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Environmental requirement of living in dry areas: developing climate-based architecture and an urban development planning model in Qom, Iran

M. Mirehei[a*], M. Hajilou[b]

[a] *Department of Spatial Planning, Faculty of Management and Accounting, College of Farabi, University of Tehran, Qom, Iran*
[b] *Department of Urban Management, Faculty of Management and Accounting, College of Farabi, University of Tehran, Qom, Iran*

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Abstract

Environmental factors are being increasingly taken into account in the increasing development of urbanization and citizen residential requirements. Climate and climate conditions are among the environmental factors that have always influenced human welfare. Climate has always been incorporated in old urban structures in Iran and can be easily observed. Despite the importance of climate-related elements in Iran, there has been a lack of sufficient consideration of climate conditions in urban planning during the period of fast-paced urbanization. However, in these last years the introduction of theories such as sustainable development, geographical elements and more specifically climate, have been incorporated in urban architecture and development. Accordingly, the present study first attempts to review some climate applications in the planning and construction of cities, and then proceeds to tackle some architectural factors and urban planning requirements (such as the indoor and outdoor spaces of a building) regarding the climate in the geographical area of Qom, Iran. For this purpose, Mahoney tables have been used for climatic design, and then the data was analyzed by implementing the descriptive-analytical method. Results of the study showed that various urban and architectural planning methods including compression, reducing the size of openings, double glazing windows and others have reduced the harshness of Qom's climate and changed a threat into an opportunity.

Keywords: Environmental factors; Climate; Architecture; Urban development; Desert areas; Iran; Qom

1. Introduction

The last decade has witnessed an upheaval in the demographic aspect of urbanization. Today more than half of the world's population lives in urban environments. Projections for the years 2020–2050 predict further growth in urban population, primarily in less developed regions which will account for most of this growth (United Nations Department of Economic Affairs, 2010). Invariably, various urban phenomena such as urban climate, urban pollution, urban sprawls and urban runoff are influenced by the process of urbanization (Grimmond, 2007; Cui and Shi, 2012; Qiao *et al*., 2013; Miller *et al*., 2014; Targhi and Van Dessel, 2015).

It can be clearly seen that there are two distinct architectural movements: the contemporary and the traditional. While the former was not successful, the latter seems to have gained renewed interest (Heidari, 2010). When previous civilizations in the Middle East erected and designed sophisticated buildings, their main concerns were the thermal, social and functional performance of their designs. Generally speaking, these builders were integrated with their physical environment, and their designs and constructions were accomplished with functionality in mind rather than decoration (Heschong, 1979). Such architecture is known as vernacular architecture. One of the most important meanings for the term "vernacular" is specific

* Corresponding author. Tel.: +98 912 6985397
Fax: +98 25 36166126
E-mail address: mirehei@ut.ac.ir

building environments (Dincyurek, 2002). Buildings are designed to create a suitable internal environment for human comfort. The successful design of comfortable buildings relies on an appropriate understanding of the climate (Emmanuel *et al*., 2013).

Most modern buildings are designed without adequate attention to environmental impacts, whereas the history of architecture exhibits a positive correlation between the environment and traditional buildings, which have been designed with careful attention to climatic requirements and socio-cultural contexts (Soflaei *et al*., 2017). Paying slight attention and thought to the life, development and activities of inhabitants of dry areas in Iran would show that there is a lack of in-depth understanding in this area. Because of the lack of understanding about past lessons and experiences, and the emphasis placed on appearances and physical being instead of thoughtfulness in principles and fundamentals, enormous sources of knowledge, experience, art and technology inherited by a civilization have been ignored and foreign, non-native models have become commonplace. The latter are alien to native culture, nature, and many social and economic conditions existing in society (Naghizadeh and Aminzadeh, 2001).

It is widely acknowledged that vernacular architecture adapts well to local climate, topographical features and available resources in terms of settlement pattern, building volume configuration, semi-open and open space arrangements, not to mention terms of materials and construction techniques. Vernacular architecture can be therefore described as a genuine climate-responsive and environmentally-friendly architecture. A particular interest in the investigation of the environmental aspects of vernacular architecture first appeared in the early 1980s (Vellinga, 2014). Vernacular architecture is the functional architecture of the common people of a certain area, which possesses certain environmental characteristics, socio-cultural features coupled with traditional technology and available material (it tends to emphasize the utilization of local building resources), and is known for the use of passive and low-energy strategies that could lead to reduce the need for both air conditioning and lighting requirements (Roodgar *et al*., 2011; Mashhadi, 2012).

Climate is one of the most effective and important factors in the formation of the urban fabrics of an area. This factor has also long been effective on culture, human behavior, construction and generally human lifestyle. However, “most researchers agree on the fact that, in spite of available knowledge about the climate and some good examples of climatic design, the impact of climate in the urban planning process in practice is usually low” (Eliasson, 2000). McGuffie and Henderson-Sellers (2005) broadly defined Climate as:

‘All of the statistics describing the atmosphere and ocean determined over an agreed time interval -seasons, decades or longer-computed for the globe or possibly for a selected region’.

Fortunately, today, with the emergence of theories such as sustainable development and its special emphasis on preserving and adapting to the natural environment, climate, as one of the most important natural conditions, has grown to be of even greater importance, and its applications have been particularly highlighted in urban planning. The concept of sustainable development is defined as development that satisfies the needs of the present without compromising the ability of future generations to satisfy theirs (Brundtland Commission, 1987; Dasgupta, 2007). It has been discussed under three dimensions: economic, environmental and social (Boulanger, 2008; Riahi *et al*., 2014), and has been developed by some scholars to include the fourth dimension of culture (Scerri and James, 2010; James *et al*., 2015). Environmental sustainability concentrates on issues of natural resource preservation, such as air, water, and climate change (Intergovernmental Panel on Climate Change, 2014). A full understanding of the local climate is the main requirement for the designs of climate-responsive architecture towards sustainable development. This requirement indicates that designers should be supported by suitable weather-analysis tools rather than relying completely on statistical climatic data from other providers (Nguyen and Reiter, 2014). Climate has been significantly incorporated as one of the most important natural conditions, a matter reflected in its applications in urban planning, which include:

1. Commercial applications in the selection of appropriate building materials.
2. Classification of different neighborhood based on weather conditions.
3. Locating industrial, residential, service, office and commercial applications.
4. Selection of plant species adapted to climate and environment in the development of green spaces and parks in cities and artificial plantation of the border.

5. Prediction of the power and preventive effects of climatic elements in urban transport and travel.
6. Protection of cities against the risks of flooding and due damages.
7. Balanced use of thermal energy heating systems.
8. Selection of architecture most suited to local conditions (Rahnamaiee, 2004).

As mentioned above, the climate is one of the determinants of housing and architecture design. Thus, the present study aims to first study the ancient urban construction of Qom vis-à-vis climatic conditions, and then provide recommendations on housing design in the city of Qom according to statistics obtained from the Qom meteorological station.

2. Materials and Methods

2.1. Geographical Location

The Geographical location of the present study is capital of Qom province, the city of Qom, and namely its old districts. It lies between 53' 50' E38' 34' N, in the heart of Iran, bordering the Kavir desert and the salt lake, and is 135 kilometers southwest of Tehran (by road).

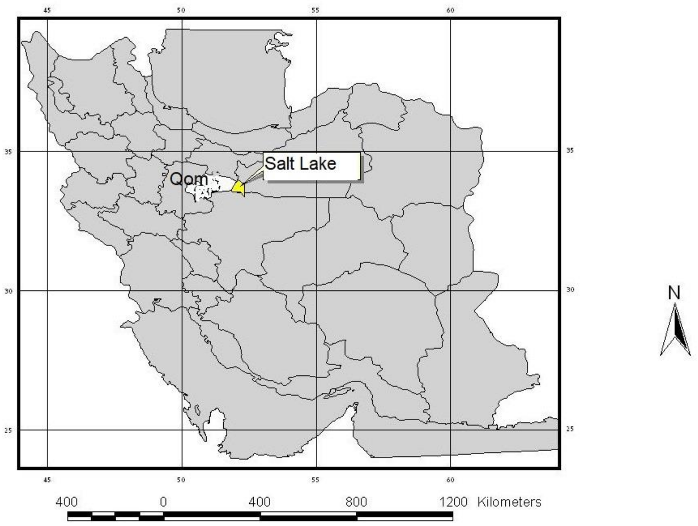

Fig. 1. Geographical location of Qom

2.2. Research Time Period

This conducted study is based on statistics and information obtained within a 40–year frame (2015- 1975), particularly the temperature, humidity, and rainfall recorded in the Qom climatological station, as well as 10 years of data related to wind movements recorded in the Qom Synoptic station, all of which were extracted from the meteorological website of Iran.

2.3. Mahoney Table

The present study makes use of a descriptive-analytical method based on the Mahoney table[1]. The Mahoney method is a well-known procedure in providing initial design recommendations for the climatic performance of any building (Djamila, 2017).

This method includes three stages below:

1. Recording the most important climatic data, then guiding and determining the used data
2. Recognizing the type of climate and creating indices
3. Changing the data into performance features and provide some design recommendations (Razjouyan, 2010; Kasmaiee, 1989).

2.3.1. Step 1: Recording the most important climatic data, guiding and determining the used data

As observed in table 2, Qom's mean annual temperature in the course of this 40-year period was 19.5 degrees centigrade, and the mean annual fluctuation was 41.3 degrees. The annual maximum and minimum temperatures were 40.1 (in August) and -1.2 (in January),

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[1] These tables were first used in 1971 as a guide to climate-appropriate design. They are named after architect Carl Mahoney *et al*., whose article was published in the Climate and House Design journal as a series of house design methods used by the United Nations (ref. Razjouyan, 2010; Kasmaiee, 1989)

respectively. Furthermore, it should be mentioned that the maximum and minimum temperatures during these 40 years were 46 degrees centigrade (19 July, 1978) and -.16.6 degrees (11 January, 1993), respectively.

Table 1. Mean Temperature of Qom (1975-2015)
(I.R. Of Iran Meteorological Organization Website, Statistics of 40 years (1975 to 2015), Qom climatological station)

Temperature C°	January	February	March	April	May	June	July	August	September	October	November	December
Max for each month	9.5	12.5	17.9	25.2	31.7	37.7	40.1	38.8	34.3	26.8	18.9	12.1
Min for each month	-1.2	0.9	5.1	10.4	15.5	20.1	22.9	21	16.1	11.1	5.2	0.8
Mean for each month	10.7	11.6	12.8	14.8	16.2	17.6	17.2	17.8	18.2	15.7	13.7	11.3
Annual Mean	19.5											
Annual Fluctuation Mean	41.3											
Max.	40.1											
Min.	-1.2											

Table 2. Determining humidity for each month based on following criteria (Kasmaiee, 1989, 486)

Group 1	If relative humidity is less than 3%
Group 2	30-50%
Group 3	50-70%
Group 4	> 70%

Table 3. Information on the percentage of relative humidity in Qom (1975-2015), and the humidity group for each month based on previous tables (Meteorological Organization Website, Statistics of 40 years (1960 to 2000), Qom climatological station)

Relative humidity %	January	February	March	April	May	June	July	August	September	October	November	December
Max. monthly mean	78	74	67	58	48	36	35	35	39	51	64	75
Min. monthly mean	50	44	35	28	22	16	15	16	18	26	34	46
Total mean	64	59	51	43	35	26	25	25.5	28.5	38.5	49	60.5
Humidity group	3	3	3	2	2	1	1	1	1	2	2	3

Table 4. Values of total annual and monthly rainfall in millimeters in Qom (2015-1975)
(Meteorological Organization Website, Statistics of 40 years (1975 to 2015), Qom climatological station)

Monthly rainfall Mm.	January	February	March	April	May	June	July	August	September	October	November	December
	24.8	23.1	27.1	23.2	12.3	1.5	1.5	0.4	0.5	8.2	11.1	18.1
Total annual rainfall Mm.	151.8											

According to the data presented in table above, Qom is one of the country's most arid areas. Most of its rain is in March and the lowest rainfall is in August.

Table 5. Determining the direction of the prevailing wind direction and second degree wind per month in Qom (I.R. Of Iran Meteorological Organization Website, Statistics of 40 years (1975 to 2015), Qom climatological station)

Wind	January	February	March	April	May	June	July	August	September	October	November	December
Prevailing wind	W	W	W	NW	NW	NW	E	E	E	NW	W	W
Second degree winds	-	NW	NW	W	W	E	-	-	N	N	NW	NW

It should be mentioned that wind is one of the most important climatic elements in determining the location of urban activities. Based on the data obtained from Qom's synoptic stations, the most common winds originate from the west and northwest, while eastern winds are more prevalent only in the summer.

Table 6. Comfort ranges for humidity groups with annual temperature ranges (Kasmaiee, 1989, 478)

Humidity group	Mean annual temperature more than C 20 °		C 15-20°		C 15° less than	
	Day	Night	Day	Night	Day	Night
1	26-34	17-25	23-32	14-23	30-21	12-21
2	25-31	17-24	22-30	14-22	20-27	12-20
3	23-29	17-23	21-28	14-21	19-26	12-19
4	22-27	17-21	20-25	14-20	18-24	12-18

2.3.2. Step 2: Recognizing the type of climates and creating the indices

Based on previous statistics and data, as well as the Mahoney tables' criteria, the rate of thermal comfort during the day for different months and the day and night temperatures were matched for different months (maximum monthly mean of comfort during day, the minimum monthly mean of comfort at night). The results of the comparison are presented in the two final rows as warm, cold and mild temperature.

Table 7. Determining the daily and nightly comfort ranges for various months

Temperature Centigrade	January	February	March	April	May	June	July	August	September	October	November	December
Max. monthly mean	9.5	12.5	17.9	25.2	31.7	37.7	40.1	38.8	34.3	26.8	18.8	12.1
Max. comfort during day	28	28	28	30	30	32	32	32	32	30	30	28
Min. comfort during day	21	21	21	22	22	23	23	23	23	22	22	21
Min. monthly mean	— 1.2	0.9	5.1	10.4	15.5	20.1	22.9	21	16.1	11.1	5.2	0.8
Max. comfort at night	21	21	21	22	22	23	23	23	23	22	22	21
Min. comfort at night	14	14	14	14	14	14	14	14	14	14	14	14
Temperature during day	cold	cold	cold	mild	warm	warm	warm	warm	warm	mild	cold	cold
Temperature at night	cold	cold	cold	cold	mild	mild	mild	mild	mild	cold	cold	cold

Table 8. Creating Various Indices (Kasmaiee, 1989)

Meaning of Indices	Thermal condition		Rain	Humidity group	Monthly temperature fluctuation C°
	Day	Night			
The air flow is necessary H_1	Warm Warm			4 3 , 2	Less than 10
The air flow is good H_2	mild			4	
Protection against rain H_3			More than 200mm		
The air capacity is necessary A_1				1,2, and 3	More than 10
Free space for sleeping A_2	 warm	Warm Mild		1 and 2 1 and 2	 More than 10
Protection against cold A_3	cold				

At this step, the indices related to design are determined and then the data of the Qom station is matched with the data provided in table 2-2. Then, if the city had had such requirements every month as per the indices, the month is marked and then the total marks of each index (all months having the indices) are recorded in a separate row. All of this is presented in the following table for the city of Qom.

As observed in the table above, the indices of H1 (air flow is necessary), H2 (air flow is good), and H3 (protection against rain) are not required due to low rainfall and relative percentage of humidity in Qom.

Index A1 (air capacity is necessary) is required due to high temperature fluctuation throughout the year.

Index A2 (free space for sleeping) is required in Qom due to warm days and high temperature fluctuations at the end of spring and during summer.

Index A3 (protection against cold) is required because of 5 months that have cold days. Thus, house design is discussed based on these indices, and accordingly proper construction material and architecture is suggested for Qom.

Table 9. Compatibility of Qom's condition with indices

Indices	January	February	March	April	May	June	July	August	September	October	November	December	Total
Humidity H_1	-	-	-	-	-	-	-	-	-	-	-	-	0
H_2	-	-	-	-	-	-	-	-	-	-	-	-	0
H_3	-	-	-	-	-	-	-	-	-	-	-	-	0
Dryness A_1	*	*	*	*	*	*	*	*	*	*	*	*	12
A_2	-	-	-	-	*	*	*	*	*	-	-	-	5
A_3	*	*	*		-	-	-	-	-		*	*	7

2.3.3. Step 3: Converting the collected data to practical features and offering design suggestions

In this part, by regarding the climate in the geographical area of Qom and Mahoney tables, has been presented some architectural factors and urban planning requirements (such as the indoor and outdoor spaces of a building).

Set of indices of table 2					
H_1	H_2	H_3	A_1	A_2	A_3
٠	٠	٠	12	5	5

Table 11. Converting the collected data to practical features and design suggestions

Building Placement						
North-south direction (longer axis of the building in the East-West)	1	*	5-12	0-10		
Compression around the yard	2		0-4	11 and 12		
Spacing (special planning)						
Wide space design to use air flow	3					11 and 12
Same as above but protected from the wind and cold	4					2-10
Compressed space design	5	*				0 and 1
Air flow						
Predicting steady air flow for all rooms connected to outer space from both sides	6			0-5		3-12
Predicting temporary air flow for all rooms connected to outer space from one side	7			6-12	2-12	1 and 2
Air flow is not required	8	*			0 and 1	
Dimensions of Openings						
Big 40-80%	9		٠	0 and 1		
Very small 10-20%	10		0 and 1	11 and 12		
average 20-40%	11	*			Any other condition	
Placement of openings						
In the northern and southern walls, openings placed on the height of the body, against wind direction	12		5-0			3-12
Same as above, with some openings on internal walls	13		12-6		2-12	1-2
Protection of openings						
Preventing direct sunlight on the windows	14		0-2			
Protection against rain	15				12-2	
Walls						
Lightweight and low thermal capacity	16			0-2		
Heavy with a time delay of more than 8 hours	17	*		3-12		
Roofs						
Lightweight, reflective surface, hollow	18			0-2		10-12
Lightweight, good thermal insulation	19			3-12		
Heavy and with a time delay of more than 8 hours	20	*		0-5 6-12		9-0
External details						
Predicting sleeping space outside	21	*	-12			
Predicting proper canals for rainfall	22				12-1	
Predicting protection against heavy rains is required	23				2-3	

3. Results and Discussion

3.1. Building Placement

Building placement is very important when taking climatic conditions into account. The results of the study indicated that the best placement for buildings in Qom is in the North – South direction. That is to say, one façade of the building should be to the north and the other to the south (east-west direction). A compact house design built with a yard around it is ruled out there are more than 4 months with cold days (5 months with cold days).

In Qom, in addition to the need to protect buildings from summer solar radiation, there is a need to use solar radiation during winter due to cold weather, the south is thus the most desirable direction since in “mid-latitude during winter, south-facing walls receive solar energy about three times more than western or eastern walls, while in summer the amount of energy received to the southern walls is almost half of the energy radiated to the northern, eastern and western walls (Kasmaiee, 2015). In Qom and in general “in hot and dry climates, the worst building direction would be to the west because the maximum intensity of radiation in the western façade coincides with the maximum temperature, and thus increases the maximum heat load” (Kasmaiee, 1989).

Further, it is better to build less important and underutilized spaces such as parking and storage to the east and west directions and spaces highly usedduring the day by residents should be built facing the south.

3.2. Spacing (spatial planning)

According to table 3.2, air flow is not required in Qom when designing the buildings and during special planning. Thus, buildings should have a compressed distribution. This distribution is clearly observed in old areas of the city. Thus, the distribution of buildings in the city should be dense and shaded to prevent the penetration of sunlight indoors. In the past, to remedy this problem, alleys were built more narrowly (of course, the prerequisite of defense cannot be forgotten for the creation of narrow streets and alleys) and it is suggested that roof shelters be elongated to shade the alley, make yard deeper, and also overshadow the roofs of houses (Tavasoli, 2002).

Some advantages of dense tissue in relation to climate are:

1. Reduces direct sunlight and therefore evaporation.
2. Minimizes heat gain during the day and heat loss at night.
3. Increases shade and cool weather.
4. Makes transportation easier in the city .
5. Reduces the intensity of very hot winds during the days and cold winds at night.
6. Reduces adverse effects of dust storms (Kheirabadi, 2000).

Nowadays, this technique (narrow streets) is not rational due to the need for wider roads and more open space for traffic. As such it is better to populate open spaces with trees so that these spaces would take in less sun, since trees, in addition to preventing direct annoying emissions of the sun during the summer, which hinder daily life in warm and dry areas such as Qom, thereby altering urban activities, trees regulate the climate and add to the beauty of the urban landscape.

3.3. Air Flow

Regarding the lack of necessity for H indices (humidity) in Qom and the city’s low relative humidity, there is basically no need for air flow, the prediction of air flow for rooms or even the rooms connected to the outside. Furthermore, there is no need for the rooms related outside. However, if there is no main air flow forless than a month, the rooms can then be one–sided, leaving no need for strong air flow. It should be mentioned that, although the tables have shown there is no need for air flow in the internal space of the building, this does not mean that wind and air flow can be forgotten in an urban system. Wind is one of the most important climatic factors playing a significant role in urban areas. For example, northwest and west of the city are inadvisable locations for industries, more specifically polluting industries or brick kilns (which are highly distributed in Qom), not to mention public graveyards, since most of the winds in Qom are western or northwestern winds that could spread pollution and diseases in the city. In addition, air flow is important for opening placement, the case which will be explained below.

3.4. Dimensions of the openings

The openings suggested for use in the buildings of Qom should not be very large or very small. It is suggested that they should be medium-sized and cover 20 to 40 percent of the wall area. It is more specifically applicable if the thermal storage is not more than one month and there is a cool season. However, it should be mentioned that due to high temperature fluctuations in Qom throughout the year or between day and night, then windows should be double-glazedand insulator sheets should be used in the making of openings frames.

3.5. Placement of the openings

The city of Qom does not have any of the criteria mentioned in the Mahoney table, but in general, if the cold season is long (which is normally observed in Qom), there may be need for openings on east walls. However, “it is not acceptable to have openings on west-facing wall, more specifically in hot areas, under any condition” (Kasmaiee, 1989) since high radiation during summer afternoonsalways shine on the west.

As it was mentioned above, air flow is one of the determining factors for locating the openings of a domicile, and since the prevailing winds of Qom in the summer and winter are form west, north-west and east, and following the table, there is no need for air flow in Qom. Thus, the best placement of the windows in this city would be on the south walls.

3.6. Protecting the openings

Since the city of Qom does not have any of the features mentioned in the table, as the number of cold or rainy months is not less than 2 (it has 5 cold months), there is need to protect the openings against rain and direct radiation. However, since this is not taken into consideration in the city, then there is a need for some solutions for openings, especially those subject to severe radiation. These solutions include using blind curtains since they are the most effective regulator against energy input and output, and are used in various seasons based on the house’s thermal needs , or even for air flow control.

3.7. Complementary Discussion on Openings

Since there are not enough suggestions on Mahoney’s tables regarding openings, and due to the importance of the issue in house design in Qom, options for light and using solar energy, following a complementary discussion on the issue, are presented since light and a huge among of thermal exchanges are done through openings.

The most effective parameter in designing openings is the radiation angle which differs in various seasons and latitudes. The following formula can be used in order to determine the radiation angle in each area (Rahnamaiee, 2004):

$$\alpha^\circ = 90 + \lambda^\circ - \varphi^\circ \quad (1)$$

α° = Angle or height of the sun (2)

λ° = Declination of the sun (3)

φ° = Latitude of the location (4)

Since λ° differs in various seasons and consequently the radiation angle also differs;

λ° In April and September equinoxes = 0° (5)

λ° In early August = 45/23° (6)

λ° On January = -45/23° (7)

The radiation angle calculated from this formula for the city of Qom in various seasons is: 22'-55° in early April and September, 49'-78° in early August and 55'-31° in early January.

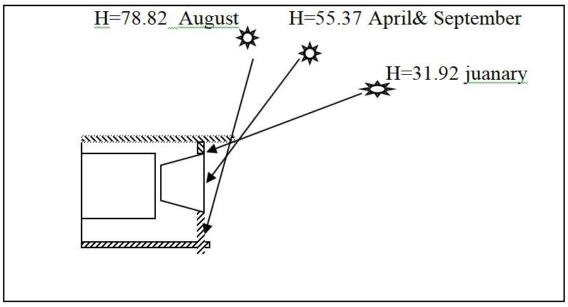

Fig. 2. The sun at the equinoxes (September and April) and solstices (the first of January - first of August)

Now, based on the radiation angle in various seasons and the need for gaining maximum radiation in cold seasons and the minimum radiation in hot seasons, various placements, opening sizes and awnings are examined below. For this purpose, the following formulas can be used (Ghayour, 1995b).

$$Lower\ edge\ openings = radiation\ angle\ tangent\ \times Awning$$
$$Upper\ edge\ of\ openings = radiation\ angle\ tangent\ \times Awning$$

Two examples are provided for better understanding:

1. What is the best placement for openings in designing a building with a height of 4 m and awning of 60 cm according to the climate of Qom?

As mentioned before, the best placement for the openings is on the south side of the building and it should be noted that in the south, Azimuth equals zero. Also, as calculated before, the radiation angles in early August and January in Qom are 78°-49′ and 31°-55′, respectively; thus, based on the above formula and by replacing the data of Qom station, the minimum and maximum size of the openings for Qom will be: the lower edge of the windows should be 95 cm above ground level (AGL) and the upper edge should be 360 cm AGL.

2. What is the best placement for the upper edge and awning of a building with 4 m height and a lower edge of 50 cm on the south façade?

In order to calculate the awning, the tangent of the radiation angle on the 1st of August is divided into the lower edge of the opening under the roof, the result of which is 1.44 meters. By obtaining the awning, using the above formula, the upper edge of the opening is obtained which is 90 cm under the roof (3.1 meter AGL).

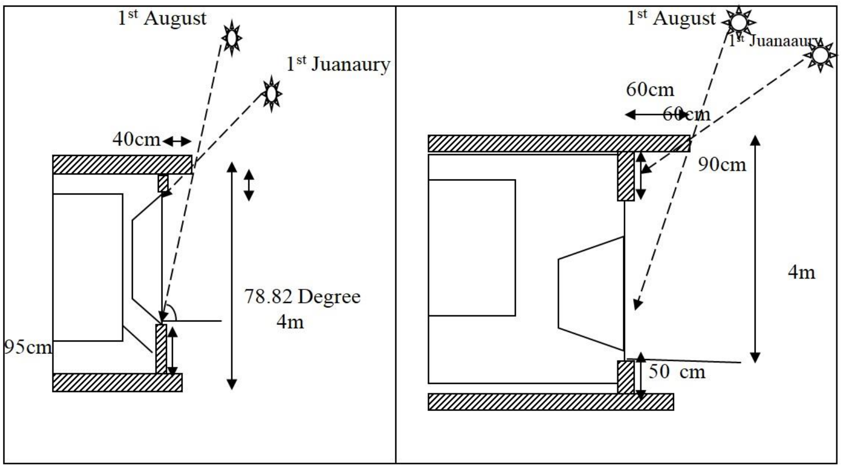

Fig. 3.The suggested size for windows and awnings for Qom city

3.8. Walls

The walls of a building are considered its most important elements, so designing and selecting their materials should be done cautiously. According to the data collected by the Qom station, heavy walls or a delay of more than 8 hours should be implemented; that is, the walls must have thermal capacity. This is due to high temperature fluctuations between day and night, which means that the walls should prevent the high energy exchange between the indoors and outdoors. High temperature fluctuation in a geographical area is due to that area's continentality. The index of an area's continentality can be calculated using Conrad Formula (Ghayour, 1995a).

$$k = \frac{1.7\ (A)}{Sin\ (Q+10)} - 14 \quad (8)$$

K: index of continentality
A: annual range of temperature
Q: geographical latitude

This coefficient can range from 0 in a purely oceanic climate to 100 in extremely continental climate areas with a high annual range of temperature. This index is calculated as 86 for Qom which indeed proves high temperature fluctuation.

Thus the walls in these areas should be thick in order to prevent the penetration of unbearable heat, especially in the summer, to the inside of the house, and should penetrate it with a delay: that is, when the peak of daily heat at 14:00 seeps into houses at night when there is more need for heat, and due to the thickness of the walls, the heat will leave the house later on (this mechanism is also applied in winter to reduce the thermal interaction between houses and their surrounding environment). In the past, some materials such as brick were used. However, today bricks cannot be used due to the prevalence of apartment housing. Thus, it is suggested that materials such as both bricks and cement blocks be used, with double-walls and glass wools in walls. This material with a thickness of 300 mm would meet the required needs and if the wall is insulated from outside, a thickness of less than 100 mm can also meet these needs (Kasmaiee, 1989). Another technique suggested today is to use plants on the wall (Watson and Labs, 1993). The common plant type used for this purpose is ivy which easily grows on the wall and can grow upwards. This technique is important for: 1) the beauty of the city landscape, 2) balancing the temperature, 3) reducing air pollution and 4) preventing quick thermal exchange between the housing and the environment due to humidity and the plants' high thermal capacity.

3.9. Roofs

The best roofs for city of Qom are the heavy ones with a time delay of 8 hours. For areas with high thermal fluctuation such as Qom, materials with high thermal capacity should be used to create thermal delay since the roofs receive the brunt of the sun, and there is a high thermal exchange between houses and the environment through the roofs. For example, Watson and Labs (1993) have suggested delay times for roof and various walls for buildings in California: "east and north walls cause 0 hours, south and west walls: 8 hours and roofs: 12 hours delay in thermal exchange between house and environment".

3.10. External Details

When index A2 (free space for sleeping) is one or more, there is a need for external sleep space. Since, the index is calculated as 5 for Qom, thus there is a need for a sleeping space in hot seasons and thus roofs are suggested for sleep during summer nights. So, the roofs should be persistent for walling; balconies and walled terraces can also be used for summer breezes, and the east and north sides should be open to create a proper space for night sleep. Due to the lack of severe rainfalls in Qom, there is no need to protect the buildings, and also proper downpipes are not needed and are not considered a priority in desigs.

4. Conclusion

In the modern era, with the emergence of sustainable development, scholars of various sciences including geography, environment, urban planning and architecture, have been concerned with the proper use of environmental sources and the compatibility of this use with the environment so that there would be a logical balance between human beings and their environment. However, in the past we have observed this balance traditionally and locally. The present studytackles the issue scientifically.
Climate is one of the most important environmental conditions. Thus, this study was conducted based on statistics and information from a 40-year time periodincluding temperature, humidity and rainfall recorded by the Qom climatological station, and 10-year wind data recorded in Qom Synoptic station, all of which were extracted from the meteorological website of Iran. The following suggestions were provided accordingly:

1. The north-south direction is the best placement for buildings in the city of Qom
2. Compact space plan for buildings, coupled with less spacing between buildings, is recommended, and trees can be used to cover open spaces as much as possible.
3. Leaving the southern side of the building open with an angle of at least 30 degrees on each side.
4. Assigning the southern parts of the building to the spaces that are most used during the day.
5. Air flow is not very important in buildings.
6. The opening size should be average (20 to 40 percent of the wall).
7. The use of double-glazed glass in the openings.
8. The use of blind curtains behind the openings
9. Placement of openings to the west is not suggested at all and it is better that the openings be to the south and southeast.
10. Reducing the use of northern and large openings.
11. Walls and roofs should be made of materials that have higher thermal capacities. Thus creating heavy roofs and walls is recommended.
12. Due to the hot weather, it is necessary to use the outer space to sleep in the summer.
13. Due to lack of heavy rain, it is not necessary to protect buildings and the related equipment from rain.

It is hoped that by applying the suggestions one can take a small step toward sustainable development since one of the most essential pre-requisites for reaching sustainable development is to build proper and resistant shelter, at harmony with the environment.

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