mats are the most famous souvenir of Bam.

Fig. 3.87 (top) Fig. 3.88 (bottom)

3.8.3. Adaptability Over Time

The study of students' age groups and parental conditions[35] demonstrates that as time passes, the students' requirements will change. As demonstrated in Appendix A.3., today over 40% of students are female elementary students. In five years these students will become teenagers with very different space requirements than today. In ten years, the majority of students will be in secondary school, demanding much more classroom space and less play area than they require today in their elementary school age. As the orphans of the 2003 earthquake grow older, the institution will adopt new students from all ages. It is estimated that in twenty-five years, there will be almost the same number of students from all age groups attending this institution.

The students' psychological conditions will also change over time, as today most of the students are orphans of the earthquake and dealing with the trauma of losing their parents. As these students grow, the admission criteria will change; there will be more students with incompetent parental conditions, such as drug addicted or alcoholic parents, admitted to the school. The space and facility requirements for these students will be different, and the project must adapt itself to the new requirements. There is also the possibility of other disasters in, or around Bam, leading to adoption of more orphans by the Institute. The Pilot Project has been spatially designed to adapt to all changing conditions, as the spaces are flexible and easy to alter.

The Pilot Project is made of a combination of small buildings with flexible spaces. The buildings are easy to alter in size by adding rooms to increase the size or dividing existing rooms to smaller spaces. The buildings could also join one another to create larger spaces. Fig. 3.80 and Fig. 3.83 demonstrates how the Dome and Vault Typologies can expand over time. The possibility of expansion will be considered during construction, and future door openings will be constructed with more flexible sandbag connections to facilitate future alterations.

35 Charts drawn by Author, based on study performed by Rahavard Mehr Va Danesh Institute in 2009, see appendix A.3.

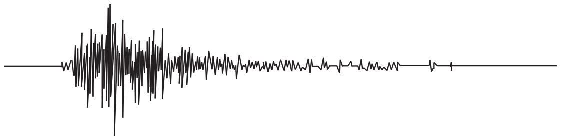
3.9. Project at a Larger Scope

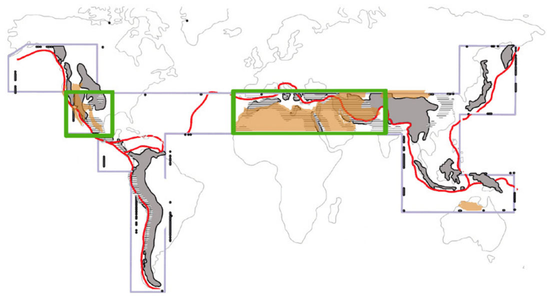
Involvement of residents in the construction process will create a bond and a sense of unity amongst them. Every volunteer will gain self-confidence and a sense of success. The positive effects of users' involvement in construction of a project such as Bam's Pilot Project is so essential that, as Hassan Fathy has written, "the transformation brought about in the personalities of the peasants when they build their own village is of greater value than the transformation in their material condition".[36] Each craftsman individually gains in understanding and dignity, while the city collectively acquires a sense of society, of interdependence and brotherhood that only such cooperative achievements can provide. Reconstruction of buildings also changes the appearance of the city, facilitating its rejuvenation and economical growth.

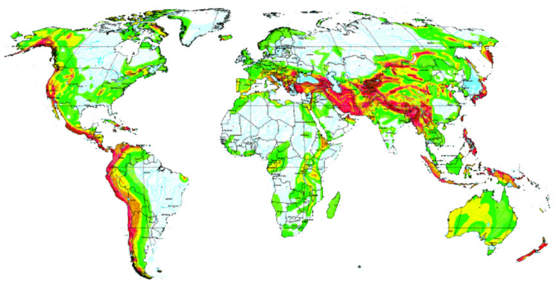
The goal of this project is to educate residents of Bam and other post disaster cities about the proposed architecture and construction technique demonstrated through the pilot project. This project educates the residents of disaster prone areas and prepares them to reconstruct their homes in post-disaster conditions. It familiarizes the residents with the proposed design and construction technique, in order for them to be able to follow the 'Build it Yourself' manual in post-disaster conditions. At the time of future earthquakes, a 'How to Design and Build it Yourself' manual will be published by the author for any post disaster city based on its distinct social, cultural, and vernacular characteristics. The manual will direct the users to customize the design and build it using available resources. In every city, groups of residents and volunteers will gather together, constructing homes for all group members one after the other. It is essential that the manual includes thorough details on design and construction, and is easy to follow, as in many post-disaster conditions, an architect's supervision will not be possible and residents are on their own to construct their homes. Through self-help, rejuvenation of cities will accelerate, and survivors will take a major step towards building their future.

36 Hassan Fathy, Architecture for the Poor, P 123.

Conclusion







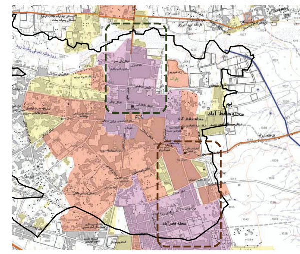
Dancing to the Desert provides a thorough analysis of the current conditions of Bam and many other seismic-prone cities in the developing world. Through a discourse on the effects of the vernacular and modern architecture on the social, cultural, and environmental context of post-disaster cities within the hot-arid climates, this thesis concludes that the epidemic of replacing the vernacular architecture with the Western contemporary architecture does not lead to reduced fatalities in case of disaster. Rather, it creates socially, culturally, and environmentally inappropriate spaces that are unfamiliar to the inhabitants. *Dancing to the Desert* implements a combination of traditional and contemporary architectural elements that are appropriate for the specific context of Bam, Iran. This thesis proposes an asset-based, self-help strategy for post-disaster construction of the developing regions within the hot-arid climate, providing opportunities for low-cost post-disaster construction.

In addition to an architectural proposal, *Dancing to the Desert* also tackles the issue of poor construction and high fatality rates in the developing world at a deeper level and suggests that public education can play a key role in improving the architecture and reducing the fatalities in these regions. This thesis undertakes various educational strategies including workshops and newspaper articles to raise public awareness for disaster prevention and mitigation, as well as for encouraging context-appropriate architecture.

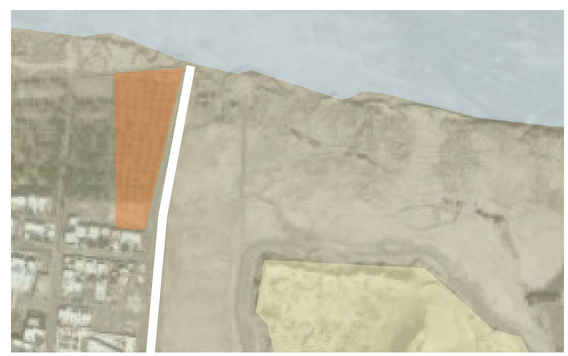
Dancing to the Desert includes three main chapters: Global Issues, Typical City, and Pilot Project. Incorporated together, these chapters offer the reader an in-depth examination of global seismic conditions, an analysis of Bam as a typical post-disaster developing city, and a proposed Pilot Project for Bam, adaptable to any post-disaster desert city. The following is a brief description of each chapter's contribution to this thesis.

Chapter One starts with an analysis of current global seismic conditions. It makes the point across that hot-arid regions of the developing world have the highest seismic hazard risk due to unreinforced earthen buildings and lack of seismic prevention. This thesis selects the city of Bam as a typical post-disaster city suffering to this day from a 6.6 Richter earthquake that killed over 40,000 people and destroyed 80% of all buildings in 2003. Bam's high-hazard seismic location in the Persian Plateau along with its typical Western-inspired modern post-disaster construction makes this city a typical developing hot-arid seismic prone city.

Chapter Two analyzes the geographical, historical, and social context of Bam, as well as the traditional and contemporary architecture and urban plan of this city and many other Persian desert cities. This thesis addresses the inappropriate mimicking of Western architecture as a harmful epidemic in developing countries. Even though contemporary architecture has the potential of providing stronger structures through modern technological advancements, studies in Chapter Two demonstrate that the earthquake equally destroyed the traditional and modern buildings in Bam due to inadequate structural detailing. Unlike traditional architecture, the contemporary architecture of Bam does not consider social, cultural, and environmental context, which leads to the creation of uncomfortable spaces for the inhabitants. This thesis combines positive aspects of the traditional and contemporary architecture to create a building that is culturally, environmentally, and socially appropriate, as well as structurally stable against seismic forces. The result is a comfortable building with environmentally suitable traditional elements such as the wind catcher and the courtyard typology, with a modern touch of slanted glass and simple geometric forms. The building can be constructed by unskilled volunteers, and can be altered as the program requirements change over time.



Chapter Three demonstrates how the analysis in Chapters One and Two can be incorporated in a site-specific design. The Pilot Project for Rahavard Mehr Va Danesh Institute proposes a design that is adaptable both at an architectural scale as well as an urban scale. Through the use of regional architecture that adapts the positive aspects of traditional architecture and the structural and technological benefits of modern architecture, this project offers a sustainable, environmental, and cultural friendly building. The self-help, asset-based construction process allows for a wide range of possibilities in post-disaster conditions. Involvement of volunteers and inhabitants in the construction process encourages a sense of unity among the citizens and assists in the psychological improvement of disaster victims. Possibilities of renting guest suites and providing tours of the buildings to the public creates educational programs as well as a source of income for the Institute. The Pilot Project does not only provide shelter for the survivors, it also offers




skill training for future job opportunities, promotes physical activity in order to improve the physical and mental health of volunteers, and provides public education all within the same resilient culture-rich and environment-friendly building.

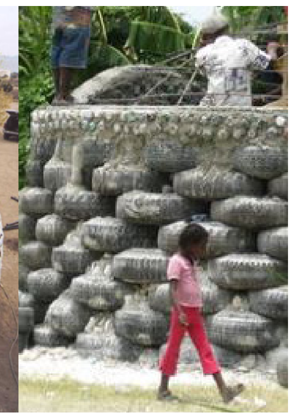
The Pilot Project is only a schematic proposal for incorporation of the discussed subject matters into an architectural form. Architectural details such as the required number of entrances and emergency axes, facade material requirements, and possibility of construction amongst the palms have not been coordinated with the requirements of Bam's Building Code. The proposed design must be altered according to the code requirements before application for a building permit.

Throughout the research and design process, the Author faced many obstacles that affected the research and design process. Political issues and lack of available public resources in Iran played a major role in the analysis component of this thesis. The majority of the references used in this thesis include non-governmental and out-of-country resources, as political constraints restrict primary research in Iran. Statistics such as post-disaster unemployment rates, physical and mental health status of the survivors, and rate of poverty and homelessness after the earthquake could have played a significant role in determining how this proposal can affect the city on a larger scale. However, unfortunately, concealing this database from the public prevented detailed analysis in this matter. This led the Author to use informal conversations with the public as the means to determine the employment, economic, mental, and physical health status of the general public.

Dancing to the Desert is only a starting point for a larger movement by the Author. Future steps following this thesis include writing and publishing articles on the traditional and contemporary architecture of Bam, organizing and undertaking workshops to educate the public about context-appropriate architecture, disaster prevention and mitigation, fundraising for the project, site purchase, cost analysis, creating construction drawings, attaining a construction permit, gathering the volunteers, and starting the construction of the Pilot Project.

Key initiative steps have been taken towards construction of the Pilot Project. About two-thirds of the cost for the purchase of the site has been collected from private donations, and two registered Canadian charities have declared interest in supporting the fundraising. The next fund-raising event will be a public fund-raiser and will mark the anniversary of Bam's earthquake on 26 December 2011. This event will consist of two parts: first is informative and subsequently, the second is entertaining. The event will provide a thorough description of the students' condition at Rahavard Mehr va Danesh, and describe the Pilot Project, asking for financial support for construction of the project. The entertainment component of the event will help to increase funding for the event.

It is crucial to have an estimate of the project cost prior to attempting large scale fund-raising. The cost estimate is not provided in this thesis because the attempt to calculate an estimate has been unsuccessful due to high price fluctuations in Iran. It is extremely difficult and inaccurate to determine the cost of construction, as the material costs fluctuate on daily basis due to international sanctions and other political issues in Iran. As the estimated cost will be very inaccurate, it is preferred to determine the cost when the country is at a more stable economic status, or immediately prior to the fundraising event to have an up-to-date estimate.



Another foreseen difficulty in the construction process is attaining a construction permit from the City of Bam. Constructing buildings out of innovative construction materials such as earthbags and car tires is not common in developing countries such as Iran, and it is more difficult to attain a permit for these buildings. However, fortunately, recently Iran has been more open to new and innovative construction strategies, and the Author hopes to be able to attain a permit for the building. Authorities at the City of Tehran have encouraged the Author of persuing the project, and have declared interest in supporting the project for construction in Bam.

Construction of Bam's Pilot Project will provide a physical prototype for future post-disaster housing in hot-arid climates, and provides a center for public education in disaster prevention and mitigation in Bam, as well as shelter for the orphans at Rahavard Mehr Va Danesh Institute. Volunteers who assist in construction of this project will learn the

required skills to build earthbag and car tire buildings, and can use this skill for low-income housing, disaster prevention, and possible future disaster mitigation. The analysis and design procedure of Bam's Pilot Project is adaptable to any low-income seismic-prone region in the developing world, and is a wake-up call to all developing countries to incorporate architecture appropriate for their specific environmental, social, cultural, and geographic context. If appropriate architecture is incorporated in construction of buildings, the built environment acts as a part of its surrounding natural context, and will be sustainable, resilient, and ever-lasting.

Bibliography

Adams, Beverley J. Huyck, Charles K. "MCEER Earthquake Reconnaissance Investigation. The Bam (Iran) Earthquake of December 26, 2003: Preliminary Reconnaissance Using Remotely Sensed Data and the Views." Global Security.

Aga Khan Award for Architecture: The Fifth Award Cycle 1990-1992. Geneva, Switzerland: Aga Khan Award for Architecture, 1992.

Abdollahyan, Hamid. Conceptualization of Reality in Historical Sociology: Narrating Absentee Landloridism in Iran. Tehran: Sayeroshan, 2004.

Addis, William. Building with Reclaimed Components and Materials: A Design Handbook for Reuse and Recycling. London; Sterling, VA: Earthscan, 2006.

AlSayyad, Neza. Consuming Tradition, Manufacturing Heritage: Global Norms and Urban Forms in the Age of Tourism. London; New York: Routledge, 2001.

AlSayyad, Nezar. End of Tradition?. London; New York: Routledge, 2004.

Ambrose, James E. and Dimitry Vergun. Design for Earthquakes. New York; Chichester, [England]: John Wiley, 1999.

American Society of Civil Engineers. Earthquake Investigations Committee. and Anshel J. Schiff. Guide to Post-Earthquake Investigations of Lifelines. Monograph (American Society of Civil Engineers. Technical Council on Lifeline Earthquake Engineering); no. 3. New York, N.Y.: American Society of Civil Engineers, 1991.

Arizona State University. College of Architecture and J. W. Scalise. Earth Integrated Architecture: An Alternative Method for Creating Livable Environments with an Emphasis on Arid Regions. 1975.

Arnold, Christopher and Robert Reitherman. Building Configuration and Seismic Design. New York; Toronto: Wiley, 1982.

Avin, Ahmet and Darl Rastorfer. Aga Khan Award for Architecture: Awards, 1983, Presented by His Highness the Aga Khan at Istanbul, Turkey. Geneva, Switzerland: Aga Khan Award for Architecture, 1983.

Baird, John C. and Anthony D. Lutkus. Mind Child Architecture. Hanover, NH: Published for Dartmouth College by University Press of New England, 1982.

Ballesteros, Mario. Verb Crisis. Verb (Barcelona, Spain) ; 6th Issue. Barcelona: Actar, 2008.

Bally, A. W. Seismic Expression of Structural Styles: A Picture and Work Atlas. AAPG Studies in Geology; no. 15. Tulsa, Okla., U.S.A.: American Association of Petroleum Geologists, 1983.

Bam's Disability Center, "Bam's Disability Center: Semi-Annual Report", 2008.

Ban, Shigeru. Shigeru Ban: Projects in Process to Japanese Pavilion Expo 2000 Hanover = Ban Shigeru Purojekutsu in Purosesu : Hanoba Banpaku 2000 Nihonkan Mad. Gyarari Ma Sosho ; 12. Tokyo: TOTO Shuppan, 1999.

Ban, Shigeru and David N. Buck. Shigeru Ban. GG Portfolio. Barcelona: G. Gili, 1997.

Beazley, Elisabeth, Michael Harverson, and Susan Roaf. Living with the Desert: Working Buildings of the Iranian Plateau. Warminster, Wilts, England: Aris & Phillips, 1982.

Bell, Bryan and Katie Wakeford. Expanding Architecture: Design as Activism. New York: Metropolis Books, 2008.

Beny, Roloff and Freya Stark. Thrones of Earth and Heaven. New York: H.N. Abrams, 1958.

Bier, Lionel. Sarvistan: A Study in Early Iranian Architecture. Monographs on the Fine Arts ; 4. University Park: Published for the College Art Association of America by Pennsylvania State University Press, 1986.

Booth, E. D. (Edmund D.). and David Key. Earthquake Design Practice for Buildings. 2nd ed. / Edmund Booth and David Key ed. London: Thomas Telford, 2006.

Booth-Clibborn, Edward and Nasr Allah Purjavadi. Splendour of Iran. London: Booth-Clibborn Editions, 2001.

Bourdier, Jean-Paul and Nezar AlSayyad. Dwellings, Settlements, and Tradition: Cross-Cultural Perspectives. Lanham: Berkeley: University Press of America ; International Association for the Study of Traditional Environments, 1989.

Brown, G. Z. Sun, Wind, and Light: Architectural Design Strategies. New York; Toronto: Wiley, 1985.

Brown, G. Z. and Mark DeKay. Sun, Wind & Light: Architectural Design Strategies. 2nd ed ed. New York; Chichester [England]: John Wiley, 2001.

Bryce, Herrington J. Revitalizing Cities. The Urban Roundtable Serie. Lexington, Mass.: Lexington Books, 1979.

Buntrock, Dana. Japanese Architecture as a Collaborative Process : Opportunities in a Flexible Construction Culture. London; New York: Spon Press, 2002.

Cache, Bernard and Michael Speaks. Earth Moves: The Furnishing of Territories. Writing Architectur. Cambridge, Mass.: MIT Press, 1995.

Canada. Dept. of Industry,Trade and Commerce. Directory of Modular Building Components - Beam Program. (2Nd Ed.) 1971.

Canizaro, Vincent B. Architectural Regionalism: Collected Writings on Place, Identity, Modernity, and Tradition. 1st ed. New York: Princeton Architectural Press, 2007.

Clark, Kenneth N. and Patricia Paylore. Desert Housing: Balancing Experience and Technology for Dwelling in Hot Arid Zones. Tucson, Ariz.: University of Arizona, Office of Arid Lands Studies, 1980.

Crouch, Dora P. and June G. Johnson. Traditions in Architecture: Africa, America, Asia, and Oceania. New York: Oxford University, 2001.

Crowther, Richard L. Sun, Earth : Alternative Energy Design for Architecture. Updated and enl. ed. - ed. New York; Toronto: Van Nostrand Reinhold Co., 1983.

Curatola, Giovanni and Gianroberto Scarcia. Art and Architecture of Persia. 1st ed ed. New York: Abbeville Press, 2007.

Dethier, Jea. Down to Earth: Adobe Architecture, an Old Idea, a New Future : Based on an Exhibition at the Centre Georges Pompidou. New York, N.Y: Facts on File, 1983, 1983.

Dollens, Dennis. Simone Swan: Adobe Building. Santa Fe, N.M.: SITES Books, 2006.

"Durability of Building Materials and Components: Proceedings of the International Conference." Durability of Building Materials and Components: Proceedings of the International Conference. (1978): v.

Drew, Philip. Touch this Earth Lightly: Glenn Murcutt in His Own Words. Potts Points, N.S.W.: Duffy & Snellgrove, 1999.

Dwyer, D. J. (Denis John. City in the Third World. New York: Barnes & Noble Books, 1974.

Dwyer, D. J. (Denis John). City in the Third World; Edited by D. J. Dwyer. [London] Macmillan [c1974]: 1974.

"Earthquake Resistant Regulations, a World List." Earthquake Resistant Regulations, a World List (1963): v.

"Earthship Biotecture", 2010. www.earthship.com

Ehrenkrantz, Ezra D. Architectural Systems: A Needs, Resources, and Design Approach. New York; Toronto: McGraw-Hill, 1989.

Elizabeth, Lynne and Cassandra Adams. Alternative Construction: Contemporary Natural Building Methods. Hoboken, NJ: John Wiley, 2005.

Fathy, Hassan. Architecture for the Poor; an Experiment in Rural Egypt. Chicago: University of Chicago Press, 1976, 1973.

Fathy, Hassan, Walter Shearer, and Abd al-Rahman Sultan. Natural Energy and Vernacular Architecture: Principles and Examples with Reference to Hot Arid Climates. Chicago: Published for the United Nations University by the University of Chicago Press, 1986.

Fathy, Hassan. Gourna: a Tale of Two Village. Architecture for the Poor: An Experiment in Rural Egypt. Chicago: University of Chicago Press, 1973.

Feireiss, Lukas and Kristin Feireiss. Architecture of Change: Sustainability and Humanity in the Built Environment. Berlin: Gestalten, 2008.

Friedman, Donald and Nathaniel Oppenheimer. Design of Renovations. 1st ed. New York; London: W.W. Norton, 1997.

García, Belén. Earthquake Architecture: New Construction Techniques for Earthquake Prevention. New York: Loft and HBI, 2000.

Global Seismic Hazard Assessment Progam. and D. Grünthal. Global Seismic Hazard Map. Zurich, Switzerland: Swiss Seismological Service [distributor], 1999.

Golany, Gideon. Earth-Sheltered Habitat: History, Architecture, and Urban Design. New York; Toronto: Van Nostrand Reinhold, 1983.

Goter, Susan K. Map Showing Global Distribution of Seismicity, 1977-1986. Geophysical Investigations (Geological Survey (U.S.)) ; Map GP-989. Reston, Va.: Geological Survey, 1988.

Green, Norman B. Earthquake Resistant Building Design and Construction. 2nd ed. New York: Van Nostrand Reinhold, 1981.

Guarneri, Andrea Bocco and Bernard Rudofsky 1905-1988.Selections. Bernard Rudofsky: A Humane Designer. New York: SpringerWien, 2003.

Gursky, Andreas, Ralf Beil, and Sonja Fessel. Andreas Gursky : Architecture. Ostfildern: Hatje Cantz, 2008.

Habraken, N. J. Supports: An Alternative to Mass Housing. London: Architectural Press, 1972.

Hall, Peter Geoffrey and Colin Ward. Sociable Cities: The Legacy of Ebenezer Howard. Chichester, West Sussex, England; New York: J. Wiley, 1998.

Hamdi, Nabeel. Housing without Houses: Participation, Flexibility, Enablement. New York, N.Y.: Van Nostrand Reinhold, 1991.

Handelman, Howard. Challenge of Third World Development. 5th ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2009.

Handelman, Howard. Challenge of Third World Development. 4th ed. Upper Saddle River, N.J.: Pearson/Prentice Hall, 2006.

Hartman, Chester W. and Gregory D. Squires. There is no such Thing as a Natural Disaster: Race, Class, and Hurricane Katrina. New York: Routledge, 2006.

Hejazi, M. M. (Mehrdad M.). Historical Buildings of Iran: Their Architecture and Structure. International Series on Advances in Architecture; v. 2. Southampton, UK: Computational Mechanics Publications, 1997.

Herdeg, Klaus. Formal Structure in Islamic Architecture of Iran and Turkestan. New York: Rizzoli, 1990.

Hewitt, Mischa, Kevin Telfer, and Kevin McCloud. Earthships: Building a Zero Carbon Future for Homes. Berkshire: IHS BRE Press, 2007.

Hill, Jonathan. Occupying Architecture: Between the Architect and the User. London; New York: Routledge, 1998.

Hillenbrand, Robert. Islamic Architecture: Form, Function, and Meaning. Casebound ed. New York: Columbia University Press, 1994.

Holcomb, H. Briavel and Robert Beauregard. Revitalizing Cities. Resource Publications in Geograph. Washington, D.C: Association of American Geographers, 1981.

Holdsworth, W. J. and Antony Sealey. Healthy Buildings: A Design Primer for a Living Environment. Harlow, Essex, England: Longman, 1992.

Holod, Renat. Architecture and Community: Building in the Islamic World Today : The Aga Khan Award for Architecture. New York: Aperture, 1983.

Hyde, Richard. Bioclimatic Housing: Innovative Designs for Warm Climates. London; Sterling, VA: Earthscan, 2008.

International Atomic Energy Agency. Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting : A Safety Guide. IAEA Safety Series; no. 50-SG-S1 (Rev.1; IAEA Safety Guides. Vienna: International Atomic Energy Agency, 1991.

International Atomic Energy Agency. Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting. IAEA Safety Series; no.50-SG-S1; IAEA Safety Guides. Vienna: The Agency, 1979.

Jacobs, Jane and Dendy, William, 1948-, former owner. Death and Life of Great American Cities. New York: Vintage Books, 1961.

Jodidio, Philip. Iran, Architecture for Changing Societies: An International Seminar. Turin: U. Allemandi for Aga Khan Award for Architecture, 2004.

Joshan, Saeed, "Color and Form in Persian Architecture", 2011.

Judge, Tim. Re-Entry: Forging a New Relationship with Earth: 5B Thesis. Waterloo, Ont.: University of Waterloo, 2005.

Kanaori, Y. (Yuji). Earthquake Proof Design and Active Faults. Developments in Geotechnical Engineeiing;8. Amsterdam: Elsevier, 1997.

Kapfinger, Otto and Martin Rauch. Martin Rauch: Rammed Earth = Lehm Und Architektur = Terra Cruda. Basel; Boston: Birkhäuser, 2001.

Key, David. Earthquake Design Practice for Buildings. Civil Engineering Desig. London: Telford, 1988.

Khalili, Nader. Racing Alone: A Visionary Architect's Quest for Houses made with Earth and Fire. 1st ed. - ed. San Francisco: Harper & Row, 1983.

Khalili, Nader and Nader Ceramic houses Khalili. Ceramic Houses and Earth Architecture: How to Build Your Own. Hesperia, Calif.: Cal-Earth Press, 1996.

Khanbani, Hoda. Ghassemzadeh, Saba. Student Workshop, Rahavard Mehr Va Danesh Institute, Bam, 2009.

King, Bruce. Buildings of Earth and Straw: Structural Design for Rammed Earth and Straw-Bale Architecture. Sausalito, Calif.: Ecological Design Press, 1996.

Klotz, Heinrich. Paper Architecture: New Projects from the Soviet Union. New York: Rizzoli, 1990.

Kodama, Yuichiro, Jeffrey Cook, and Simos Yannas. Passive and Low Energy Architecture: PLEA. Process; 98. Tokyo: Process Architecture, 1991.

Kroll, Lucien and Peter Blundell-Jones. Architecture of Complexity. 1st MIT Press ed. Cambridge, Mass.: MIT Press, 1987.

Kronenburg, Robert. Flexible: Architecture that Responds to Change. London: Laurence King, 2007.

Kropotkin, Petr Alekseevich, kniaz and Huxley, Thomas Henry, 1825-1895. Struggle for existence in human society. Mutual Aid: A Factor of Evolution. 1st Canadian ed ed. Montreal: Black Rose Books, 1989.

Kruis, Leo. Flexible Housing. [Waterloo, Ont.: University of Waterloo], 1974.

Lawson, Bryan. Language of Space. Oxford; Boston: Architectural Press, 2001.

Magwood, Chris and Chris Walker. Straw Bale Details: A Manual for Designers and Builders. Gabriola Island, B.C.: New Society Publishers, 2001.

Margolis, Richard J. Something to Build on: The Future of Self-Help Housing in the Struggle Against Poverty. Washington, D.C.: International Self-help Housing Associates and the American Friends Service Committee, 1967.

McCue, Gerald M., Ann Skaff, and John W. Boyce. Architectural Design of Building Components for Earthquakes. San Francisco: MBT Associates, 1978.

McGuire, Robin K. Practice of Earthquake Hazard Assessment. [Denver?]: International Association of Seismology and Physics of the Earth's Interior, 1993.

McQuaid, Matilda. Shigeru Ban. London: Phaidon, 2003.

Mehdi Zar. "Earthquake of 26 December 2003, Mw 6.5: A Preliminary Seismological Overview." Observatories and Research Facilities for European Seismology, Orfeus Newsletter, Vol. 6, no.1., July 2004.

Meinhold, Bridgette. "Earthquake Resistant Tire Earthships for Haiti Disaster Relief". Inhabitat- Design will Save the World, 2 July 2010. http://inhabitat.com/earthquake-resistant-earthships-for-haiti-disaster-relief/.

Melis, Liesbeth. Parasite Paradise: A Manifesto for Temporary Architecture and Flexible Urbanism. Rotterdam: NAi Publishers, 2003.

Merrill, Anthony French. Rammed-Earth House. New York: Harper, 1947.

Milne, Peter. Design of a Medium Density, Static and Flexible Housing Environment for an Urban Core Area. [Waterloo, Ont.: University of Waterloo], 1973.

Minke, Gernot and Friedemann Mahlke. Building with Straw: Design and Technology of a Sustainable Architecture. Basel ; Boston: Birkhäuser, 2005.

Minke, Gernot and Gernot Lehmbau-Handbuch Minke. Earth Construction Handbook: The Building Material Earth in Modern Architecture. International Series on Advances in Architecture; v. 1. Southhampton [UK]; Boston: WIT Press, 2000.

Minke, Gernot and Gernot Neue Lehmbau-Handbuch Minke. Building with Earth: Design and Technology of a Sustainable Architecture. Basel; Boston: Birkhauser-Publishers for Architecture, 2006.

Mithraratne, Nalanie, Brenda Vale, and Robert James Dennis Vale. Sustainable Living: The Role of Whole Life Costs and Values. Amsterdam; New York: Butterworth-Heinemann, 2007.

Ministry of Housing and Urban Development Secretariat of Iranian High Council for Urban Planning and Architecture. Typology and Design Guideline for Housing in Bam. Tehran: Ministry of Housing and Urban Development, Office of Architecture and Urban Planning, 2007.

Modarres, Ali. Modernizing Yazd : Selective Historical Memory and the Fate of Vernacular Architecture. Bibliotheca Iranica. Urban Planning History of Iranian Cities; no. Costa Mesa, Calif.: Mazda Publishers, 2006.

Moos, David and Gail Andrews Trechsel. Samuel Mockbee and the Rural Studio: Community Architecture. Birmingham, Ala. : New York, NY: Birmingham Museum of Art ; D.A.P./Distributed Art Publishers, 2003.

Morgan, William N. Earth Architecture: From Ancient to Modern. Gainesville: University Press of Florida, 2008.

Mostaedi, Arian, Jacobo Krauel, and William George. Great Spaces. Ed. 2006 ed. [Barcelona]: Links, 2006.

Naeim, Farzad. Seismic Design Handbook. Structural Engineering Series (New York, N.Y. New York: Van Nostrand Reinhold, 1989.

National Geographic Maps (Firm). Earthquake Risk a Global View. Washington, D.C.: National Geographic Society, 2006.

National Geographic Maps (Firm), Linda R. Kriete, and Eric Hanson. Earthquake Risk, a Global View Danger Zones: [the World]. Washington, D.C.: National Geographic Society, 2006.

National Heritage Institute: Third Congress of the History of Iranian Architecture and Urbanism. Bam Citadel Research Center, 2005

Nejad, Sara. Bam's Anniversary Removed from Iran's Official Calendar. Shahrvand Newspaper, Vol .20, No. 1315, 6 January 2011,38.

Nejad, Sara. Current Conditions of Bam. Shahrvand Newspaper, Vol. 20, No. 1312, 16 December 2010, 40.

Nejad, Sara. Earthquake Hazard Threatens Tehran. Shahrvand Newspaper, Vol. 20, 23 December 2010, 38.

Nejad, Sara. Earthquake Shakes Bam once more on the Anniversary of the Earthquake. Shahrvand Newspaper, Vol. 20, No. 1312, 16 December 2010, 36.

Nejad, Sara. The Ravaging Pulse- Documentary film, 2011

Nelson, John B. and Robert A. Ganse. Significant Earthquakes 1900-1979. Boulder, CO: National Geophysical and Solar-Terrestrial Data Center: World Data Center A for Solid Earth Geophysics, 1981.

Nissen, Henrick. Industrialized Building and Modular Design. London: Cement and Concrete Association, 1972.

Oliver, Paul. Built to Meet Needs : Cultural Issues in Vernacular Architecture. 1st ed ed. Amsterdam; Boston ; London: Architectural Press, 2006.

Pearson, David. Earth to Spirit : In Search of Natural Architecture. San Francisco: Chronicle Books, 1994.

Pinós, Carme. Carme Pinós : Plym Distinguished Professor in Architecture, 1994-1995. [Champaign, Ill.]: School of Architecture, University of Illinois at Urbana-Champaign, 1995.

Pope, Arthur Upham. Persian Architecture; the Triumph of Form and Color. New York: G. Braziller [1965], 19uu.

Powell, Robert. Architecture of Housing: Proceedings of an International Seminar Sponsored by the Aga Khan Award for Architecture, the African Union of Architects,. Exploring Architecture in Islamic Cultures. [Geneva, Switzerland]: Aga Khan Award for Architecture, 1990.

Quantrill, Malcolm. Environmental Memory: Man and Architecture in the Landscape of Ideas. New York: Schocken Books, 1987.

Rainer, Roland. Anonymes Bauen Im Iran: Stadtplanungsabt. d. N.I.S.C. (National Iranian Steel Corporation). Graz: Akadem. Druck- u. Verlagsanst., 1977.

Rammed Earth: Design and Construction Guidelines. Watsford [England]: BRE Bookshop, 2005.

Refugees: The Dynamics of Displacement: A Report for the Independent Commission on International Humanitarian Issues. London; Atlantic Highlands, N.J.: Zed Books, 1986.

Restless Earth Plate Tectonics & Volcanoes. Understanding Global Issues; 93/2. Cheltenham, England: European Schoolbooks Publishing Ltd., 1993.

Roaf, Susan, Manuel Fuentes, and Stephanie Thomas. Ecohouse 2 : A Design Guide. 2nd ed. Oxford: Architectural Press, 2003.

Roy, Ananya and Nezar AlSayyad. Urban Informality: Transnational Perspectives from the Middle East, Latin America, and South Asia. Transnational Perspectives on Space and Plac. Lanham, Md.; Toronto : Berkeley, Calif.: Lexington Books ; Center for Middle Eastern Studies, University of California at Berkeley, 2004.

Rudofsky, Bernard. Architecture without Architects: A Short Introduction to Non-Pedigree Architecture. New York: Doubleday, 1964.

Sanyal, Bishwapriya. Comparative Planning Cultures. New York: Routledge, 2005.

Scalise, James W. and Andrew J. Abernathy. Earth Integrated Architecture: An Alternative Method for Creating Livable Environments with an Emphasis on Arid Regions. Tempe: College of Architecture Research and Service Foundation, College of Architecture, Arizona State University, 1975.

Scarlat, Adrian S. Approximate Methods in Structural Seismic Design. 1st ed. London ; New York: E & FN Spon, 1996.

Schneider, Tatjana and Jeremy Till. Flexible Housing. 1st ed ed. Amsterdam; Boston: Architectural Press, 2007.

Schwartz-Clauss, Mathias and Alexander von Vegesack. Living in Motion: Design and Architecture for Flexible Dwelling. Weil am Rhein: Vitra Design Museum, 2002.

Sinclair, Cameron. Design Like You Give a Damn: Architectural Responses to Humanitarian Crisis, edited by Kate Stohr. New York, NY: Metropolis Books, 2006.

Smiles, Samuel. Character. New York: A. L. Burt, 1880.

Smiles, Samuel, Charles A. Gaskell, Louis Jacob Breithaupt, Ezra Carl Breithaupt, Martha Edna Breithaupt, J. Russell Hewetson, and Winifred Hewetson. Happy Homes and the Hearts that make them, Or, Thrifty People and Why they Thrive. Chicago: U.S. Pub. House, 1883.

Smith, Stephanie. Beyond Green : Toward a Sustainable Art. Chicago : Smart Museum of Art, University of Chicago ; New York: Independent Curators International, 2005.

Steen, Athena Swentzell. Straw Bale House. Real Goods Independent Living Boo. White River Junction, Vt.: Chelsea Green Pub. Co., 1994.

Suchman, Diane R. Revitalizing Low-Income Neighborhoods: Recommendations from ULI Advisory Services Panels. Washington, D.C.: Urban Land Institute, 1994.

Swan, James A. and Roberta Swan. Dialogues with the Living Earth: New Ideas on the Spirit of Place from Designers, Architects, & Innovators. 1st Quest ed. Wheaton, Ill.: Theosophical Pub. House, 1996.

Thornton, J. Initial Material Characterization of Straw Light Clay. Research Report (Canada Mortgage and Housing Corporation. [Ottawa]: CMHC, 2004.

Tibbalds, Francis. Making People-Friendly Towns: Improving the Public Environment in Towns and Cities. London; New York: Spon Press, 2001.

Tomazevic, Miha. Earthquake-Resistant Design of Masonry Buildings. Series on Innovations in Structures and Construction ; v. 1. London: Singapore ; River Edge, NJ ; London: Imperial College ; Distributed by World Scientific Publishing Co., 1999.

Toppozada, Tousson R. Planning Scenario in Humboldt and Del Norte Counties, California, for a Great Earthquake on the Cascadia Subduction Zone. Special Publication (California. Division of Mines and Geology) 115. Sacramento, Calif. (801 K Street, Sacramento 95814-3531): California Dept. of Conservation, Division of Mines and Geology, 1995.

Toppozada, Tousson R., Glenn A. Borchardt, and Claudia L. Hallstrom. Planning Scenario for a Major Earthquake on the San Jacinto Fault in the San Bernardino Area. Special Publication (California. Division of Mines and Geology); 102. Sacramento, Calif. (801 K Street, MS 12-30, Sacramento 95814-3531): California Dept. of Conservation, Division of Mines and Geology, 1993.

Trulove, James Grayson and Nora Richter Greer. Hot Dirt, Cool Straw. New York: HarperCollins, 2001.

Tuan, Yi-fu. Escapism. Baltimore, Md. ; London: Johns Hopkins University

Press, 1998.

Tuan, Yi-fu. Man and Nature. Resource Paper (Association of American Geographers. Commission on College Geography); 10. Washington: Association of American Geographers, Commission on College Geography, 1971.

Tuan, Yi-fu and Tammy Mercure. Place, Art and Self. Santa Fe, NM; Staunton, VA: Center for American Places: [Distributed by the University of Virginia Press], 2004.

Turner, John F. C. Housing by People : Towards Autonomy in Building Environments. London: Marion Boyars, 1976.

United Nations. Dept. of International Economic and Social Affair. Non-Conventional Financing of Housing for Low-Income Households, 1978.

United States. Dept. of Agriculture, M. C. Betts, and T. A. H. Miller. Rammed Earth Walls for Buildings. USDA Farmers' Bulletin. 150. 1926.

United States. Dept. of Housing and Urban Development. Office of International Affairs. Urban Development in Iran. Us Hud International Brief. 1971.

United States. National Bureau of Standards, R. A. CRIST, and L. E. CATTANEO. Earthquake Resistance Masonry Construction: National Workshop.

Vandenberg, Maritz. Cable Nets. Detail in Buildin. Chichester: Academy Editions, 1998.

Vegesack, Alexander von and Jochen Eisenbrand. Open House: Architecture and Technology for Intelligent Living. 1st ed. Weil am Rhein: Vitra Design Stiftung, 2006.

Vellinga, Marcel, Paul Oliver, and Alexander Bridge. Atlas of Vernacular Architecture of the World. New York, NY: Routledge, 2007.

Vellinga, Marcel. Encyclopedia of Vernacular Architecture of the World. Cambridge; New York: Cambridge University Press, 1997.

Vyzoviti, Sophia. Supersurfaces: Folding as a Method of Generating Forms for Architecture, Products and Fashion. Corte Madera, Calif.: Gingko Press, 2006.

Wakabayashi, Minoru. Design of Earthquake-Resistant Buildings. New York: McGraw-Hill, 1986.

Watson, Georgia Butina and Ian Bentley. Identity by Design. Oxford; Burlington, MA: Architectural, 2007.

Wojciechowska, Paulina. Building with Earth: A Guide to Flexible-Form Earthbag Construction. Real Goods Solar Living Book. White River Junction, VT: Chelsea Green Pub. Co., 2001.

Woods, Charles G. Natural Architecture: 40 Earth Sheltered House Designs. Rev. Ed ed. New York; Toronto: Van Nostrand Reinhold Co, 1984.

Wright, Frank Lloyd, Iovanna Lloyd Wright, and Patricia Coyle Nicholson. Architecture: Man in Possession of His Earth. 1st ed. Garden City, N.Y.: Doubleday, 1962.

Yeagley, David. "Providence in Iran?" Journal Weblog, 28 December, 2003.

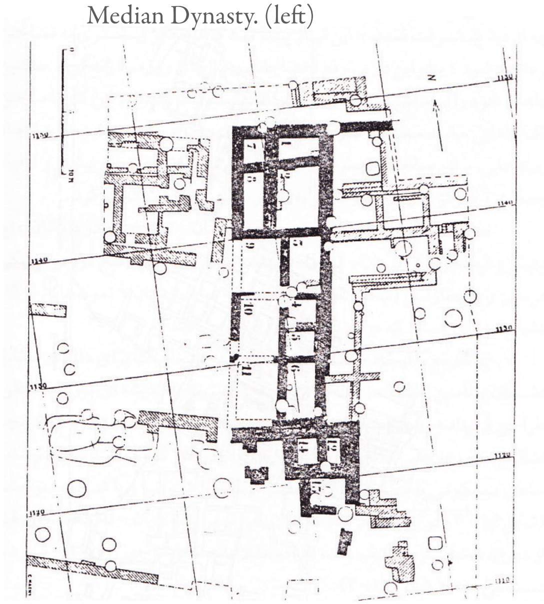
Appendix

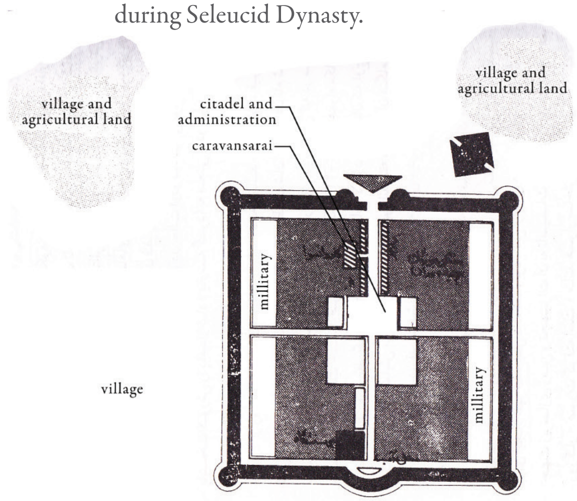
Appendix. A.1. Historical Maps of Bam

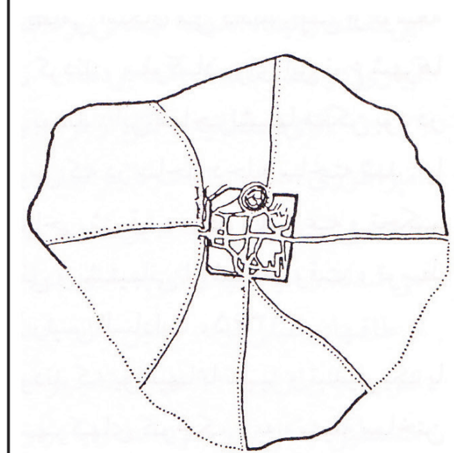
FIG.A.01. Worker's Town: One of the first Persian urban centers during Median Dynasty. (left)

FIG.A.02. Typical Persian city during Achaemenian Dynasty. (center)

FIG.A.03. City of Merv, a typical city during Seleucid Dynasty.







Worker's Town	Typical Persian city	City of Marv- Seleucids
- First Persian urban centers	- These cities were mostly based on the emperor's decisions and did not consider environmental factors.	- Hypodam Cities: two major routes of north-south and east-west with minor streets parallel to major streets
Median 728-550 BCE	Achaemenian 559-330 BCE	Alexander and the Seleucids 330-247 BCE

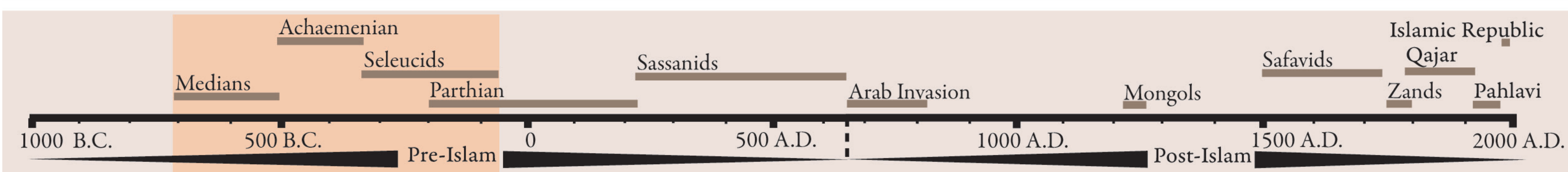
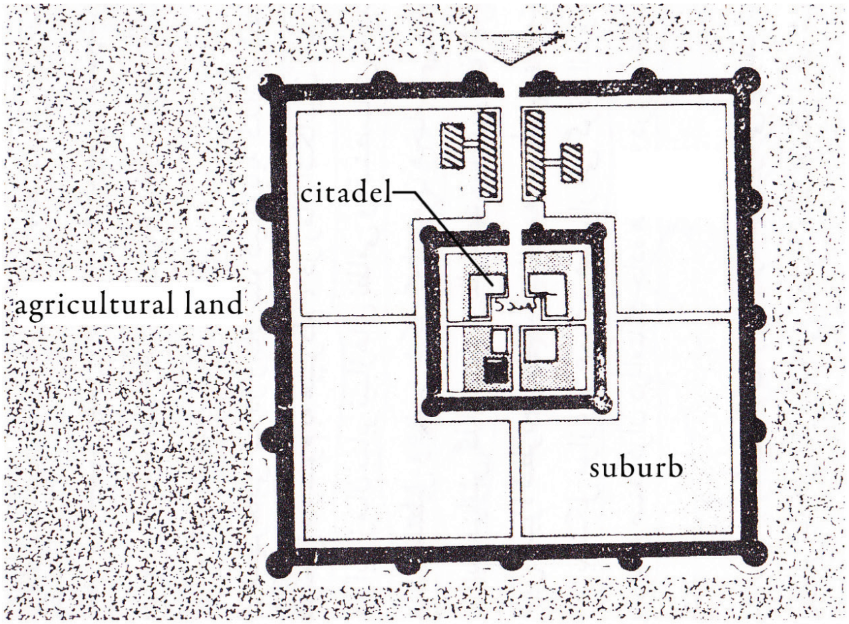
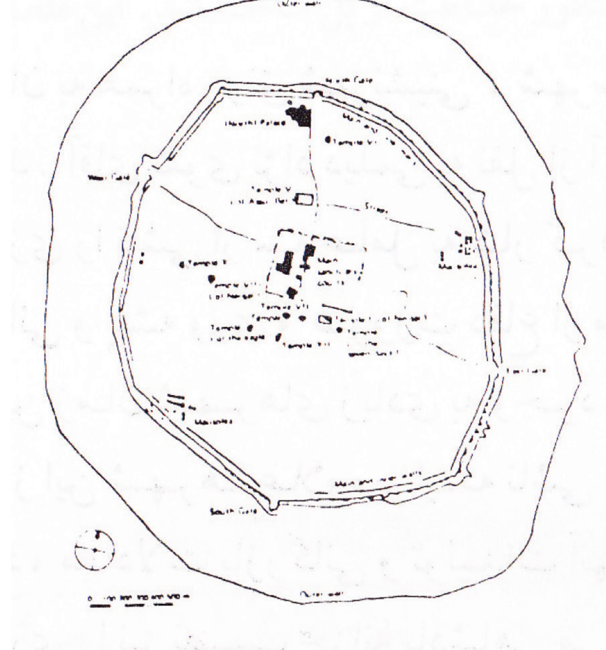


FIG.A.04. Typical Persian city during Seleucid and Aracid Dynasty



Typical Persian city during Seleucids and Arsacids

FIG.A.05. City of Hetra



Ciy of Hetra, 2nd century A.D., Arsacid Dynasty

- continuation of Hypodam cities. More rectangular and square shaped cities due to - economical and millitary reasons. Bazars located along major routes that continue to city gates.
- some circular cities. Circular cities shows lack of political stability.
- from middle of city to the perimeter: citadel, governmental centers, residential areas, agricultural districts

Parthian (Arsacid)
247 BCE o 224 CE

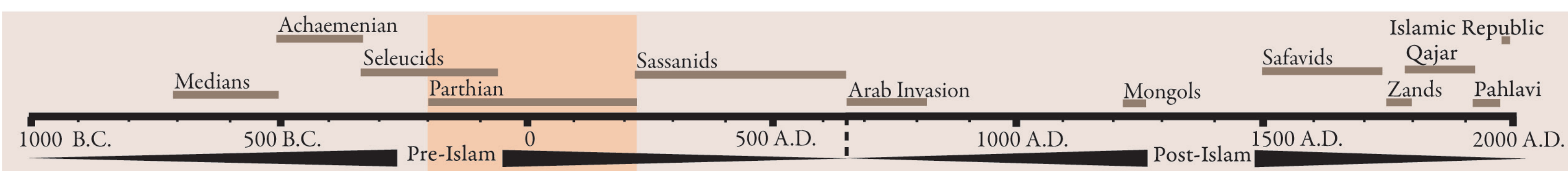
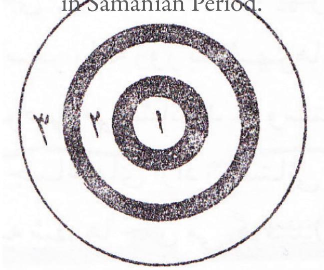
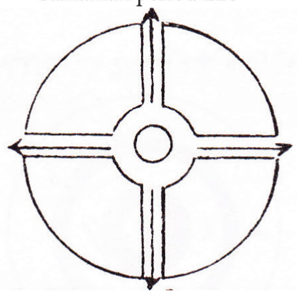


FIG.A.06. Cities were designed in three divisions and based on cardinal axes in Samanian Period.

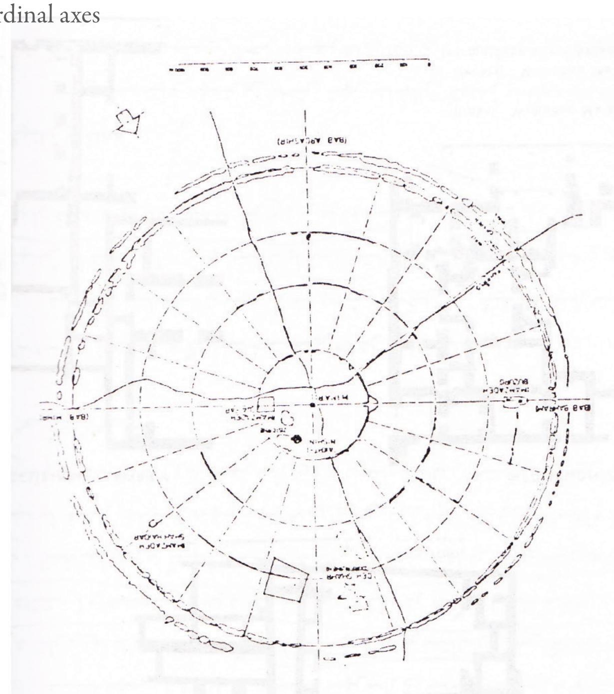


three-division city of Samanian period 226



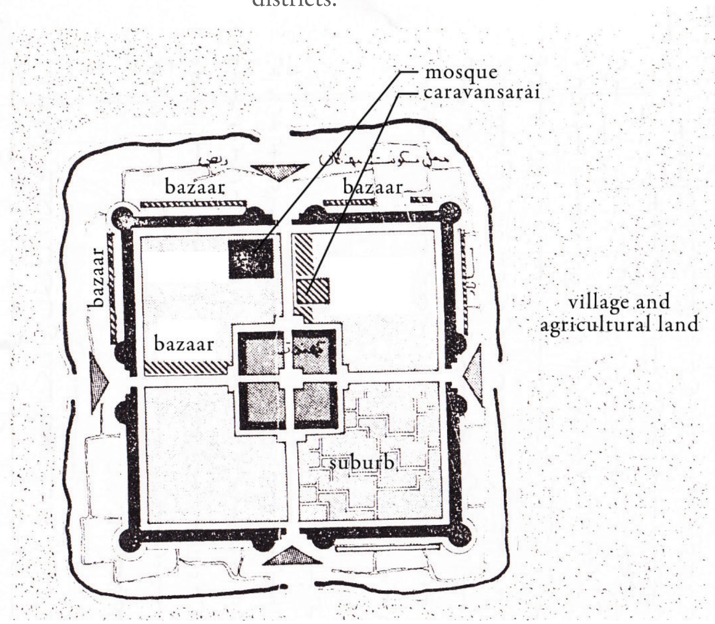
Sasanian city based on cardinal axes

FIG.A.07. Firouzabad, a circular city.



Firouzabad, 219

FIG.A.08. A typical Sasani city based on cardinal axes, citadel, bazar, caravansarai, and residential districts.



Typical Persian city during Sasanians, 224

- planned urban fabric
- rectangular, square, or circular shaped cities
- three divisions in the city: Citadel, City, Sunurbs.
- location of city gates and major routes along cardinal directions.

Sasanids
224-651

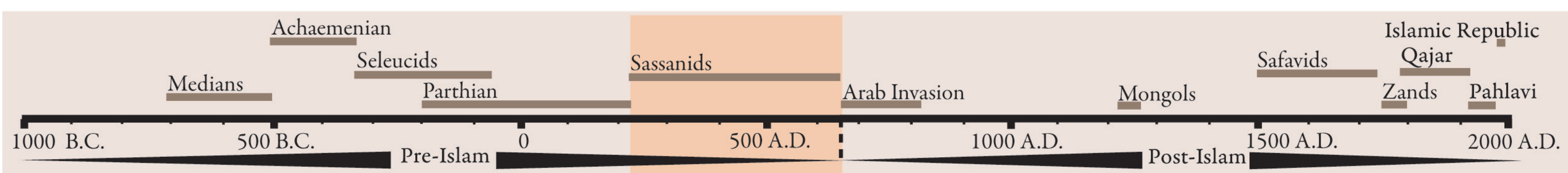
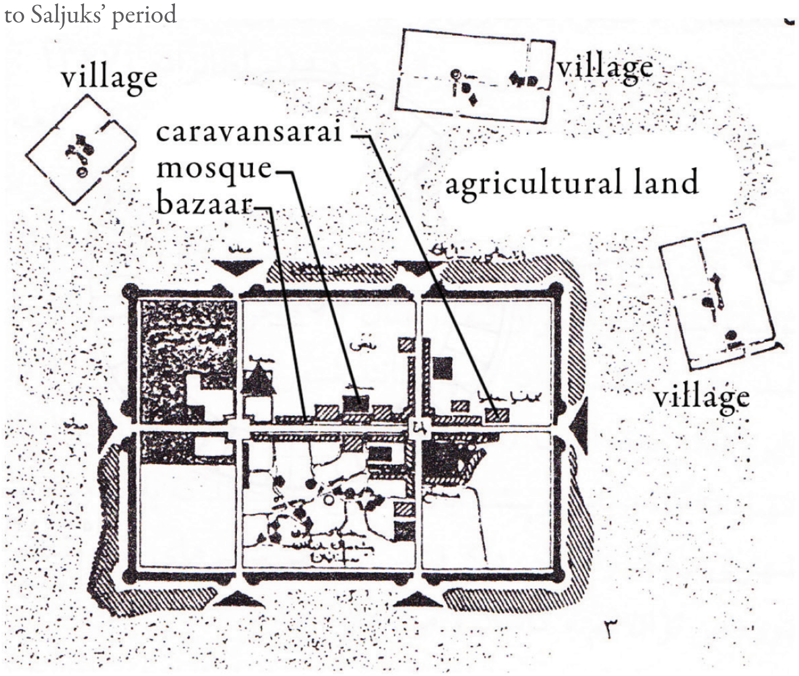


FIG.A.09. Typical Iranian City from
Al-buyeh to Saljuks' period



Typical Iranian city during Al-buyeh,
Samanian, and Saljuks. 234

- new urban plan as a result of combination of Islamic culture and existing Sasani urban plan. - three main elements of these cities, bazar, citadel, and mosque, along with other urban elements such as water basins an schools created typical Iranian-Islamic cities. - cities got more compacted -gradual city growth over time due to political stability, economical growth, and finantial improvements. - as cities became stable, attention was spent on architectural detailing	- many cities were destroyed by Mongols, many of which were never revitalized.
Arab invasion and the advent of Islam 640-829	Mongols 1220- 1335

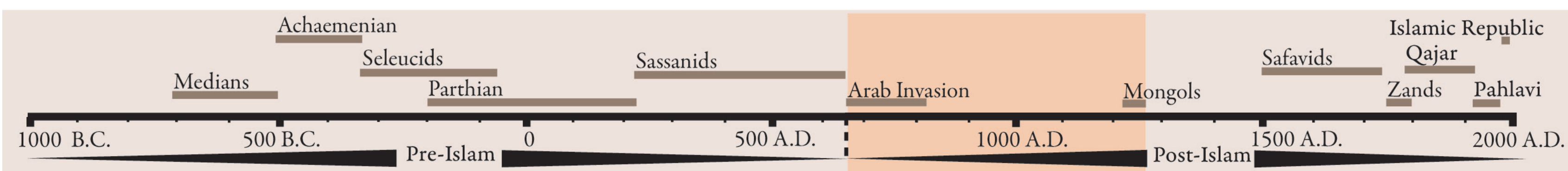


FIG.A.10. Typical Iranian City during Safavid's period

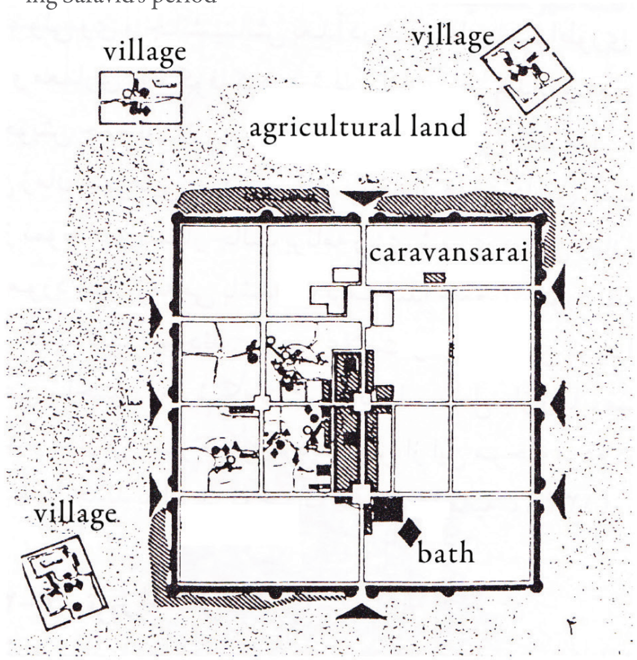
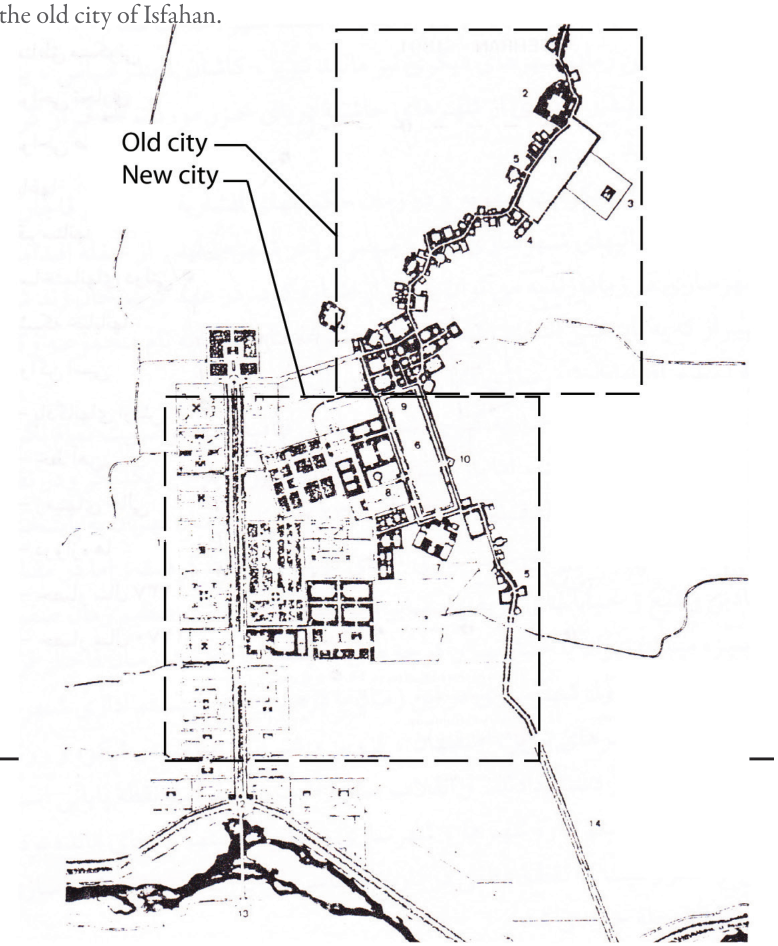


FIG.A.11. Modern city of Isfahan built next to the old city of Isfahan.



Typical Iranian city during Safavid's period.

The new city of Isfahan built during Safavid's period next to the old city of Isfahan. 241

- art, architecture, and urban planning was at its peak during Safavid's dynasty. most beautiful bazars, caravansarais, streets, and urban centers of the Persian Islamic world was built during this period.
- capital: Isfahan
- bazar as the spine of the city with its financial and economical attractions
- city square, mosque, and bazar working together as the urban center

Safavids
1502-1736

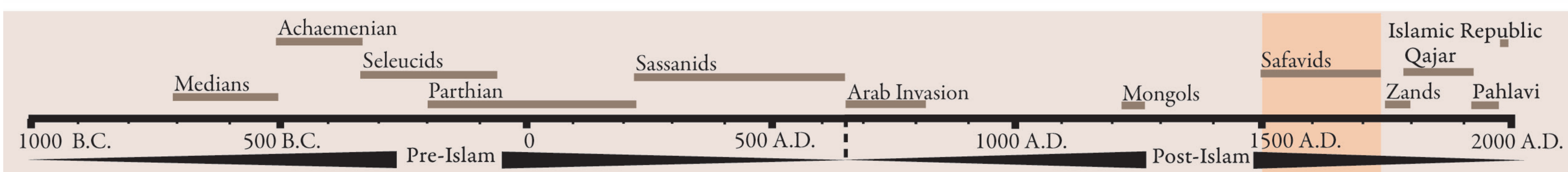
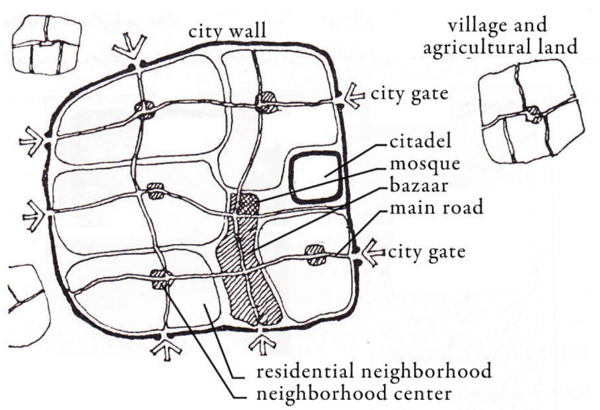


FIG.A.12. Typical Iranian Feudal city



Typical Iranian feudal city

- no significant change in urban planning - capital: Shiraz	- capital: Tehran - decline of urban planning - new stage in urban planning as Constitutional Revolution started a new stage in politics. - less gap between city and suburbs due to economical and financial growth. - feudal cities were shaped with four centers of the city: 1) city with rich residences, 2) school, mosque, and religious centers, 3) bazar, caravansarai, and financial centers, 4) bazar alleys with smaller businesses
Zand 1750-1779	Qajars 1794-1925

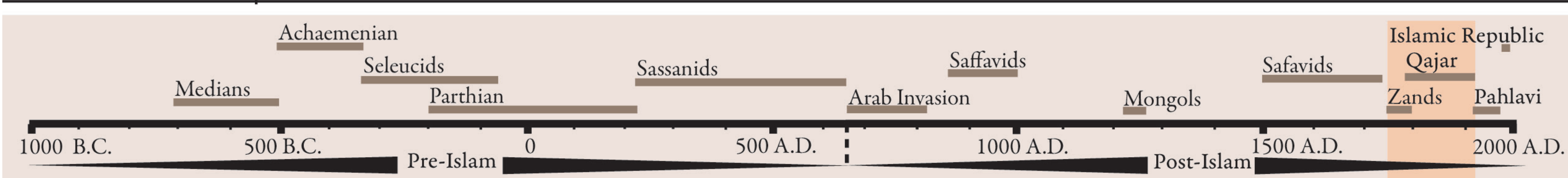


FIG.A.13. Juxtaposition of modern urban plan on traditional urban plan of Qazvin

New streets of Qazvin extend to the old district of Qazvin

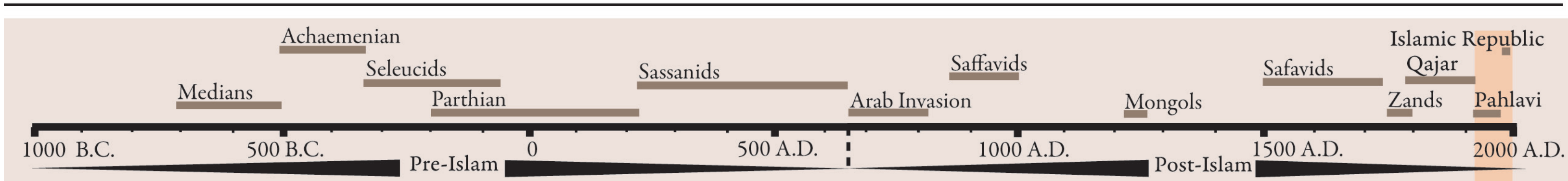
FIG.A.14. Juxtaposition of modern urban plan on traditional urban plan of Kerman

New streets tearing up the old fabric of Kerman

- modern urban plan with wide, vehicle friendly streets and grid pattern layouts were introduced
- modern urban plan was used to build new cities, as well as to revise older urban plans.

Pahlavi
1925-1979

Islamic Republic
1979-present



Appendix. A.2. Author's Published Articles

FIG.A.15. Shahrvand Newspaper article Current Conditions of Bam.

40 | شهروند | بیست و پنج آذر ۱۳۸۹ . شماره ۱۳۱۲

امروز در بم چه می‌گذرد؟

سارا خاکباز

هفت سال از زلزله مرگبار بم می‌گذرد. در این هفت سال بر بم چه گذشته است؟ کودکانی که والدین، اقوام و دوستانشان را از دست داده اند امروز چه می کنند؟ مردمانی که خانه‌هایشان ویران گردید، امروز کجا زندگی می کنند؟ نخل‌هایی که در اثر ویران شدن قنات‌ها خشکیدند، آیا دوباره قد کشیده اند؟ اینها سئوالاتی بودند که هر سال، روز سالگرد زلزله ی بم از خود می‌پرسیدم تا اینکه دو سال پیش برای اولین بار به دیدن بم رفتم. از تورنتو به قصد دیدن بم به تهران، و سپس به بم رفتم. جالب است که سالیان سال راجع به بم، زیبایی، و آثار تاریخیش شنیده بودم، اما فقط وقتی به دیدارش رفتم که همه چیز در آن ویران شده بود.

وقتی به بم رسیدم، همه چیز با آنچه در عکسها می دیدم فرق داشت؛ ارگ زیبا و پر ابهتی که در کتابها دیده بودم، چند تپه خاک بیش نبود. مدارس و مسجدها که حمایت دولتی داشتند، و برخی مراکز عمومی مثل استادیوم های ورزشی که حمایت شرکت‌های خارجی را همراه داشتند بازسازی شده بودند. آنچه از همه بیشتر توجه مرا جلب کرد مردمی بودند که پنج سال پس از زلزله هنوز در چادر و کانکس (جعبه‌های فلزی) زندگی می کردند.

در سفرم به بم با گروه زیادی از مردم شهر آشنا شدم، اما گروهی که بیش از همه بر من تاثیر گذاشت، انجمنی بود به نام انجمن نیکوکاری راه آورد مهر و دانش. این انجمن به دست یک زوج جوان به نام‌های علی و سارا شروع به کار کرده بود و سرپرستی کودکان بی سرپرست را بر عهده داشت.

علی و سارا پیش از زلزله ساکن تهران بودند و پس از وقوع زلزله برای تهیه فیلمی مستند به بم رفتند. آنها مثل تمام کمک رسانان دیگر پس از رسیدن به شهر در چادر مستقر شدند. گویی آنها هم انتظار دیدن چنین شرایطی را نداشتند. مردم بی گناهی که زیر آوار جلو چشمانشان جان می دادند، مجروحانی که امیدی برای زنده ماندنشان نبود، و باید با درد در انتظار مرگ رها می شدند، و کودکان بی سرپرستی که والدین خود را از دست داده بودند و خطر ربوده شدنشان بسیار بود. علی و سارا آنچه از دستشان بر می‌آمد انجام دادند؛ ساختن فیلم را کنار گذشته و به رسیدگی به بازماندگان زلزله پرداختند. آنها کودکان بی سرپرست را به چادر خود می‌آوردند و زیر پوشش و سرپرستی خود قرار می دادند، تا شاید اقوام و خویشاوندان آنها را پیدا کنند. کم کم خبر نگهداری علی و سارا از کودکان بی سرپرست در بم پیچید، و کودکانی که والدین خود را از دست داده بودند

با پای خود به چادر آنها می‌آمدند. سارا و علی پوشش خود را از یک چادر به شش چادر گسترش دادند، اما تعداد کودکان محتاج به کمک بیش از این بود. تعداد کودکان کم کم به ۳۰۰ نفر رسیده بود، و نگهداری از اینهمه کودک در آن شرایط ناممکن بود. سارا و علی مجبور به عدم پذیرش تعداد زیادی از این کودکان شدند. کودکانی که اقوامی برای سرپرستی داشتند، به خویشاوندانشان محوّل گشتند، و حدود سی کودک تحت سرپرستی علی و سارا قرار گرفتند. علی و سارا موفق به اجاره شش عدد کانکس شدند که در آن‌ها به نگهداری کودکان بپردازند. حدود دو سال پس از زلزله، گروه دیگری از خیرین به همکاری با علی و سارا مشغول شدند، که این همکاری متأسفانه موفق آمیز نبود. سارا و علی نگهداری بچه‌ها را به گروه جدید محوّل کردند و راهی تهران شدند تا سارا به ادامه تحصیل برای فوق لیسانس، و علی به فیلم سازی بپردازد.

بیش از دو ماه از بازگشت سارا و علی به تهران نگذشته بود که این زوج جوان متوجه شدند که جای خالی بچه‌ها در زندگیشان در تهران پر شدنی نیست، و تاثیر بچه‌ها در زندگیشان بیش از آن بوده که بتوانند آنها را ترک کنند و به زندگی معمولشان در تهران ادامه دهند. علی و سارا دوباره بار سفر به بم را بستند، اما این بار برای بازگشت به زندگی بچه‌ها در بم برای همیشه، راهی که زندگیشان را برای همیشه تغییر می داد.

زمانی که من به بم سفر کردم، سارا و علی در یک خانه چهار خوابه اجاره‌ای از ۱۱۲ کودک نگهداری می کردند. این کودکان اکثرا بازماندگان زلزله بودند، اما چند نفری هم به دلیل اعتیاد یا بی صلاحیتی والدین پذیرفته شده بودند. سن کودکان از کودک یکی دو ساله تا نوجوانان سن دبیرستان بود، و همه همراه سارا و علی با نظم و انضباط در این خانه کوچک چهار خوابه زندگی می کردند.

انجمن نیکوکاری راه آورد مهر و دانش هیچ وابستگی دولتی یا مذهبی ندارد، و تنها هدفش ایجاد محیطی فرهنگی برای تربیت و آموزش کودکان بی سرپرست می‌باشد. طی هفت سال گذشته این مجموعه بدون هیچ کمک دولتی، و فقط به کمک و همیاری خیرین موفق به نگهداری، آموزش، و تربیت صدها کودک بی سرپرست بوده است. هدف این انجمن گسترش خدمات فرهنگی و آموزشی به کودکان است.

در حال حاضر سارا و علی درصدد انتقال کودکان به محلی بزرگتر با امکانات بیشتر هستند، که فقط با کمک خیرین امکان پذیر می‌باشد.

برای اطلاعات بیشتر در مورد این مجموعه با ای میل زیر تماس حاصل فرمایید.

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FIG.A.16. Shahrvand Newspaper article Earthquake Hazard Threatens Tehran.

زلزله تهران را تهدید میکند!

سارا خاکباز

هفت سال از سانحه مرگبار زلزله ی بم می‌گذرد. روزی که زلزله ی بم اتفاق افتاد، نه فقط ما ایرانیان، بلکه تمام دنیا متاثر شد: برای چهل هزار انسان بیگناه که زیر آوار هزاران سال خاطره جان خود را از دست دادند، برای ارگ ۲۵۰۰ ساله ی بم که بزرگترین ساختمان خشت و گلی جهان بود، و برای از بین رفتن سالها خاطره و میراث ملی. طی چند ماه پس از وقوع زمین لرزه از سرتاسر دنیا کمک‌های فراوان نقدی و غیر نقدی روانه بم شد. این که چه مقدار از این کمک‌ها به دست بازماندگان زلزله رسید، خارج از بحث این مقاله است. اما مسلم این است که خیلی زود پس از زلزله، دنیا بم و باز ماندگان زلزله را فراموش کرد.

اگر زلزله اتفاقی بود که هر از چند گاهی اتفاق می‌افتاد، و میزان تلفات زیادی در بر نداشت، شاید فراموش کردن اینهمه قربانی کار راحت تری بود، اما متاسفانه آمار، ارقام هولناکی را در بر دارد. سالیانه ۳.۳ میلیون نفر جان خود را بر اثر سوانح طبیعی از دست می دهند و بیشترین تعداد قربانیان در اثر سیل و زلزله کشته می شوند. آمار نشان می دهد که بیشترین تعداد تلفات در کشورهای در حال توسعه است، و این به دلیل عدم آمادگی در مقابل سوانح طبیعی و سست بودن ساختمان‌ها است. فقط در ماه گذشته، از ۲۳ اکتبر ۲۰۱۰ تا ۲۱ نوامبر ۲۰۱۰، تعداد ۹۷۰ زلزله در ایران اتفاق افتاده است. در ماه‌های قبل از آن، از ۲۳ سپتامبر تا ۲۲ اکتبر، تعداد ۹۴۰ زمین لرزه، و در ماه‌های پیش از آن به ترتیب ۱۱۰۰، ۸۴۰، و ۸۲۰ زمین لرزه در هر ماه اتفاق افتاده است. بسیاری از این زلزله‌ها کوچک و نامحسوس هستند، اما احتمال اتفاق زلزله‌های بزرگ و مخّرب هم بسیار زیاد است.

چهار روز قبل از زلزله بم، در روز ۲۲ دسامبر ۲۰۰۳، زلزله‌ای شهر سن سیمئون کالیفرنیا را لرزاند. هر دو زلزله ی بم و زلزله سیمئون، ۶.۶ ریشتر و با عمق ۵ مایلی بودند. این دو زلزله بسیار شبیه هم بودند، اما خسارات و تلفات آن دو بسیار متفاوت بودند. در زلزله سن سیمئون، فقط ۲ نفر کشته شدند و ۴۰ ساختمان ویران شد. در حالی که زلزله بم ۴۰هزار قربانی داشت، بیش از ۸۰ درصد ساختمان‌های این شهر ویران، و بیش از ۱۰۰هزار نفر بیخانمان شدند. این تفاوت به دلیل ساختمان سازی متفاوت در این دو شهر بود. ساختمان‌های سن سیمئون کالیفرنیا با محاسبات مقاومت در برابر زلزله ساخته شده بودند، در حالی که ساختمان‌های قدیمی بم از خشت و گل و بدون محاسبات مقاومت ساخته شده بودند.

وقوع زلزله بم در سال ۲۰۰۳ همه را به فکر واداشت. سئوالی که ذهن همه را مشغول کرده بود این بود که اگر زمین لرزه تهران را بلرزاند چه خواهد شد؟ متاسفانه تحقیقات زمین شناسی در مورد تهران پیشگویی خوش آیندی ندارد. شهر تهران بر روی چند گسل اصلی قرار دارد. این شهر از شمال بر روی دو گسل موشا و تهران قرار دارد، و از جنوب بر روی گسل ری. شهر تهران یکی از ۵ زلزله ی بزرگ آتی در دنیا پیش بینی شده است. این شهر با جمعیت بیش از ۱۳ میلیون نفر، قربانیان بسیاری به همراه خواهد داشت. احتمال این زلزله آنچنان زیاد، و تخریبات حاصل از این زلزله آنچنان جبران ناپذیر است که طرح تغییر پایتخت از تهران به یکی از شهرستانها چند بار ارائه شده است. متاسفانه به دلیل هزینه بالای ۳۰۰ میلیارد دلاری این پروژه مورد قبول قرار نگرفت و پایتخت ایران، همچنان مورد تهدید زمین لرزه‌ای هولناک قرار دارد. در ازای منتقل نکردن پایتخت از تهران، پروژه ی استقامت بخشی به ساختمان‌ها ارائه شد که با هزینه ی ۷۵ میلیارد دلار، بسیار ارزانتر از هزینه انتقال پایتخت بود. در سال ۱۹۸۶، کد ساختمان سازی در تهران، استقامت ساختمان‌ها برای زمین لرزه ۷ ریشتری را الزامی نمود. گرچه قوانین ساخت و ساز، ضدّ زلزله بودن ساختمان‌ها را الزامی کرده، اما متاسفانه به دلیل عدم بررسی و نظارت، بسیاری از ساختمان‌ها بدون استقامت لازم ساخته می شوند. اکثر ساختمان‌های بلند مرتبه تهران در شمال شهر واقع شده اند، یعنی درست بر روی دو گسل موشا و تهران، جایی که در صورت وقوع زلزله بیش از همه مورد تخریب قرار خواهد گرفت.

اکثر ساختمان‌های بلند مرتبه تهران در شمال شهر واقع شده اند، جایی که در صورت وقوع زلزله بیش از همه مورد تخریب قرار خواهد گرفت.

زمین لرزه پیش بینی شده در تهران، شبیه زلزله بم، و در حدود شش و نیم ریشتر می‌باشد. در صورت وقوع زلزله، به دلیل فشردگی و پر جمعیت بودن شهر، دسترسی امداد به آسیب دیدگان بسیار دشوار و یا حتی ناممکن خواهد بود. با وجود گاز لوله کشی در زیر شهر، خطر آتش سوزی بسیار بزرگی هم در صورت وقوع زلزله شهر تهران را تهدید می کند. تصویر شهری با جمعیت بیش از ۱۳ میلیون نفر، با خیابان‌های باریک و ساختمان‌های بلند مرتبه، پس از زمین لرزه‌ای که همراه با آتش سوزی، میلیون‌ها کشته، زخمی، و ویرانی به بار می‌آورد بسیار ناهنجار است. این که شهری که تصور می‌کنیم، روزی خانه ی من و شما بوده، و امروز اقوام، بستگان، و دوستان ما در آن زندگی میکنند، این تصویر را هزاران بار هولناکتر می‌کند.

دو سال پیش، وقتی تحقیقاتم را در مورد تهران شروع کردم، در صدد راه حلی برای این شهر بودم، اما متأسفانه به این نتیجه رسیدم که مشکل بزرگتر از این است که به دست یک یا چند نفر حل شود. تهران تنها شهری نیست که ساختمان‌های قدیمی آن مورد تهدید تخریب در اثر زمین لرزه هستند. صدها و یا شاید هزاران شهر دیگر در کشورهای در حال توسعه در همین شرایط وجود دارد. نجات کامل یک شهر از دست ساختمان های شکننده در زلزله از ما بر نمی آید، اما اطلاع رسانی در مورد خطری که این شهر را تهدید می‌کند، آموزش کمک‌های اولیه، آموزش اینکه در صورت وقوع زلزله چه باید کرد و به کجا پناه برد، کارهای کوچکی هستند که از ما بر می‌آید و زندگی بسیاری را نجات می دهد.

یکی از بزرگترین تفاوتها بین ایران و کشورهای پیشرفته زلزله خیز همچون ژاپن و آمریکا سیستم آموزش و اطلاع رسانی در مورد زمین لرزه است. در کشورهای پیش رفته خطر وقوع زمین لرزه آشکار است، و همه برای مقابله با آن آماده هستند. در مدارس به دانش آموزان آموخته می شود که در صورت وقوع زمین لرزه به کجا پناه برند، و اگر با مصدومی برخورد کردند چه کمکی از آنها برمی آید. متاسفانه در ایران هیچ آموزشی برای مقابله با سوانح ناشی از زلزله داده نمی‌شود، گویا که این خطر اصلا ایران را تهدید نمی کند، غافل از این که ایران یکی از زلزله خیزترین کشورهای جهان است.

باید از گذشته درس بگیریم. ۴۰هزار قربانی بم، ۱۲هزار قربانی بوئین زهرا، ۱۵هزار قربانی طبس، ۴۵هزار قربانی رودبار و منجیل، و هزاران هزار قربانی دیگر کافی نیستند تا به ما درسی بیاموزند؟ چرا کشورهای پیشرفته که بسی زلزله خیزتر از ایران هستند، تلفات ناچیزی در مقابل زلزله دارند؟ درست است که دلیل اصلی ضعف ساختمان سازی است، اما حتی آن هم ریشه ی فرهنگی دارد. در تهران سالهاست که طرح ضدّ زلزله بودن ساختمان‌ها اجباریست، اما شواهد نشان میدهد که اکثر ساختمان‌ها واقعا طبق محاسبات انجام شده ساخت نمی شوند. کسانی که این ساختمان‌ها را می سازند هم افرادی هستند همچون من و شما؛ آنها هم همشهری تهرانی ما هستند، و همچون من و شما اقوام و دوستانی ساکن تهران دارند. پس چرا در ساخت ساختمان‌ها آنقدر سهل انگاری می کنند؟ یکی از دلایل این است که آنها هم عمق این فاجعه را نمی دانند. اگر می دانستند چه خطر بزرگی در انتظار تهران است، و چه مسئولیت سنگینی بر دوش هر یک از این ساختمان هاست، شاید بسی بیشتر تأمل و دقت می کردند.

باید از ریشه به حل این مساله پرداخت؛ باید جامعه را برای مقابله با وقوع زلزله آگاه و آماده کرد. حل مساله زلزله، همچون بسیار مسائل دیگر ایران، یک روزه میسّر نیست، اما اگر هر کدام از ما گوشه‌ای از این مسئولیت را متقبل شویم و در حد امکان خود اطلاع رسانی و کمک رسانی کنیم، به مرور زمان جامعه‌ای آگاهتر خواهیم داشت که در حل مسائل بسیار موفقتر خواهند بود. دوستان و آشنایان خود را در تهران و در دیگر مناطق زلزله خیز ایران از خطر زلزله آگاه کنید. در صورت آگاهی و آمادگی برای وقوع زلزله، صدمات و تلفات بسیار کمتر خواهد بود.

برای دریافت اطلاعات بیشتر در این موضوع با ای میل bamschildren@gmail.com تماس بگیرید.

* سارا خاکباز، متولد تهران، در سن ۱۴ سالگی به تورنتو کانادا مهاجرت و تحصیلات لیسانس و فوق لیسانس خود را در رشته معماری در دانشگاه واترلو کانادا به اتمام رساند، و مدرک طراحی ساختمان‌های کم مصرف را از انجمن ساختمان سبز کانادا دریافت کرده است.

سالروز زلزله بم از تقویم رسمی ایران حذف شد!

سارا خاکباز

هفته پیش به مناسبت سالروز زلزله بم، مقاله‌ای در مورد خطر وقوع زلزله در سایر نقاط ایران از جمله تهران، و اهمیت اطلاع رسانی و فعالیت‌های آموزشی در مورد زلزله در شهروند نوشتم. این مقاله دو گروه خواننده داشت: گروه اول خوانندگانی بودند که از خطر وقوع زلزله مطّلع بودند، ولی از هراس عمق فاجعه درصدد فراموش کردن آن بودند. آنان عقیده داشتند که مشکل بزرگتر از آن است که ما درصدد حل آن برآییم، و وقتی‌که زلزله شهر را لرزاند با این مساله برخورد خواهیم کرد. گروه دوم کسانی بودند که اعتقاد داشتند هر کس به نوبه خود مسئول کمک رسانی است، و تا حد ممکن باید از وقوع حادثه پیشگیری کرد. از این که چند نفری از گروه دوم را پیدا کرده بودم، بسیار خوشحال بودم، تا این که خبر اسفناکی را شنیدم: سالروز زلزله بم از تقویم رسمی‌ایران حذف شد! پس از فاجعه بم، پنجم دی ماه، به عنوان روز ملی ایمنی در برابر زلزله در تقویم رسمی کشور نامگذاری و ثبت شده بود، تا اینکه در پنجم مهرماه امسال این روز در کنار روزهایی مثل روز گل و گیاه و روز گفت وگوی تمدن ها به تصمیم شورای فرهنگ عمومی از تقویم رسمی کشور حذف شد.

ثبت سالروز زلزله بم به عنوان روز ملی ایمنی در برابر زلزله در تقویم ایران قدم بسیار مفیدی برای یادآوری خطر زلزله و پیش گیری‌های لازم برای گریز از سوانح طبیعی بود. هر ساله به مناسبت این روز ملی سمینارهای علمی، فعالیت های آموزشی، و بحث های تخصصی و علمی در خصوص زلزله در گوشه و کنار ایران ، و همچنین در خارج از کشور شکل می‌گرفت. متخصصان و مسئولان یادآور فاجعه زلزله بم می شدند، و درصدد پیشگیری از وقوع دوباره چنین سوانحی بر می‌آمدند. نتیجه این انجمن ها توجه ویژه به آیین نامه های مربوط به ایمنی و استانداردسازی ساختمان ها و تقویت زیرساخت ها بود. ساختمان‌های سست بزرگ‌ترین عامل خسارت و کشتار در زلزله‌های ایران هستند، و مقاوم سازی آنان مهمترین پیشگیری از خسارت‌های وارده بر اثر زمین لرزه‌های آتی می‌باشد.روز ملی ایمنی در برابر زلزله بدون مشورت با کارشناسان و متخصصان امور زلزله و پژوهشگاه زلزله شناسی از تقویم رسمی حذف شد و موجب انتقادات بسیاری از جانب متخصصانی چون دکتر زمردیان، استاد پیشکسوت ژئوفیزیک و بهرام عکاشه، استاد زلزله شناسی شد. کارشناسان معتقد هستند که تصمیم شورای فرهنگ عمومی برای حذف روز ملی ایمنی در برابر زلزله از تقویم، برای کشور بسیار زیان آور خواهد بود، چرا که این روز یادآور تمام کشته شدگان و خسارات ناشی از زلزله بوده، و بازماندگان، متخصصان، و مسئولان را به فکر جلوگیری از خسارات ممکن آتی وا می داشت.

سالروزهای ملی در تمام کشورها یادآور وقایع مهم می باشند. در بسیاری کشورها سالروز سوانح طبیعی به عنوان روز ملی‌ثبت می شود تا هر ساله بانی تفکرات جدیدی برای پیشگیری از بلایای طبیعی باشند. کشور ژاپن روز اول سپتامبر را که سالروز زلزله کانتو بود و ۱۴۰هزار قربانی داشت، در سال ۱۹۶۰ به عنوان روز پیشگیری از حوادث ثبت کرد. کشور چین امسال دومین سالروز ملی پیشگیری حوادث را در روز ۱۲ می، سالروز زلزله سیشوان برگزار کرد. در ترکمنستان ۶ اکتبر، مصادف با زلزله سال ۱۹۴۸ عشق آباد، یک تعطیلی‌عمومی است. سازمان ملل متحد (UN)، در تاریخ ۲۲ دسامبر ۱۹۸۹، دومین چهارشنبه ماه اکتبر را روز بین المللی تقلیل سوانح طبیعی ثبت کرد، و هر ساله در این روز ملل و دولت‌ها را تشویق به همکاری برای ساختن جوامع آگاه تر در قبال حوادث طبیعی می‌کند.

در حالی‌که نود و پنج درصد خاک ایران در معرض خطر زلزله قرار دارد و هر ۷ سال در ایران انتظار یک زلزله بزرگ می رود، آگاه‌سازی و ارتقای فرهنگ عمومی در برابر زلزله برای کاهش تلفات و خسارات ناشی از آن بسیار مهم است. با حذف شدن سالروز زلزله بم از تقویم رسمی، طبیعتاً از کمک رسانه‌ها برای یادآوری این روز کاسته خواهد شد، اما این ما مردم هستیم که باید برای زنده نگه داشتن یاد قربانیان و پیشگیری از وقوع دوباره سوانح بکوشیم.

اگر شما جزو گروه دوم خوانندگان این مقاله هستید، و معتقدید که با اطلاع رسانی و آموزش صحیح می‌توان قدم‌های بهتری به سوی آینده برداشت، برای همفکری و همکاری با bamschildren@gmail.com تماس بگیرید.

قبل از زلزله

بعد از زلزله

FIG.A.17. Shahrvand Newspaper article Bam's Anniversary Removed from Iran's Official Calendar.

FIG.A.18. Shahrvand Newspaper article Earthquake Shook Bam once more on the Anniversary of the Earthquake.

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شانزدهم دی ۱۳۸۹ . شماره ۱۳۱۵

در سالگرد زمین لرزه بم
زلزله دوباره این شهر را لرزاند!

سارا خاکباز،
علی دیوسلا

شش روز پیش از سالگرد زلزله بم، در تاریخ ۲۰ دسامبر ۲۰۱۰، زمین لرزه ی ۶/۵ ریشتری شهرستان کرمان را دوباره لرزاند. مرکز این زمین لرزه در ۲۰ کیلومتری حسین آباد، و در ۱۰۰ کیلومتری بم بود. این زلزله ۱۱ کشته، بیش از ۱۰۰ زخمی، و خسارات بسیار در روستاهای چاه قنبر و ریگان بر جا گذشت. این زمین لرزه شهر بم را نیز لرزاند، اما خوشبختانه خسارتی به این شهر داغ دیده وارد نکرد. روستاهای آسیب دیده اکثرا روستاهای کم جمعیت بودند. به همین دلیل تعداد قربانیان نسبت به مقیاس زلزله بالا نیست، ولی‌به دلیل دشواری دسترسی‌به این روستاها، کمک رسانی به آسیب دیدگان در این مناطق بسیار دشوار است.
گزارش زیر، حاصل مشاهدات یک شاهد عینی، علی دیوسالار، ساعاتی چند پس از وقوع زلزله می‌باشد.

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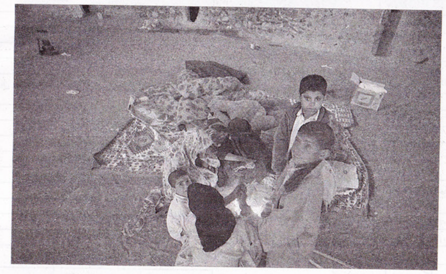
زلزله ای با قدرت ۶/۳ ریشتر، ساعت ۲۲ و ۱۲ دقیقه ۲۹ آذر، مناطقی از جنوب شرق ایران را لرزاند. دو شهرستان ریگان و فهرج در جنوب بم، مرکز این زلزله بودند. بیشترین آسیب به روستای چاه قنبر ریگان وارد شد. خانه ها ویران،۴ کودک کشته و تعداد زیادی دام تلف شدند. این گزارش به ۱۲ تا ۳۶ ساعت پس از وقوع زلزله مربوط می شود.

محسن مثل هر روز جلوی سیاه چادر می ایستد، به اطراف نگاه می کند و الهه را صدا می زند. از الهه خبری نیست. محسن بازی می کند و این بار بهزاد را صدا می زند. چشم به اطراف می چرخاند و ناامید می شود. به داخل سیاه چادر برمی گردد.کنار مادرش می نشیند و در کاسه فلزی ماست و برنج می خورد. سیر که شد با کاسه از سیاه چادر بیرون می آید و برنج مانده را برای مرغ ها و جوجه ها می ریزد. به اطراف نگاه می کند و زینب را صدا می کند. زینب را پیدا نمی کند. زینب جواب نمی دهد. محسن سه ساله پا برهنه در اطراف سیاه چادر و خانه های سنگی ویران شده به دنبال بزها می دود و هر چند وقت یکبار خواهرها و برادرش را صدا می کند و هر بار هیچ جوابی نمی شنود. زینب ۱۳ ساله، بهزاد۱۱ساله، و الهه۶ ساله هر سه در روستای چاه قنبر ریگان در ۱۵۰ کیلومتری بم، در خانه سنگی بر اثر زلزله جان خود را از دست دادند. پدر، مادر و بقیه خانواده در سیاه چادر استراحت می کردند. بچه ها پای تلویزیون در خانه سنگی نشسته بودند که زلزله شد و هر سه زیر سنگ های دیوار و سقف چوبی و گلی ماندند و از دنیا رفتند.
روستای عشایرنشین چاه قنبر ۱۰ خانوار سکنه دارد. دیوار خانه ها از سنگ کوه های اطراف ساخته شده و سقف آن ترکیبی از چوب و پیش(ساقه و برگ نخل) و گل است. دو سیاه چادر بزرگ و یکی دو پلاس هم کنار خانه ها بر پا شده است.
سیف الله سه فرزند خود را از دست داده است. پسرش در اهواز سرباز و بی خبر است و دختر جوانش که زخم برداشته در بیمارستان بستری است. سیف الله، محسن را روی زانوانش می نشاند و باهم نان و دوغ می خورند. او مثل بقیه ی اهالی روزی و رزقش را از دامداری و نگهداری بز و گوسفندان اهالی روستا به دست می آورد. خودش ۱۰ بز و گوسفند داشت و حالا نمی داند چند تا هستند. شب زلزله همه ی گوسفندان داخل آغل بزرگ بودند که سقف آغل پایین آمد و تلفات زیادی داشتند. اهالی روستا می گویند: "الان دو شب است که حیوانات ما در سرما هستند. باید فکری برای آغل ها کرد. آغل هم مثل خانه برای ما مهم است. حیوان ها این جوری تلف می شوند". زن ها داخل سیاه چادر نشسته اند. گاهی صدای مویه آنها به گوش می رسد. زن سیف الله هم کنار آنهاست. او این روزها نان نمی پزد، آشپزی نمی کند، به مرغ و خروس ها کاری ندارد و ظهرها منتظر بچه هایش نیست تا از مدرسه برگردند. گاهی محسن را در آغوش می گیرد و به نقطه ای دور خیره می شود.
از ریگان تا چاه قنبر، حدود ۵۰ کیلومتر است که با ماشین شاسی بلند و کمک دار حداقل یک ساعت و نیم راه است. جاده خاکی و پر دست انداز و مملو از سنگلاخ است. برای دسترسی به منطقه زلزله زده پس از حادثه با گریدر و بولدوزر توانسته اند وضعیت جاده را کمی بهتر کنند. در مسیر و کنار جاده یک کوه آتش فشان وجود دارد و جلوتر روستای زهسر است که خسارت و تلفات نداشته، اما مردم به شدت ترسیده و به چادرهای هلال احمر پناه آورده اند. روستای سیف الدینی و سرموتور در اطراف چاه قنبر هم خسارت دیده اند. اهالی آنجا از بستگان و آشنایان چاه قنبری ها هستند. تعدادی از آنها برای همدردی و تسلیت نزد سیف الله و خانواده اش آمده اند. آنها که برای پُرسه آمده بودند می گفتند که "باید به سیف الله چادر اضافه می دادند تا بتواند به مهمانهایش جا بدهد. باید خرما و غذای بیشتری در اختیار او می گذاشتند". سیف الله ساکت بود و نگاه می کرد. یک دختر دیگر هم از روستای مجاور در چاه قنبر در زیر آوار جان داده است. چون در روستایش مدرسه نبود، نزد فامیلش در چاه قنبر زندگی می کرد و به مدرسه می رفت. دبستان کوچک روستا که از سنگ و چوب و گل ساخته شده بود، فروریخته است. تخته سبز کلاس میان سنگ ها گیر افتاده و سقف روی میز و چند صندلی و نیمکت پایین آمده است.یک پوستر آموزش الفبا هم بیرون دبستان افتاده است. این دبستان کمتر از ۱۰ شاگرد دختر و پسر داشته است.



حالا هر خانواده یک چادر دارد، اما همچنان زیر سیاه چادر هستند. به آنها موکت، پتو، والور و نان و کنسرو لوبیا و ماهی داده اند. آنها به امدادرسانان می گفتند از کمک هایی که آوردید ممنون هستیم، اما کاش برایمان آرد می آوردید.

این منطقه تلفن ندارد و موبایل ها آنتن نمی دهند. شب حادثه، یکی از اهالی با موتور به ریگان می رود و همه را بعد از دو ساعت باخبر می کند. در اثر زلزله چند تیر برق در مسیر شکسته و باعث قطعی برق منطقه شده بود. در طول مسیر عده ای در حال تعمیر و بازسازی تیرها و سیم ها بودند. برق زهسر ۲۴ ساعت پس از زلزله وصل شد و تلاش برای برق رسانی به چاه قنبر ادامه داشت. آنجا آب لوله کشی ندارد، با تانکر برایشان آب می آورند. در چاه قنبر حمام نیست. مردها با آب سرد کنار تانکر خود را می شویند و زن ها نمی دانم کجا، اما بچه ها می گویند"ما ریگان که پیش فامیل مان می رویم، حمام دارند". آنها هر دو سه ماه یکبار به ریگان می روند. کودکان کنار خرابه ها و چادرها پرسه می زنند و نگاه می کنند. آنها از کودکی، چوپان های کوچکی هستند با فاصله زیاد از دوران و دنیای کودکی. در وسایل اهدایی و کمک شده، نشانی از شکلات یا بیسکویت و هیچ وسیله بازی و سرگرمی برای کودکان نبود.

آزمایشگاه سیار آب و فاضلاب به چاه قنبر آمده بود، اما از حضور پزشک و پرستار و حمایت های درمانی خبری نبود. بعد از امداد و نجات اولیه که تا ۱۲ ساعت طول کشید، خدمات درمانی تا ۲۴ ساعت بعد وجود نداشت. در این فاصله دو نفر، یکی برای چسب زخم و دیگری برای قرص سرماخوردگی مراجعه کردند، ولی کسی و چیزی نبود. از پزشکی قانونی برای تایید مرگ کودکان و ثبت آن آمده بودند. گروه امداد و نجات و جوانان هلال احمر در منطقه حاضر بود، اما از حضور واحد دامپزشکی با وجود بز و گوسفند های کشته شده و تعداد قابل توجه حیوانات اهلی زنده در محل، خبری نبود.

پسرهای کوچک به سئوال ها پاسخ می دهند، اما دخترهای کوچک صورت خود را پنهان می کنند و ساکت هستند، ولی لبخند می زنند. مردم خسارت دیده و مصیبت دیده ظاهری آرام داشتند، هیاهو و بلوا نمی کردند. قبلا آنقدر سختی کشیده بودند که انگار هیچ کدام این نداشتن ها و محرومیت ها و زخم ها تازگی نداشت. مردم چاه قنبر می گفتند خوب شد که شب داخل سیاه چادر بودیم و گرنه همه ی ما در خانه های سنگی از بین می رفتیم.
■

Appendix. A.3. Age-Gender ratio of Students at Rahavard Mehr Va Danesh Institute.

FIG.A.19. Change in age and gender of students over time requires the building to be able to users' changing requirements over time.

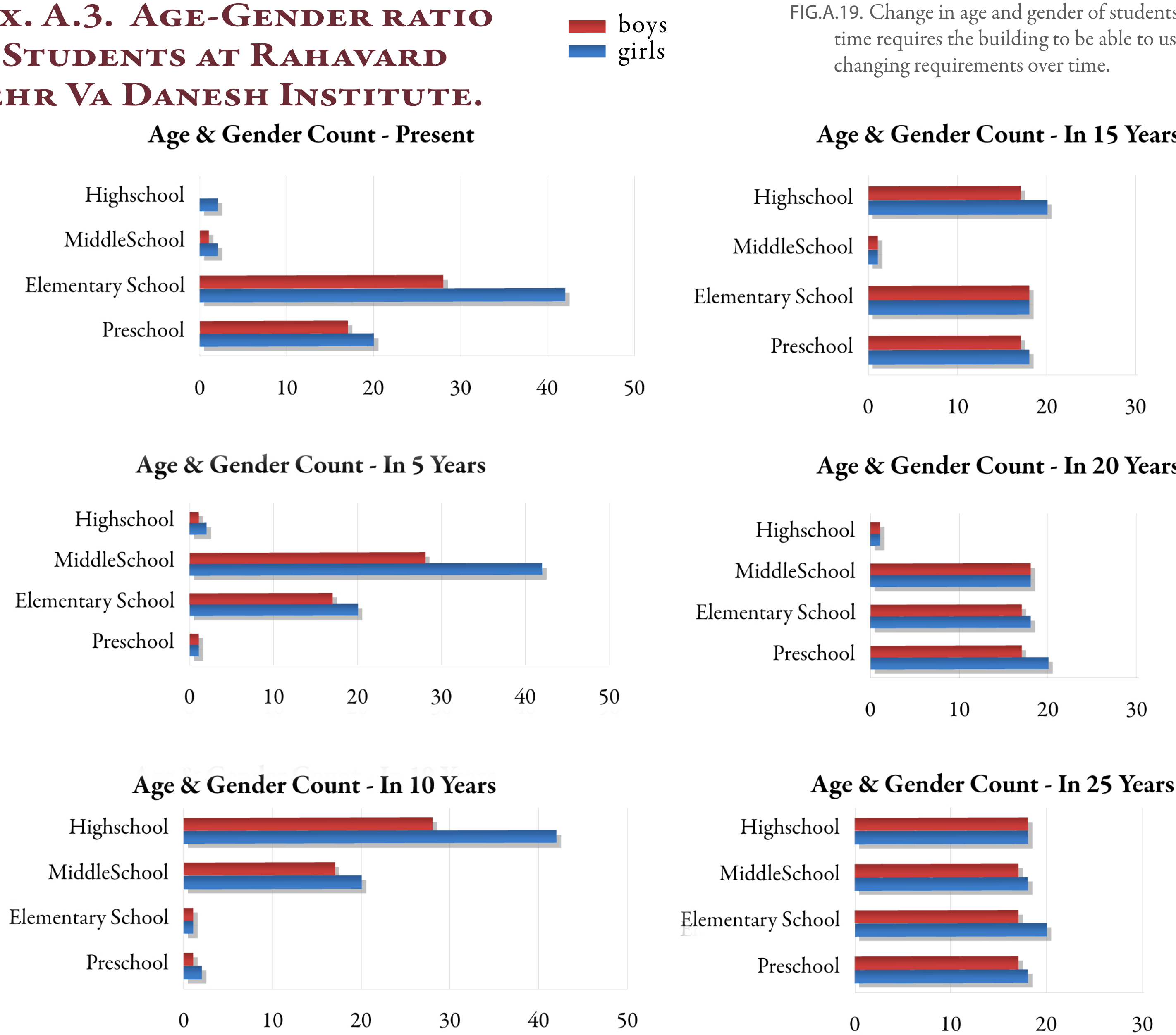


FIG.A.20. Change in parental condition of students over time requires the building to be able to users' changing requirements over time.