Learning from the Past: Case Study of Traditional Architecture of Southern Shores of Caspian Sea Region in Iran

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Abstract

Climate has a vital role in the design of buildings. Today we are facing some environmental problems such as global warming, Ozone layer depletion and shortage of fossil fuels which make it necessary to consider the effects of climate in the building design. Traditional architecture has always been a good example of climatic design and represents the techniques which our ancestors have found to improve their living conditions. In addition, traditional architecture can be a source of inspiration in the contemporary building design to learn from it and try to adapt modern buildings with the natural environment as far as possible. In this paper traditional architecture of southern shores of Caspian Sea region in Iran is explored to find the role of climate in the formation of the buildings. Also Mahoney tables which provide design recommendations on the building design are used to compare with the design techniques in traditional architecture of this region.

Key words: traditional architecture, climate responsive design, design guidelines, Caspian Sea, Iran.

Introduction

Climate and environmental factors have been one of the most important parameters in the designing process of buildings, amongst other factors such as sociocultural, economic, or religious, the availability of materials, technical and other resources. In the schematic reconstruction of a part of Çatal Hüyük (located in Anatoly, 5900-6000 BC) climatic consideration can be seen. The compact form of the buildings for the minimum exposure to the sunlight and also for mutual sheltering, and small openings near the roof to provide diffuse light are some of passive techniques used.(Gardner, 1986)

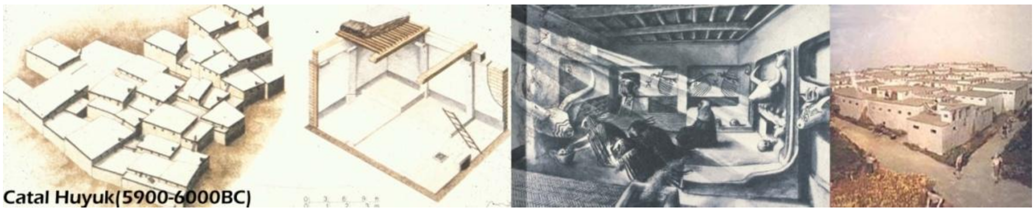

Figure 1. Çatal Hüyük (located in Anatoly, 5900-6000 BC)

Although climatic considerations have been ignored or forgotten by architects in last few decades in architectural design decision making process, nowadays it is again becoming important because of some environmental issues such as global warming, ozone layer depletion, greenhouse effect, energy crisis and etc. Traditional architecture -so often forgotten in official circles- is the result of centuries of optimisation in the use of resources, materials, construction techniques and climate considerations which are achieved through a trial and error process. Traditional architecture can teach us how to assimilate bioclimatic approach in the practice of architectural design in the contemporary architecture. (Coch, 1998) This paper investigates climate responsive building design in the mild and humid climatic zone of Iran by analysing traditional architecture of this region and is supported by the Mahoney tables.

Climate and Location

In Iran-a vast country with four different climatic zones (hot arid, hot humid, mild humid and cold (Hosseyn Ganji) - contemporary architecture and urban design does not consider climatic and environmental parameters appropriately in the designing process. This results in buildings and urban spaces which are not comfortable for the people. Although traditional architecture and urbanism of Iran includes magnificent examples of climatic design, most of the modern buildings cannot provide comfort conditions to their inhabitants for most part of the year without using mechanical devices. According to building bioclimatic charts (Givoni,1976)and bioclimatic charts (Olgyay,1962) and climatic analysis of traditional architecture of Iran (Kasmaee, 2003) it is possible to decrease energy consumption in these buildings significantly by using approp[riate passive techniques.

Mild and humid climatic zone of Iran is located in southern shores of Caspian Sea and is particularly known as “Sothern Shores of Caspian Sea Region”. It is located at 49˚-36´ E longitude and 37˚- 16´ latitude and altitude of -7 m measured from the sea level. (Book of Guilan)

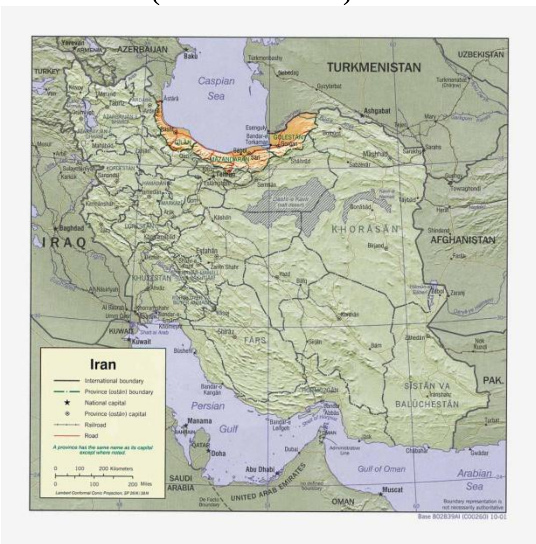

Figure 2. Southern shores of Caspian Sea region

Despite of the narrowness of this region, it has two distinct parts. First is the prairie region which continues like a narrow strip along the coastline and includes big cities and broad plantations and fields. The second part is the mountainous region (the northern parts of Alborz mountains) which includes forests. (Ghobadian, 2003)

Climatic specifications of this region are:

a. Extreme precipitation whole the year, especially in autumn and winter
b. High humidity ratio, whole the year
c. Low diurnal temperature changes
d. Extensive distribution of vegetations(Kasmaee, 2003)

Traditional architecture

1. Scattered buildings

In the southern shores of Caspian Sea region because of high amount of precipitation and extensive distribution of vegetations humidity level in the atmosphere and soil is high. Therefore one of the main problems in the buildings and urban spaces in this region is how to deal with the high humidity ratio. Humid air is heavier than the arid air and goes beneath the arid air, so if the spaces are closed and ventilation does not exist, spaces will become uncomfortable because of high density of moisture in the ambient air (Watson, 1988). In traditional architecture of this region, scattered buildings are preferred in order to create the possibility for natural ventilation.

2. Structure

There are different structural systems in the southern shores of Caspian Sea region such as wooden frame, timber structure, stone masonry systems, sun-dried brick and brick systems. But, the most commonly used structural systems are based on wooden systems. Wooden structures have many advantages, for example, they are resistant in earthquakes because of special structural behavior of woods (Moore,1999), they are light materials and available in the site. In addition, wood is a material with high thermal capacity which helps the building to encounter with temperature changes. (Watson, 1988)

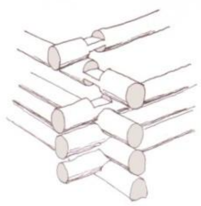

Figure 3. Wall structure which makes the wall more stable

3. Materials

Choice of building materials play a great role in the overall thermal performance and a standard recommendation about choosing the building materials is to use local materials as far as possible (Rosenlund, 2008).

One of the main principles of Iranian traditional architecture is self-sufficiency (Pirnia, 2004). It means building materials usually achieved from the place which they were going to be built. Because of the climate of the southern shores of Caspian Sea region and abundance of plants and forests, the most common building materials are wood and other plants. In this region wood is the main construction material especially for structural uses (Zomorshidi, 2005). Wood is divided to two types; hard woods such as boxwood, acacia, oak, mulberry tree, walnut tree and soft woods such as alder, poplar, plane tree, maple, pine tree. In this region hard woods usually were used in the foundation of the buildings because they are resistant against humidity, moisture and insects. Because hard woods are not straight and long enough to be used as beams and trusses soft woods such as poplar, alder or spruce pine were used as long beams and trusses (Ghobadian, 2003).

Variety of materials were used to cover the roof in this region such as wooden laths, clay roof tiles and galvanized iron sheets but the most common used material was straw which was cheap, abundant and easy to work with. Floors, roofs and walls were made of mixture of clay, straw, salt and ashes on a wooden structure. Clay as a natural material absorbs the surrounding moisture in high-humidity conditions and discharges the moisture in low humidity conditions. In addition, it has relatively high thermal capacity and also its capacity for insulation is comparatively high (Watson, 1983). Hence the environment of the room is controlled according to the changes in the surrounding environment. Straw which is mixed with the clay prevents from splits on walls because of fluctuations in the moisture level in the surrounding atmosphere (Pirnia, 2003).

4. Role of climatic factors on traditional architecture of the southern shores of Caspian Sea region

4.1. Rain

In this region precipitation is comparatively higher than other climatic zones of Iran and this makes the architecture of this region different from other parts of the country. Average rainfall in this region is 1338/4 mm and maximum daily rainfall is 133 mm in October (Bureau of Meteorology of Iran, 2008). Effects of rain on the architecture of this region are as follows:

4.1.1. Plan

In Moderate climates one of the effective ways of protecting the buildings and external walls from the rain is use of verandas (Hyde, 2000). In order to protect entrances, doors, windows and walls from the rain associated with the wind, semi-open spaces formed around the buildings or on the entrance side to create a buffer space.

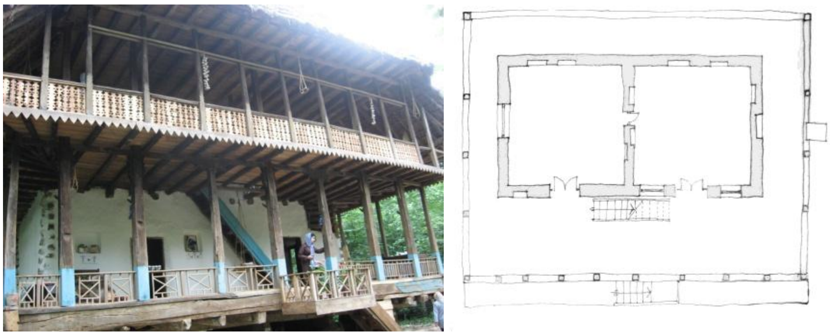

Figure 4. Use of veranda as a buffer space to protect the building from rain

4.1.2. External walls

The finishing layer on the walls is a layer of a mixture of clay, straw, salt and sometimes ashes when this layer becomes wet changes to a plastic layer which is almost water-proof. (Tavassoli,2002).

4.1.3. Roof

Because of excessive amount of rain in this region, the roofs are very inclined with the slope of 100% to 150%. Most common type of roof in this region is hipped roof with four pitches and usually covered by straw. Traditional buildings in this region usually have large eaves in all sides except southern side. The function of eaves is to protect the walls from the rain and also to provide a temporary protection for some households and agricultural tools from the rain.

Figure 5. High slope of roofs in order to protect buildings from the rain and snow

4.2. Moisture

Southern shores of Caspian Sea region is a humid area and the humidity ratio is above 80% almost whole the year. In addition the amount of humidity in the prairie part of this region is higher than mountainous part.

4.2.1. Plan

Creation of air movement in the plan is the main strategy to deal with the humidity ratio therefore opposing entrances and windows, single layer spaces and semi-open spaces were used to create airflow to remove the moisture.

4.2.2. External walls

Because of excessive precipitation and intense vegetation, the moisture in the soil especially in the prairie part of southern shores of Caspian Sea region is very high. The excessive moisture in the soil has decaying effect on the wood components that are connected to the soil. To deal with this problem there are several ways which traditional builders used in their buildings. For instance, the walls are not connected to the soil and they start from ground floor which is 0.5m to 2m above the level of the earth and call *Kursi* (Ghobadian, 2003). *Kursi* is like a platform made of rubble with lime as mortar or made of hard woods which called *Shakili*. (Museum of rural houses, 2008)

Figure 6.Walls are not connected to the ground so are protected from moisture

4.2.3. Roof

High amounts of moisture in the atmosphere and the soil makes it necessary to have ventilation in order to achieve the comfort. (Hyde, 2000). In vernacular houses in this region usually daily activities and cooking take place in semi-open spaces which are naturally ventilated but for a better ventilation in semi-open spaces and eaves the lower surface of roofs are not boarded and so polluted and humid air can be ventilated easily.

4.3. Wind

In the southern shores of Caspian Sea region appropriate winds blow from north-east and sea to the land during the day and land to the sea during the night which is called breeze (breeze is only effective in areas near the coast).Inappropriate wind which is associated with the rain blows north-west direction and is the dominant direction of the wind in cold seasons (Kasmaee, 2003). Effects of the wind on the buildings are as follows:

4.3.1. Plan

In traditional architecture of this region buildings are faced to the south direction and there is no entrance on the sides facing northerly-westerly winds.

Figure 7. A traditional house faced to the south with openings only on the southern elevation

4.3.2. External walls

On the walls facing the winds that do not create undesirable conditions in terms of heat and comfort especially in coldest times, there are more openings. On the other hand, there are a few openings on the walls facing north and northwest.

4.3.3. Exterior of the buildings

Designing the microclimate is known as one of the effective ways in saving energy as a recent study in Japan demonstrates that buildings with micro-climate conscious planning consume significantly less electric power than others without. (Iwamura, 2006) In the southern shores of Caspian Sea region the site is designed to create a micro-climate which improves the comfort level in the surrounding spaces of the building and the building as well. In the case of winds, curtaining with the evergreen trees is the most commonly used strategy.

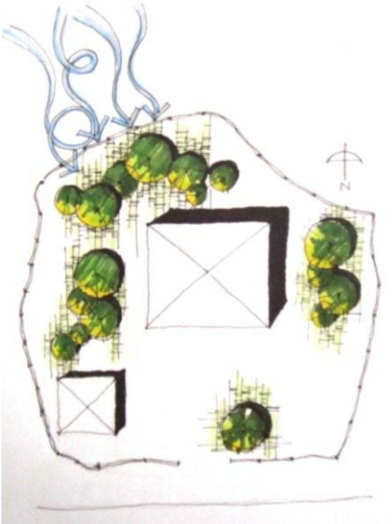

Figure 8.Designing the site to protect the building from unpleasant northerly-westerly winds

4.4. Sunlight

High density of water vapour in the southern shores of Caspian Sea region blocks the sunlight and reduces its density. In addition, number of cloudy days during the cold seasons is significant. The sides facing north does not receive direct sunlight except in spring and summer during the morning. The sides facing east does not receive direct sunlight in the afternoons and the sides facing west does not receive it in the mornings. Effects of sunlight on the buildings in this region are as follows:

4.4.1. Plan

In this area plans have east-west direction and the main elevation is facing to the south and sometimes plans are slightly rotated to the southeast. Verandas in these buildings protect the building from direct sunlight during the summer while letting the light come in during the winter.

4.4.2. External walls

Because of construction limitations and cold weather during the winters the openings on the walls even on the southern walls are small and natural illumination in most of traditional buildings of this region is far below the comfort level. In the other word, interior spaces in most of the traditional buildings do have the visual comfort and it is usually devoted for thermal comfort. The same problem can be seen in Turkish traditional architecture in the eastern Black sea region (Engin, 2006) which is almost in the same latitude with the southern shores of Caspian Sea region, but because of application of translucent material in Korean traditional architecture visual comfort was provided in the interior spaces without interruption for the thermal comfort (Do-kyoung Kim, 2008).

5. Characteristics of the building forms

In the southern shores of Caspian Sea region buildings have pitched roofs with the slope of 100% to 150% and there is a veranda around the building which serves as a buffer space to protect the external walls from the rain and also direct sunlight in summer. Because of existence of natural ventilation these verandas also can be used as a comfortable place for daily activities or night sleeping during the summer. Because of high humidity ratio and high density of moisture there is no basement in the buildings of this region. In addition, in order to protect the building from moisture ground floors has been built in a higher level than the level of the earth.

In traditional architecture of this region people found use of breeze and natural ventilation as the best way of natural environmental control system to create comfortable life conditions in their dwellings. In order to get the advantage of natural ventilation buildings in this region are extroverts (outdoor dominant) and usually have two stories because wind speed in upper levels is higher.

According to role of the climate on the formation of traditional architecture of southern shores of Caspian Sea region and Ghobadian these characteristics are prevail in most of traditional buildings in this region:

a. Hipped roofs
b. Veranda around the buildings
c. There is no basement
d. Ground floor is built in a higher level than the level of the earth
e. Extrovert building form
f. Cross-ventilation

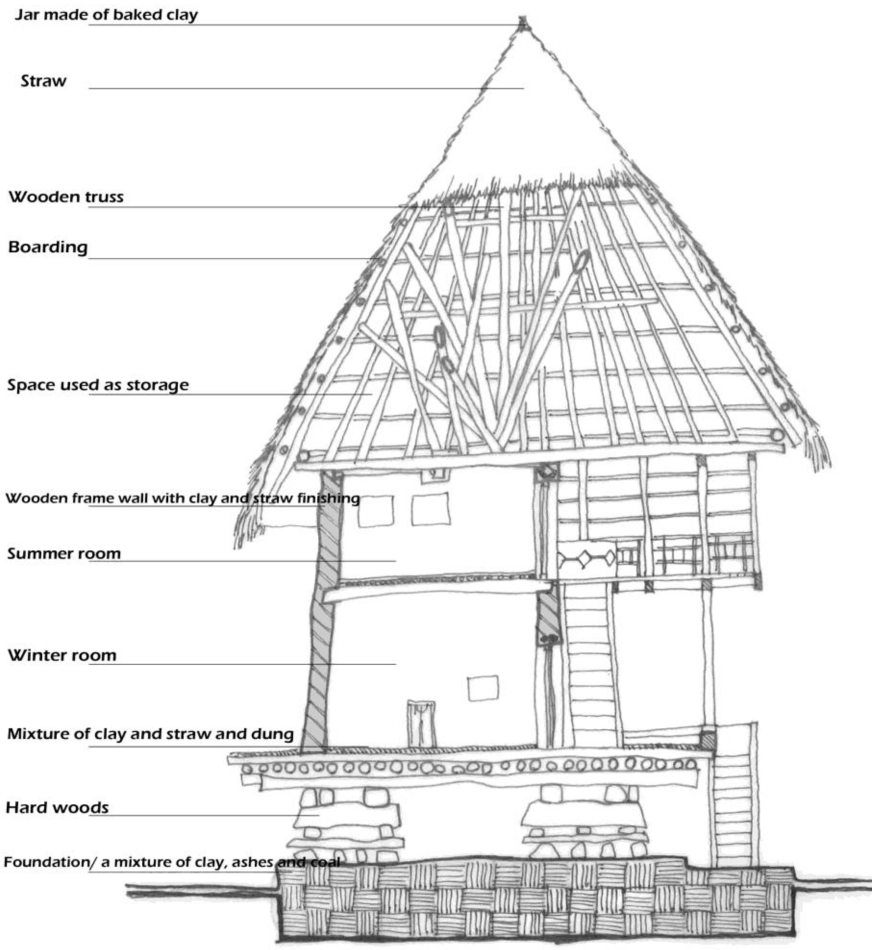

Figure 9. A climate Responsive House in southern shores of Caspian Sea region

6. Mahoney tables

Mahoney tables are a set of reference tables used as a guide to climatic design which have been proposed by Mahoney (1968) and developed by Konigsberger. These tables propose a climate analysis sequence that starts with the basic and monthly available climatic data of temperature, humidity and rainfall. These tables provide design guidelines by using climatic data and simple calculations. There are six tables; four are used to enter climatic data for comparison with the requirements for thermal comfort; and two reading off appropriate design criteria.The monthly climatic data including air temperature and relative humidity are tabulated in table1 and table2. After analyzing the climatic data in table3 thermal stress for day and night according to thermal comfort will be determined. Then the results from table1 to 3 will be classified under certain indicators in table4. The Mahoney tables include six indicators, three humidity indicator (H1-H3) and three arid indicators (A1-A3). After the total number of each indicator is determined they will be tabulated in table5 and table6 and finally design recommendations will rise from these tables.

Table 1

Air Temp Deg C	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Mean Max	11.1	11.2	13.3	18.7	24.7	28.9	30.1	29.9	26.4	22.2	17.7	13.7
Monthly Mean Min	1.5	1.9	4.5	8.4	13.5	16.7	18.9	18.9	16.4	12.2	7.2	2.3
Monthly Mean Range	6.3	6.6	8.9	13.5	19.1	23.4	24.5	24.4	21.4	17.4	12.4	8.5

Table 2

Relative humidity %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Mean Max	92.5	94	90.5	93	93	91	94	92	95	96	95	94
Monthly Mean Min	77	77	76.5	69	65	62	65	62.5	70.5	70	70.5	75
Average	84.7	85.5	82.5	81	74	76.5	79.5	72.2	82.7	82	82.9	84.5
Humidity group	4	4	4	4	4	4	4	4	4	4	4	4

Humidity group	1	below 30%
	2	30-50%
	3	50-70%
	4	Above 70%

Table 3

Diagnosis Deg C	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Max	11.1	11.2	13.3	18.7	24.7	28.9	30.1	29.9	26.4	22.2	17.7	13.7
Day comfort upper	24	24	24	24	24	24	24	24	24	24	24	24
Day comfort lower	18	18	18	18	18	18	18	18	18	18	18	18
Monthly Min	1.5	1.9	4.5	8.4	13.5	16.7	18.9	18.9	16.4	12.2	7.2	2.3
Night comfort upper	18	18	18	18	18	18	18	18	18	18	18	18
Night comfort lower	12	12	12	12	12	12	12	12	12	12	12	12
Thermal stress day	C	C	C	O	H	H	H	H	H	O	C	C
Thermal stress night	C	C	C	C	O	O	H	H	O	O	C	C

Table 4

Humid H_1					√	√	√	√	√			
H_2				√						√		
H_3												
Arid A_1												
A_2												
A_3	√	√	√								√	√

	Indicator	Thermal stress		Rainfall	Humidity group	Monthly mean Max
		Day	Night			
Air movement essential	H_1	H			4	
		H			2,3	Less than 10
Air movement desirable	H_2	O				
Rain protection necessary	H_3					
Thermal capacity necessary	A_1				1,2,3	Less than 10
Outdoor sleeping desirable	A_2		H		1,2	
		H	O		1,2	
Protection from cold	A_3	C				

Table 5- List of recommended specifications

indicators					
H1	H2	H3	A1	A2	A3
5	2	0	0	0	5

Layout

H1	H2	H3	A1	A2	A3			
			0-10			√	1	Orientation north and south (long axis east-west)
			11,12		5-12			
					0-4		2	Compact courtyard planning

Spacing

H1	H2	H3	A1	A2	A3			
11,12							3	Open for breeze penetration
2-10						√	4	As,3 but protection from hot and cold winds
0,1							5	Compact layout of estates

Air movement

H1	H2	H3	A1	A2	A3			
3-13						√	6	Rooms single banked, permanent provision for air movement
1,2			0-5					
			11,12				7	Double banked rooms, temporary provision for air movement
0	2-10							
	0,1						8	No air movement required

Openings

H1	H2	H3	A1	A2	A3			
			0,0		0		9	Large openings, 40-80%
			11,12		0,1		10	Very small openings, 10-20%
Any other conditions						√	11	Medium openings, 20-40%

Walls

			0-2			√	12	Light walls, short time lag
			3-12				13	Heavy external and internal walls

Roofs

			0-5			√	14	Light insulated roofs
			6-12				15	Heavy roofs, over 8 h time lag

Outdoor sleeping

				2-12		√	16	Light insulated roofs

Rain protection

		3-12				√	17	Light insulated roofs

Table 6- List of detailed Recommendations

Size of openings

			0,1		0		1	Large:	40-80%
					1-12	√	2	Medium:	25-40%
			2-5						
			6-10				3	Small:	15-25%
			11,12		0-3		4	Very small:	10-20%
					4-12		5	Medium:	25-40%

Protection of opening

3-12						√	6	In north and south walls at body height on windward side
			0-5					
1-2			6-12				7	As above, openings also in internal walls
0	2-12							

Protection of opening

					0-2		8	Exclude direct sunlight
		2-12				√	9	Provide protection from rain

Walls and Floors

			0-2			√	10	Light, low thermal capacity
			3-12				11	Heavy, over 8 h time lag

Roofs

			0-2			√	12	Light, reflecting surface, cavity
10-12			3-12				13	Light, well insulated
			0-5					
0-9			6-12				14	Heavy, over 8 h time lag

7. Design recommendations according to the Mahoney tables

After analyzing the climatic data in the tables1,2,3,4,5 and 6 some preliminary design recommendations are formulated which give us some recommendations on the building layout, spacing, air movement, openings, walls, roofs and rain protection. The following is a summary of design recommendations for the southern shores of Caspian Sea region in the north of Iran:

a. Layout: Orientation north and south (long axis east-west)
b. Spacing: Open spaces for breeze penetration, but protection from hot and cold winds
c. Air movement: Rooms should be single banked with permanent provision for air movement
d. Openings: Medium level of openings, 25-40%
e. Position of openings: in windward side at body height
f. Walls: Light walls, low thermal capacity, short time lag
g. Light, insulated roofs
h. Protection of openings: protection from rain

8. Conclusion

By comparing the results of climatic analysis of vernacular architecture of the southern shores of Caspian Sea region with the design recommendations from the Mahoney tables it can be seen that traditional builders already have used these design guidelines if we ignore some exceptions.

In vernacular architecture of the southern shores of Caspian Sea region the orientation of buildings is north and south slightly rotated toward east which is the same with the recommended building orientation in the Mahoney tables. Also in traditional buildings spaces are single banked and there is a good opportunity for natural ventilation which is as well recommended by the Mahoney tables. The Mahoney tables propose light walls with low thermal capacity medium openings on the walls which cannot be seen in the most of traditional buildings. The reason for this is probably the construction systems that do not allow large openings or thin walls and also the fact that traditional builders put thermal comfort during the cold seasons prior to indoor visual comfort and indoor cross-ventilation. In addition, protection from the rain which is recommended by the Mahoney tables is obviously visible in traditional architecture of this region.

Same study in Katmandu valley shows that traditional buildings were more comfortable and climate responsive design strategies were used in traditional buildings while contemporary buildings do not fallow these strategies (Kumar, 2006). Another study in turkey also shows that traditional buildings were better than contemporary buildings in terms of climatic design and thermal comfort (Yilmaz, 2007).It can be seen that traditional builders in the southern shores of Caspian Sea region knew how to build their buildings in harmony with the nature and how to use natural forces in a way that they could achieve a comfortable living condition in their dwellings. Once architects can improve the living qualities by fallowing some simple rules in architectural and urban design, simply they ignore them or misunderstood them and make the situation worse.

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