Evaluating and adapting the comfort indicators with traditional architecture solutions of Qazvin city

Kamishirazi, Seyedeh Mahsa

February 2014

Evaluating and adapting the comfort indicators with traditional architecture solutions of Qazvin city

Seyedeh Mahsa Kamishirazi
Young Researchers and Elite club, Central Tehran Branch, Islamic Azad University, Tehran, Iran
kamishirazi.mahsa@gmail.com

Abstract

The climate-compatible architecture creates a healthy environment with high comfort degree for human comfort through replacing the natural and clean sources of energy. Identification of the climate-compatible architecture methods and making them compatible with the climatic features and the needs of human lives in different regions are among the objectives of structure designers in achieving the climatic design. The local structures of Iran have the maximum compatibility with the human comfort conditions. Understanding the climatic methods and updating it can lead to an appropriate environment.

Qazvin is among the ancient cities of Iran with historical texture. The main objective of this study is to indicate that to what extent the traditional buildings of Qazvin are compatible with the human comfort indicators and to extract the solutions of traditional architecture and provide them as the principles of climatic design in Qazvin city.
To achieve the above objective, first the climatic indexes (effective temperature, Givoni, Mahoney, Evans, and texture index) and the suggested architectural solutions of each index are identified based on the ۱۵-year annual and hourly statistics of meteorological organization, Qazvin Airport synoptic station, and then obtained solutions are investigated through an adaptive consideration of main eighteen indexes in Qazvin. Finally, the traditional architectural solutions were proposed as the proposed principles of climatic design in Qazvin. Based on the research findings, suggesting the solutions by the traditional architects in Qazvin city to cope with the adverse weather conditions and use the climatic conditions of Qazvin to make the comfort status suitable, those structures which are connected to human for a long time, have more climatic points and solutions. The climatic architectural solutions in Qazvin city include the extension of structure to the East and West, compact and dense structures, applying the central courtyard, planting trees and using the water pool in the backyard and urban texture, locating a part of structure at the heart of earth, creating the air flow in inside spaces, applying the insulated window with an average size, using the light materials with high thermal capacity in the roofs and walls, and using the porch and dome.

Keywords: climate, architecture, comfort index, traditional architecture, Qazvin city

Introduction

The growing concern during the last decades of the twentieth century and especially since the beginning of the twenty-first century has increased the understanding of the causes, effects and the geography of global climatic changes on current and growing body of knowledge which can be seen in various dimensions of climatic designing, proper utilization of resources, building design, settlement planning, and environmental management. (Worpole, ۲۰۰۰; Porteous, ۲۰۰۲; Roaf, ۲۰۰۵; Thomas, ۲۰۰۸) In fact, the climate has numerous effects on the human history and his architecture, while its effects are rarely seen individually, but a significant combined effect on the overall development of human societies and cultures (Turton, ۲۰۱۲). The study on the evolution of built spaces can be an appropriate way for detecting the factors necessary for preserving, protecting and developing the human-made features according to the cultural and identity fields (Reza, ۲۰۱۱). The existence of environmental problems, which were taken into account by the human society at the end of the twentieth century caused a significant difference between the consideration of weather in the ۱۹۶۰s and the status quo (changes in viewpoints according to the scientific proof of climatic changes and its effects) (IPCC, ۲۰۰۷). Thus since a decade ago, the concepts such as energy and environmental efficiency and environment-compatible sustainability have been significantly entered the architecture issue. The architectural competition held by public bodies of construction based on the full concepts indicates that this issue is significantly important for current society and environment. (Hertzog et al., ۲۰۱۲) The studies have shown that the lack of paying attention to the climatic conditions force us to use the mechanical systems to provide the comfort conditions in buildings. Since ۱۵ to ۲۰ percent of consumed energy in each country is completely assigned to residential consumption, considering any action which reduces the energy consumption through optimal use of heat in the structure will lead to a great saving of natural resources and environmental conservation (Afshari, ۲۰۱۲).
Bioclimatic designing requires identifying the climatic needs according to the studies of human thermal comfort

(Pourvahidi & Odeniz, ۲۰۱۳). Bioclimatic designing (a title introduced by Olgay in ۱۹٦۳) simultaneously considers the proper use of energy and human comfort. Therefore, the energy and comfort in the work by architects have been the key aspects of sustainable designing since ۱۹٦۰ (Tenorio, ۲۰۱۲).

Iran is among the countries with the valuable experience in the field of applying the natural energies with passive method. The long history of residence and its magnificent civilization have created a valuable heritage of useful experiences which provides the residential facilities for people during the long years despite the vast desert areas (Tahbaz and Jalilian, ۲۰۱۱: ۱). Understanding the Iranian local architecture methods and updating it can be along with a less use of fossil energy and environmental pollution. In this regard, this paper is an attempt to investigate the climatic features and architectural techniques of traditional structures appropriate to it as the mechanism to achieve the climate-compatible designing approach in Qazvin city in order to reduce the environmental pollution and as well as paying attention to the past architectural approaches.

The conducted reviews and studies suggest that no research has been done in the field of climate and climatic designing in Qazvin city so far and this research is the first study which investigates the climatic conditions of Qazvin based on the mentioned climate indexes, thus it is new and innovative in this regard. However, the studies have been conducted in the fields of investigating the effective temperature, Olgay, Givoni, Mahoney, Evans, Penn warden and other indexes as the - single or multiple items and for climatic designing suggestions in some of the Iranian cities. For instance, Taghvaei determined the climate of Yasuj city through Celia Neff, Domarten, and bio climatic methods and then measured the comfort conditions and local architecture features of Yasuj based on the effective temperature, and Mahoney indexes (Taghvaei et al, ۲۰۱۱: ۱). Investigating the indexes such as the effective temperature, Olgay, Mahoney and Evans, Hosseini and Maleki studied the climatic impacts on the traditional and modern architecture in Arak city (Malek-Hossein and Maleki, ۲۰۱۰: ۱۳۳). Tavousi and Abdollahi evaluated the temperature conditions of Ravansar City through applying the temperature comfort indexes of Evans, Mahoney, Olgay, and Givoni and provided the architectural design strategies for Ravansar City (Tavousi and Abdollahi, ۲۰۱۰: ۱۲٥). In this study, the indexes including Baker, effective temperature, Olgay, Mahoney, and Evans are investigated and compared in Aligudarz in ۱۰, ۲۰, ٥۰-year intervals (Parvaneh et al, ۲۰۱۱: ۱۱۷) In another study, the climatic needs of Sabzevar city is initially studied through the bioclimatic-construction chart and finally the amount of radiant energy, construction al direction and structure depth are measured by the computational method (Hosseinabadi et al, ۲۰۱۲: ۱۰۳).

۲.Theoretical principles of research:

Climate-compatible Designing (passive designing)

The passive designing refers to designing based on the methods which do not need the energy consumption. (for instance, utilizing the current natural energies in the climate like the wind power, choosing the appropriate form and shell for the structure, etc.) Like any other successful design, this designing should lead to a comfortable and pleasant environment for residents. (Kock-Nielsen, ۲۰۰۲) The theory of climatic designing principles is obtained through the investigation and analysis of conditions affecting the interaction between the human with the environment and architecture. Providing the comfort in the architecture spaces depends on the performance of structure in the climate as well as the way of human behavior in different spaces of structure (Pourdeyhimi, ۲۰۱۱: ۹۸ and ۹۹). Therefore, the implementation of climatic designing is a specific construction method which is obtained by investigating the climatic conditions of location in terms of human comfort, human behavior and interaction with various spaces and environment and designing the structural body (implementation techniques of structure including the thermal insulation, installing the windows, central courtyard dimensions, etc.) (Watson and Labs, ۱۹۹۳)

Climatic design (passive design) does not refer to the removal of heating or cooling systems (active design) or reduction of comfort standards and the mere use of passive design in certain climatic conditions. It means to apply a combination of active and passive design with the objective of eliminating or reducing the mechanical systems in most of the times during a day (Kock-Nielsen, ۲۰۰۲) Thus, since the construction forms and architectural features play the key roles in the performance of energy in the structure (See studies by Cody ۲۰۱۰), this paper explores the form of local structures in Qazvin City.

۳.Thermal comfort

The thermal comfort is a perceptional condition in which the environment is satisfactory in terms of temperature. Thermal comfort is defined as a sense of satisfaction and fulfillment of surrounding temperature and depends on the physical activity and clothing, climatic factors such as the air temperature and the airflow velocity and humidity. Unfavorable parameters lead to the extreme heat or cold feeling in most of the individuals. However, the human body temperature system maintains the body temperature at ۳۷°C by hypothalamus gland and through the physical activities. (Ghiabaklou, ۲۰۱۱: ۱۱۱ and ۱۱۲) Given the parameters affecting the thermal comfort, the comfort zone in different geographical regions and cultures varies from ٥۸ degrees Fahrenheit in the United Kingdom to ۸۰°C in USA. The human body is comfortable in this zone without the use of heating and cooling systems. (Akhtarkavan, ۲۰۱۲: ۳۳). The temperature range of comfort zone in Iran can be estimated from ۲۱,٥ to ۲۹°C in the summer and from ۲۰ to ۲٥,۷°C in the winter (Kasmaei, ۲۰۱۰: ۱٦).

The climatic assessment and physiological relation of human body in the field of degree and a sense of comfort or lack of comfort in different regions can affect the climatic design of structure. Creating the condition in which the human have no feeling of coldness or heat inside and outside spaces are among the main reasons of identifying the climatic indexes in climatic design. Nowadays, the temperature can be easily controlled in internal spaces, while it is achieved in a low extent in the exterior spaces (Akhtarkavan, ٢٠١٢: ٣٣ and ٣٤).

٤.Research Zone

Qazvin city is the capital city and the largest city of Qazvin province located between the longitude ٥٠°- ٠٠' East and Latitude ٣٦°- ١٥' North at the altitude of ١٢٧٧ meters. (Kasmaei, ٢٠٠٣: ٢٨٢). This city reaches Rudbar and Kouhin counties from the North, Alvand and Abyek counties from the East, Takestan from the West, and Buin-Zahra County from the south. The average annual temperature is ١٤,٥°C over a ١٥-year period and the average annual rainfall is around ٢٩٠ mm in this statistical period. Details are shown in Tables ١ and ٢. (١٥-year Statistics of weather station in Qazvin, ١٩٩٧-٢٠١١).

Table ١- ١٥-year climatic annual statistics for Qazvin City (Source: Authors)

Average ١٥-year statistics		January	February	March	April	May	June	July	August	September	October	November	December
Temperature °C	Average maximum temperature	٧	٧	١٣	١٩	٢٤,٥	٣١	٣٥,٥	٣٦	٣٢	٢٧	١٧,٥	١٠
	Average minimum temperature	-٣,٥	-٢	١,٥	٥,٥	١٠	١٤	١٧,٥	١٨	١٥	١٠,٥	٥	٠
	Monthly fluctuations in temperature	١٠,٥	٩	١١,٥	١٣,٥	١٤,٥	١٧	١٨	١٨	١٧	١٦,٥	١٢,٥	١٠

Average annual temperature	١٤,٥
Annual fluctuation	٣٩,٥
Maximum temperature	٣٦
Minimum temperature	-٣,٥

Average ١٥-year statistics		January	February	March	April	May	June	July	August	September	October	November	December
Relative humidity (%)	Maximum Relative humidity	٨٨	٨٩	٧٨	٧٧	٨٠	٦٩	٦٨	٦٥	٦٦	٦٩	٧٨	٨٥
	Minimum Relative humidity	٤٧	٤٥	٣٠	٢٩	٢٩	١٨	١٨	١٧	١٩	٢١	٣٦	٤٥
	Total Mean	٦٧	٦٧	٥٤	٥٣	٥٤	٤٣	٤٣	٤١	٤٢	٤٥	٥٧	٦٥

Table ٢- ١٥-year hourly climatic statistics of Qazvin (Compilation: Authors)

Time \ Month		December	November	October	September	August	July	June	May	April	March	February	January
٣,٣٠	Temperature	١,٢٧	٦,٤٧	١٢,٢٤	١٦,٨٠	١٩,٥٩	١٩,٠٤	١٥,١٧	١٠,٦٢	٦,٧	٢,٤٨	-١,٣	-١,٤٨
	Relative Humidity	٧٩,٢٢	٧٢,٣٩	٥٨,٢٨	٥٩,٠٩	٥٦,٥٢	٥٩,٨٨	٦١,٠٢	٧٢,٣٨	٦٧,٩٦	٦٨,٤٣	٧٩,١٣	٨٠
٦,٣٠	Temperature	٠,٤٩	٥,٦٠	١١,٠٤	١٥,٥٨	١٩,١٢	١٩,١٩	١٦,٣٥	١٠,٩٧	٦,٠٩	١,٥٩	-٢	-٢,٥١

	Relative Humidity	٨١,٤٦	٧٥,٠٩	٦١,٨٣	٦٢,٥٢	٥٨,٨٢	٦٠,٨٥	٥٩,٧٧	٧٢,٧٩	٦٩,٩٧	٧١,٥٩	٨١,١٤	٨٢,٢٣
٩,٣٠	Temperature	٤,٣٩	١١,١٧	١٩,٧٢	٢٤,٤٠	٢٧,٢٣	٢٦,٧٢	٢٤,٢٦	١٨,١٧	٩,٥	٧,٢٣	١,٦٣	٠,٧٨
	Relative Humidity	٦٩,٨٥	٥٨,٠٧	٣٩,٠٢	٣٨,٨٧	٣٦,٦٦	٣٨,١٦	٣٦,٠٦	٤٩,٢٩	٤٩,٤٤	٥٣,٩١	٦٩,٨٤	٧٣,٢٦
١٢,٣٠	Temperature	٨,٢٤	١٥,٠٩	٢٤,٥٤	٢٩,٦٥	٣٢,٣٣	٣٢,٠٧	٢٨,٦٣	٢١,٧٣	١٢,٥	١١,٣٤	٥,٥٦	٤,٧٣
	Relative Humidity	٥٤,٤١	٤٣,٦٩	٢٥,٨٠	٢٣,٧٣	٢٢,٣١	٢٣,٤٢	٢٢,٧٣	٣٥,٨٢	٣٧,٠١	٣٧,٨٦	٥٣	٥٦,٧٢
١٥,٣٠	Temperature	٩,٢٦	١٦,٠٨	٢٥,٨٦	٣١,٥٦	٣٤,٤٨	٣٤,٢٨	٣٠,١٠	٢٢,٦٩	١٥. ٥	١٢:٥١	٦,٧٧	٥,٩٥
	Relative Humidity	٤٩,٨٧	٣٩,٨٥	٢٢,٨٢	١٩,٩٨	١٨,٩٩	١٩,٩٦	٢٠,٥١	٣٣,٧٣	٣٤,٣٥	٣٤,٢٣	٤٧,٨٣	٥١,٢٠
١٨,٣٠	Temperature	٥,٠١	١١,٣٠	٢٠,٤٢	٢٧,٠٧	٣١,٤٣	٣١,٢٣	٢٧,٢١	١٩,٧١	١٨,٥	٩,٢٢	٣,٣٧	١,٩٨
	Relative Humidity	٦٦,٠٢	٥٧,٢٦	٣٦,٦٤	٣١,٠٥	٢٦,٨٧	٢٧,٥٣	٢٨,٣٨	٤٤,٦٩	٤٤	٤٥,٠٣	٦١,١٦	٦٦,٨٥
٢١,٣٠	Temperature	٣	٨,٧١	١٦:٠٤	٢١,٣٦	٢٤,٩٠	٢٤,٥٦	٢٠,٥٥	١٤,٧٢	٢١,٥	٥,٥٨	٠,٧١	- ٠,١٣
	Relative Humidity	٧٢,٧٢	٦٥,٣٩	٤٧,٤٠	٤٤,٨٧	٤٠,٨٧	٤٣	٤٤,٤٨	٥٩,٥٠	٥٦,٣٧	٥٧,٤٣	٧٢,٢٨	٧٤,٥٦
٠٠,٣٠	Temperature	١,٩٨	٧,٤٦	١٣,٧٥	١٨,٧٠	٢١,٨٠	٢١,٥٣	١٧,٦١	١٢,٤	٠,٥	٣,٧٨	٠,٣٨	-١,١٢
	Relative Humidity	٧٦,٣٣	٦٩,٠٣	٥٤,٠٤	٥٢,٦٩	٥٢,٦٩	٥٢,٠٤	٥٣,٠٢	٦٦,٦٦	٦٢,٨٤	٦٣,٨٣	٧٥,٧١	٧٧,٦١

٥.Discussion and Analysis

Effective Temperature Index (ET)°

Diagram "ET" is used in order to obtain the effective temperature. The dry and wet temperatures are connected in this diagram and the intersection of this line with the air flow line is located on one of the effective temperature degrees, thus the numerical value of this criterion is measured (Pourdeyhimi, ٢٠١١: ١٠٦). Nowadays, it has been found that the effective temperature of comfort for the zones located in low latitude is several degrees higher than the effective temperature of zones located in the high latitude of earth (Razjouyan, ٢٠٠٩: ٢٦). Therefore, we considered the range of effective temperature in Qazvin city from ١٨ to ٢٦ degrees according to the latitude of ٣٦°. The following results are obtained according to the review and evaluation of this index which is measured through the relative humidity and dry and wet temperature in Iran during the times ٣:٣٠, ٦:٣٠, ١٢:٣٠, ١٥:٣٠, ١٨:٣٠, ٢١:٣٠, and ٠٠:٣٠ and finally through drawing in the Diagram of "ET":

Qazvin City is outside the comfort zones during the months, January, February, March and November, and tends to be cold. During the months of June, July, August, and September, it is in the summer comfort zone and mainly tends to be hot. During the months of May and October, the weather is in the winter comfort zone. Thus, the weather can be comfortable for the person wearing not-warm clothing in summer and warm clothing in winter. According to the effective temperature in the warm months of year, there is the uncomfortable sense in days and thermal comfort at nights and the cold months have totally the low temperature. According to the time statistics, ٦:٣٠ am has the lowest effective temperature during the whole year and it is at the lowest bound of comfort zone only in August. In the rest of months, the climatic condition of Qazvin in these times is outside of the comfort zone and has the cold stress. ١٥,٣٠ pm in all months has the highest effective temperature and is in the comfort zone in six months of year and outside of the comfort zone in the rest of year. Therefore, it can be generally concluded that the months, May and October, are in the comfort zone from ٩:٣٠ am to ١٨ pm and the months of June, July, August and September are in the uncomfort zones due to the hot temperature (need for shade) from ٩.٣٠ am to ١٥,٣٠ pm and the rest of years are in the cold conditions outside the comfort zone.

٦.Givoni Bioclimatic structural diagram:

The bioclimatic index of Qazvin City is inserted in Psychrometric Table based on the climatic conditions in the period of each ٣ hours per day and then inserted the smaller tables based on the classification of Givoni Tables and its guide and finally the necessary architectural suggestions are presented as follows:

١- The months of May and October are in the zone (N) and their locations on the diagram are in the zone ٥ and at the ranges of ٤ to ٧ in terms of architectural rules. The zone (N) refers to the comfort summer zone in the shade for an environment in which the average temperature is equal to the temperature at night. The human comfort is naturally provided in this zone and the temperature at night is in a way which does not require the use of any heating appliances. In this zone and according to the

architectural rules, the solar heat affecting the structure should be minimized and we should prevent from the entry of sunlight into the structure.

٢- The months of June, July, August and September are considered within the zone (M) and their locations are in the zones ١٠, ١١, ١٥ and ٧ in terms of architectural rules. The zone (M) indicates the set of conditions in which the exterior wall of structure can reduce the temperature inside compared to the outside, so that its inhabitants will have comfortable feeling while resting or doing the low home activity and in the lack of significant airflow. Therefore, the entry of hot air into the structure can be prevented with a maximum delay through applying and choosing the heavy and heat resistant materials. During the nights of this month, belonged to the zone (H) with the expansion of (H'), there is no need for applying the thermal source and mechanical exothermic devices because the minimum temperature inside the structure is higher than the external temperature. In this zone and according to the architectural rules, the solar heat affecting the structure should be minimized and we should prevent from the entry of sunlight into the structure; furthermore, the cold air due to the radiation of long wave of heat from the walls of structure should be used during the months of June, July and August as well as minimizing the heat transfer through the walls of structure, applying the air flow and cooling due to the surface evaporation.

٣- The days in the months such as November and April are within the zone (H) and its expansion (H') and position on the charts within the ranges ١ to ٣ in terms of architectural rules. The zone (H) indicates the conditions in which the minimum temperature inside the structure is sufficiently above the outside air, so that there will be no need to use the heat source. The nights of these months - are also outside the zone (H) and the heating systems should be applied to achieve the thermal comfort. Within this zone and according to the architectural rules, the heat transfer should be minimized through the walls of structure, the air infiltration be prevented and solar heat be utilized.

٤- The months of December, January, February and March are outside the zone "H" at all hours of day and night and outside Givoni bioclimatic chart on the left. (Except December at ١٢,٥ pm and ١٥,٥ pm when are in the zone H) Their positions are on the diagram in terms of architectural rules. For providing the thermal comfort in these months, application of heating appliances and mechanical heating systems is necessary along with the passive solar systems. In terms of the architectural rules, the following cases are essential: The heat transfer should be minimized through the structural wall, and the air infiltration be prevented and the solar heat be utilized.

٧.Mahoney Index:

According to the conducted analyses in Mahoney tables in the field of climatic conditions in Qazvin, the months including January, February, March, April, May, October and December are put in the humidity group ٣ (relative humidity from ٥٠ to ٧٠ percent) and the months including June, July, August, September, and October in the humidity group ٢ (relative humidity from ٣٠ to ٥٠ percent).

Furthermore, the months including January, March, April, May, June, July, August, September, October and November are put in Mahoney index A١ due to the temperature difference over ١٠ degrees between night and day and being in the subgroups ٢ and ٣. Within this range, the weather is cold during the night and it is necessary to be adapted quickly to the environment and change the clothes. The materials with medium to high heat capacity should be applied in order to solve this problem. The months including June, July, August, September and October are put in Mahoney index A٢ due to being exposure to excessive heat over ١٠ degrees at night and being in the subgroup ٢. Fortunately, the body heat is easily reduced in this condition through the radiation to the sky due to the cloudless sky and the body temperature is always six degrees cooler than the surrounding air. The months including January, February, March and December are put in the Mahoney group A٣ due to the lower temperature of day than the minimum comfort and the severe coldness is uncomfortable in this zone.

Based on the conducted assessment in Mahoney Tables, the days and nights of January, February, March, November and December, and nights of April, May and September are not in the comfort zone due to the cold weather; the days of June, July, August, September are not in the comfort zone due to the hot weather and the days of April, May and nights of June, July, August and September are in the comfort zone due to the thermal balance.

Mahoney Table provides and evaluates the climatic conditions and thermal status of a zone in addition to providing the solutions and identifying the architectural issues; the architectural suggestions of Mahoney model for Qazvin city is as follows according to the conducted studies:

١ - The way of constructing the structure along the East and West

٢- Designing the wide and open space for applying the wind in the case that the hot and cold wind is prevented.

٣- Conjoined rooms and forecasting the permanent air flow temporarily and for all rooms if necessary.

٤- Medium-sized windows with the openings with ٢٠ to ٤٠ percent of area of the northern and southern walls.

٥- Heavy walls (internal and external) with high thermal capacity.

٦- The use of heavy construction materials with the time delay of more than ٨ hours in ceilings and roofs.

٧- Building the appropriate place for sleeping (terrace) for the nights of June, July, August and September due to the moderate and comfortable weather at the range of comfort temperature.

٨.Evans index:

Based on Evans index and according to the considered stages in Evans table, the thermal status was investigated in both day and night and its results are as follows:

The weather is always cold in the days and nights of January, February, March and November and the

temperature is comfortable in the whole day of April, May, September and October and the whole night of July and August. However, the weather is cold at the nights of July and August due to the wind blowing at the velocity of one meter per second. The whole day is warm in June, July, August and September. However, the weather becomes fine in the case of blowing the wind with the velocity of one meter per second in the days of June and September (Table ٣).

According to Evans index and architectural rules: The materials with high thermal capacity and delay time should be applied during the day and night in July and August due to the high temperatures and temperature fluctuations. The structure should be protected from strong radiation and winds in April, May, June, September and October when there are comfortable days. Due to the low temperature and cool weather of day in November and December, it is necessary to have the high insulation and use the temporary heating appliances. The appropriate and permanent heating appliances are essential in January and February due to the low temperature of day and cold weather.

The appropriate insulation and structural materials with medium to high thermal capacity are essential in January, February, March, April, May, November and December due to the low air temperature at nights.

Table ٣- Climatic status of Qazvin City based on Evans criterion (Source: Authors)

Thermal status at the scales:	January	February	March	April	May	June	July	August	September	October	November	December
Day	Cold	Cold	Cold	Comfortable	Comfortable	Hot **	Hot	Hot	Hot **	Comfortable	Comfortable	Cold
Night	Cold	Cold	Cold	Cold	Cold	Cold	Comfortable*	Comfortable*	Cold	Cold	Cold	Cold

* It is cold in the case of blowing the wind with the velocity of ١ m/s.

** The weather will be fine in the case of blowing the wind with the velocity of ١ m/s.

٩.Comfort outside the structure (texture-comfort index):

The comfort status outside the structure in Qazvin city is investigated and analyzed through the average maximum and minimum temperature and the velocity of current hurricane in all months of years according to the shade comfort and sunshine zone; the results are as follows:

١- March and April under the sunshine: The early morning weather is cold in the case of blowing the wind faster than ١ meter per second and fresh at other times.

March and April under the shade: The early morning weather is cold and fresh at other times.

٢- May under the sunshine: The early morning weather is fresh in the case of wind faster than ١ meter per second and warm at other times.

May under the shade: The early morning weather is fresh and warm at other times.

٣- June, July, August, September and October under the sunshine: The early morning weather is fresh in the case of wind faster than ١ meter per second and hot at other times.

June, July, August, September and October under the shade: The morning weather is often fresh, but hot at other times. Furthermore, the early morning weather is cold in the case of wind faster than a half of meter per second.

٤- November under the sunshine: The early morning weather is cold except when the airflow is very slow. The midday weather is warm and it is fresh at other times.

November under the shade: The weather is fresh only during the midday and it is cold at other times.

٥- December, January and February under the sunshine: The early morning weather is cold except when the airflow is less than ٠,٣ meters per second. The weather is warm during the midday and is fresh at other times.

December, January and February under the shade: The weather is fresh at the midday and cold at other times.

According to the conducted assessment, the weather is fresh for pedestrian walkway either under the sunshine or shade in the morning of spring and summer with respect to the clothing proportional to the season, and it is warm during the midday. The weather is too cold in autumn (October and November) and winter (January and February) and warm during the midday and fresh at other times. Furthermore, the architectural feature of pathways and open spaces of region can be well determined through the texture-comfort index. The pathways and open spaces in Qazvin should be designed with full shade in summer and with the possibility of airflow and with sunshine and away from the wind in the winter.

١٠.Climatic requirements of Qazvin City in terms of human comfort and construction conditions:

According to the survey conducted on five climatic comfort indexes at the previous stage, the climatic requirements can be outlined in terms of comfort, overall climatic features, and climate-compatible construction conditions:

In general, the climate of Qazvin City has the relatively warm and dry weather with cold winters; and according to its architecture and the climatic indexes, avoiding the winter coldness is prior to summer heat. The need for shade is felt in May, June, July, August, September and

October due to the warm weather. The shade is not enough at the midday of June, July, August, September and October and applying the appropriate materials and evaporative cooling by water and plant will provide the comfort conditions. Except the July, August and September, when the nights are relatively comfortable (and the resting and sleeping space can be provided through the appropriate designing of the semi-open space (terrace), the other months have very cold nights and the heating appliance is necessary except for the nights of May and October. Due to the dry weather and high humidity during May, June, July, August, September and October, when are along with the high temperature during ٩ am to ٦ pm and sometimes throughout the peak summer hours, the air can be cooled be applying the evaporative cooling of water and plant surface. The freezing is possible in this climate during December, January and February. The night temperature reaches below zero in November, December, January, February, March and April; and melting, freezing, and destroying the materials can be occurred during December, January and February. In the late January and the whole February, the weather is always below ٥°C in the whole day and this is usually due to the wind flow along with the severe coldness which should be avoided. Throughout June, July, August, September, December, January and February, it is essential to apply the materials with high thermal capacity (capacitor) in order to protect the inside temperature against the outside temperature. During October, November, December, January, February and March, the heat exchange of structure wall and air infiltration from the joints and cracks should be prevented and the sunshine and its heat be applied through the climatic design and passive method (Table ٥).

According to the studied indexes, the days and nights of January, February, March, November and December and nights of April, May and September are outside of the comfort zone due to severe coldness of weather air; the days of April, May, October and November and nights of June, July, August and September are in comfort zone and the days of June, July, August, September are outside of the comfort zone due to the high temperature of weather.

Table ٤- Climatic requirements of Qazvin City (Source: Authors)

Temperature conditions	Climatic requirements of Qazvin	Time	
		Day	Night
Cold weather	Freezing	٣ months	
	Avoiding the cold winds	٢ months	٦ months
	Heating appliance		٧ months
	Capacitor materials		The whole year
	Sunshine	٥ months	
Warm weather	Shade and using the outdoor air	٧ months	
	Evaporative cooling and air flow	٥ months	
	Evaporative cooling and capacitor materials	٥ months	

Figure ١- Calendar of the need for shade and sunlight based on the bioclimatic-structural index – Source: Authors

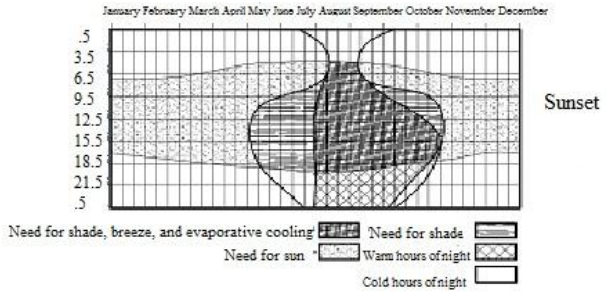
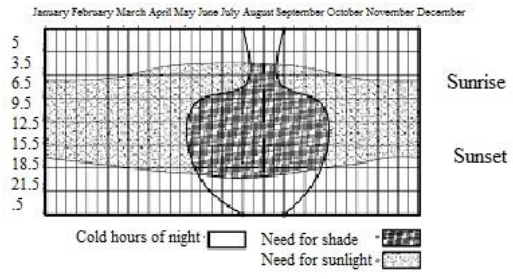


Figure ٢- Calendar of need for shade and sunlight based on the effective temperature index- Source: Authors



١١.Traditional architecture in Qazvin City:

The geographic and climatic, economic and demographic features, social status, and climatic factors are effective in creating the architectural spaces as well as the way the residential units are located towards each other and their accumulation. In terms of the way the physical spaces are situated along each other, the ancient texture of Qazvin districts is generally free connected and has the organic and non-geometric shape. Neighborhoods are mainly unique and rarely as same as other neighborhoods because of the internal forces and the gradual growth of residential areas. The houses are built in relation to the spatial organization of districts in the city and utilization of the natural sources such as light, wind and avoiding the undesirable side effects associated with designing the streets and squares. (Mojabi ٢٠٠٩, ٣٥٦) Direction and position, and the height of structures around the lane are directly related to the weather conditions and its performance. In an area of approximately ٧٥ acres of old texture of Qazvin, ٥٨٪ of houses are Northern and Southern and ٤٣٪ are Eastern-Western which indicate the understanding of angle and intensity of solar radiation and complying the weather conditions. The lanes have no serious problems of freezing and traffic due to the narrow width in the cold season and winter and the ice and snow are melt very soon while exposing the sunshine. The width of lane and height of side walls are in a way that the lane width is narrow in the by-lanes, but the pathway width is higher than the height of adjacent wall in the main streets, at the intersections especially in the pathways. (Ibid, ١٢٥)

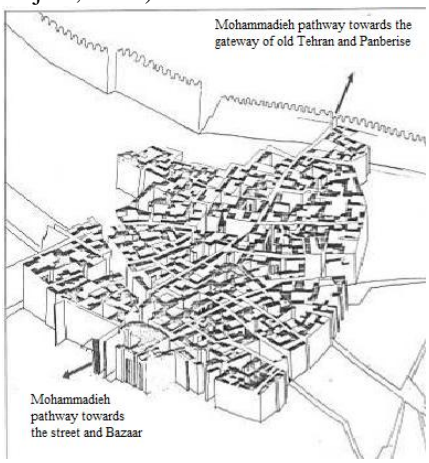
The facing-the-Qibla side of architectural design, known as Four Seasons or Doursaz (Far-construction) which were as the results of climatic conditions of Iran in Qazvin was more taken into account. The sunlight-facing side was the main side and others were quite subsidiary. At the center of house, the courtyard was covered with the bricks or circular and small river stones with the shape of asymmetrical eslimis around the garden along with a pond in the middle. Belvedere was considered as the main spaces of house for the night life of summer and it was a few steps above the floor with a half opened space that sometimes was connected to the hall with multiple door. Each of the space classification of architecture in Qazvin City have been investigated and provided as the main architectural principles which are compatible with climate; and maintaining the comfort conditions are presented as the solutions:

١٢.A. General Principles (these solutions are effective in the structures):

١- The structures in Qazvin city were often built too compact and dense in several floors and often by maintaining the concentration for not avoiding the desirable winds. The coherent and chain-like texture protected the structure against the sunshine during the summer and intense coldness in winter (Figure ٣).

Figure ٣- Old texture of Qajar era in Qazvin (Source: Mojabi, ٢٠٠٩)

Figure ٤- Panberise neighborhood of Qazvin. A model of base bed of Qazvin texture which is flat and extended along the horizontal- eastern and western axis. (Source: Mojabi, ٢٠٠٩)

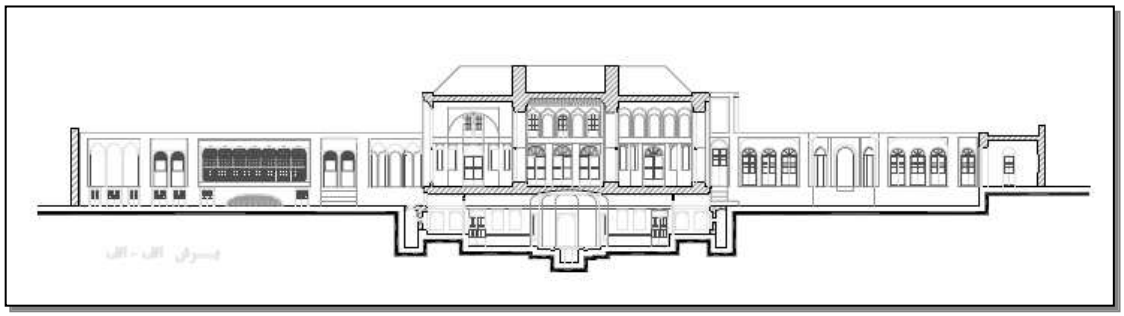


٢- Most of residential structures of this city have the eastern and western direction to avoid the coldness of winter and heat of summer which relatively occur in a third of year.

٣- To reduce the heat transfer from the exterior wall of structure in this city, the structure volume was usually considered with less lateral surface and by connecting the side walls of structure to the adjacent structures. Most of the structure plans had round and cubic shape (Figure ٤).

٤- A part of structure in Qazvin city was built inside the soil in order to provide the comfort in order to apply the cooling feature of ground and the thermal conductivity and low heat exchange (Figure ٥).

Figure ٥- Aminiha Hosseinieh. Using the basement to make the air fresh during the summer through applying the pond of water (Source: Parhizkari, ٢٠٠٦)



٥- The windows are not too small in Qazvin city. The sunshine was more utilized through the medium-sized windows and they gave the way to the desirable winds to enter into the internal space.

٦- The light materials were applied for covering of external bodies due to the harsh sunshine.

٧- The materials of ceiling and wall of structure were chosen with high thermal capacity and delay time for adjusting the temperature fluctuations of outer space of structure, thermal delay, and applying the heat stored in the walls during the cold nights of winter.

B: Open spaces

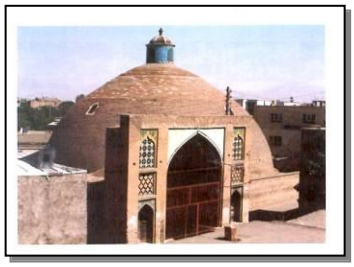
٨- The structures often have a central courtyard. The structure is built on four sides of courtyard in these types of houses. The facing-the-south spaces were applied in the winter and facing-the-summer spaces in the summer.

٩- The pond with fountains, garden and tree were applied in the yard in order to use the evaporative cooling, cool the air, and reduce the sunshine-facing surfaces in warn seasons.

١٠- The structure roof was usually built flat due to the dry weather and the possibility of using the radiative cooling feature of structure mass in order to apply the appropriate open space for applying at summer nights.

١١- The absorption of heat from the roof was avoided through applying the dome and cylindrical covers which reduced the speed of cooling or warming by increasing the volume of air in the space (Figure ٦).

Figure ٦- Sardar water reservoir of Qazvin. Using the dome to keep the water cool and avoid the coldness and heat. (Source: Mojabi, ٢٠٠٩)



١٣.C: Closed spaces:

١٢- Application of basement is very common in the summer due to the cool and humid space.

١٣- The bedchamber and hall in mosques and caravanserais with pillars and thick walls provided the required warmness during the cold weather, and the windows and openings on two opposite sides along with the domed ceiling provided the air ventilation and circulation in the space.

١٤- The main spaces of house including the bedrooms, living room, and guest room were connected together and all of them became a large unit if necessary, thus the required warmness and coldness were provided through reducing the space in the winter and connecting the spaces in the summer.

١٥- The spaces like the basement, hall, spring room (pond), Payab and Tanabi were built in the summer-stay part of structure on the southern side of house due to lack of sunlight.

١٦- The northern side of house was called the winter-stay part in which the spaces such as Tehrani, three-door, five-door, and upper seat room were built due to the sunshine and they were the appropriate places for the winter.

١٧- The summer spaces in the structure were usually larger with higher ceilings and the winter spaces were smaller with ceilings, thus the house became cooler in summer and warmer in the winter (Pirnia, ٢٠١١: ١٦٢ - ١٦٤).

١٤.D: semi-open spaces:

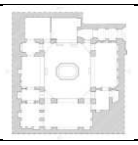
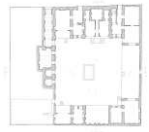
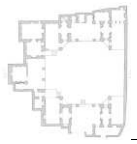
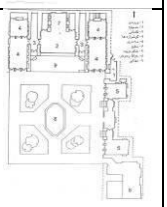
١٨- Iwans (porches) were applied as the semi-open spaces, the semi-open fore-spaces, and independent semi-open spaces to avoid the summer sunshine on the windows and walls. Iwans prevented the high temperature of room during the summer and provided the outdoor space during the hot days. They were also the mediators between the room and outside cold air.

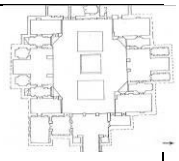
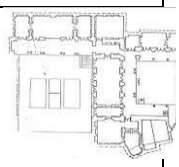
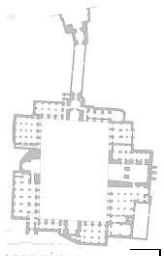
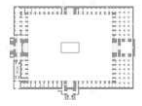
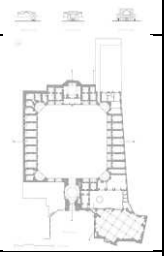
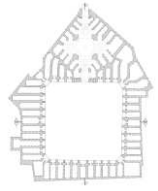
١٩- On four sides of courtyard in some of the structures, the enclosed iwans (porches) were built in front of the structure in addition to the main iwans and they were used as the semi-open space for utilizing the sunshine or shade.

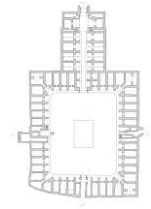
٢٠- The small iwans and porticos were usually designed in a row of Eastern and Western sides of structure due to the Western and Eastern sunshine of arches.

٢١- The Belvedere was considered as the summer-stay spaces of some houses, mosques, schools and caravansaries. Belvedere was a semi-open space with a few stairs higher than the yard floor.

Table ٥- Investigating the spatial climate-compatible elements in famous structures of Qazvin City; Source: Authors

Name of structure	History	General Principles							Open spaces				Closed spaces						Semi open-spaces				Plan
		١	٢	٣	٤	٥	٦	٧	٨	٩	١٠	١١	١٢	١٣	١٤	١٥	١٦	١٧	١٨	١٩	٢٠	٢١	
Aminiha Hosseinieh	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	
Akhavizadegan Hosseinieh	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	
Ardekani House	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	
Mirianzadeh House	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	
Behrouzi House	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	
Mortazavi House	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	
Motamedi House	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	

Ashouri House	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	
Zarrabi House	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	
The grand Mosque	The early centuries of Islam to Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓		
Sardar Mosque and school	Qajar	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓				✓	✓	✓	✓	✓	
Salehieh Mosque and school	Qajar	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓				✓	✓	✓	✓	✓	
Nabi Mosque	Qajar	✓		✓		✓	✓	✓	✓		✓	✓		✓				✓	✓	✓	✓		
Shaykh-ol-Eslam school	Qajar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	
Ettefaghieh School	Qajar	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓				✓	✓	✓	✓	✓	
Haj Reza House	Qajar	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓				✓	✓	✓	✓		

Razavi House	Safavid - Qajar	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓				✓	✓	✓	✓	
Sa'd al-Saltanah House	Qajar	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓				✓	✓	✓	✓	
Total Scores of Spaces		١٨	١٤	١٨	١٢	١٨	١٨	١٨	١٨	١٧	١٨	٩	١١	٩	٩	٩	٩	١٨	١٨	١٨	١٨	١٣	

١٥.Conclusion

According to the conducted study and perception of Qazvin traditional architectural strategies which indicate the architects' attempts to achieve the climate-compatible architectural solutions, those structures which are connected to the human in a long term such as the house, mosque, and school have more climatic strategies and tips and provide the solutions for creating the comfortable conditions at all applied hours of structure. Furthermore, the other findings of this study include the accuracy of climate-compatible comfort indexes' performance in Qazvin, similar architectural solutions and applicable comfort indexes through the traditional architecture of Qazvin. According to what is obtained from the final results of analysis, the following cases can be considered as the principles of climate-compatible architecture in Qazvin City.

- The best way of building the structure with the expansion in the East and West direction.
- The compact and dense structure plans while keeping the compression in multiple floors.
- Most of the structure plans had round and cubic shape.
- Using the central courtyard and locating the space on four sides of yard.
- Planting the trees and using the pond in the yard and urban spaces.
- Designing the appropriate outdoor space for nights of summer and warm months.
- Building a part of structure inside the ground and covering the exterior walls with soil.
- Applying the basement and water pond in the basement to use the evaporative cooling and redirecting it to the upper spaces of structure.
- The connected rooms and spaces and temporarily consideration of air flow for all rooms if necessary.
- Applying the medium-sized windows with ٢٠ to ٤٠ percent area of northern and southern walls.
- Applying the sunshine as the light and thermal energy in the structure by the windows and apertures.
- Designing the windows insulated against the cold winter along with good shade in summer.
- Applying the light materials for the side facing the sunshine and the outer body.
- Applying the materials with high thermal capacity and high delay time in inner and outer walls.
- Applying the materials with high thermal capacity and high delay time in the roofs and designing the flat roofs.
- Applying the domed and cylindrical coverage in spaces with broad areas.
- Connecting the rooms and spaces of structure with the outside and open space on the one side for the airflow in the summer.
- Applying the iwan (porch) as the fore-space in designing the structure.
- Construction of pathways and streets with full shade and wind in the summer.
- Construction of pathways and streets with full sun and far from wind in the winter.

According to the principles above, a new step can be taken in climatic designing of Qazvin City through utilizing the past architectural solutions and creating the new solutions in accordance with mentioned principles.

References

١. Akhtarkavan, Mehdi Adjusting the Iranian climate-compatible conditions. Kalhor Publications, Tehran. (٢٠١٢)

٢. Qazvin Meteorological Bureau. ١٥-year Statistics of meteorological station of Qazvin airport, (٢٠١١)

٣. Parvaneh, Behrouz; Shahrokhvandi, Seyed-Mansour; Nazari, Najmoldin Determining the status of climatic comfort at decade scale based on the bioclimatic indexes (Case study: Aligudarz City). Amayesh Geographical Journal, No. ١٤, pp. ١١٧-١٤٢. (٢٠١٠)

٤. Parhizkari, Mehrzad The map of historical structures in Qazvin Province, cultural heritage and tourism office of Qazvin Province, Qazvin. (٢٠٠٦)

٥. Pourdeyhimi, Shahram The climatic language in environmental designing, Shahid Beheshti University, Tehran, Vol. ٢. (٢٠١١)

٦. Hassanabadi, Saeed et al The climatic designing of residential structures in Sabzevar city with emphasis on the direction and depth of shade, geography and expansion, No. ٢٧, pp. ١٠٣-١١٦. (٢٠١٢)
٧. Tavousi, Taghi; Abdollahi, Aram Assessment of temperature comfort indexes and climate-compatible architecture in Ravansar. Scientific and research journal of geography and planning, University of Yazd, No. ٣٢, pp. ١٢٥-١٥٠. (٢٠١٠)
٨. Tahbaz, Mansoureh; Jalilian, Shahrbanoo The principles of designing the climate-compatible architecture in Iran with an approach to the architecture of mosque, Shahid Beheshti University Press, Tehran. (٢٠١١)
٩. Ghiabaklou, Zahra Principles of structure Physics ٢, adjusting the environmental conditions. Jahad Daneshgahi publication of Amir Kabir university branch, Tehran. (٢٠١١)
١٠. Kasmaei, Morteza The climate and architecture. Khak (soil) Publication, Isfahan. (٢٠١٠)
١١. Mojabi, Seyed-MEhdi In the search of urban identity of Qazvin. Publication of Center for Architecture and Urban Studies and Research, Tehran. (٢٠٠٩)
١٢. Malek-Hosseini, Abbas; Maleki, Alireza The effects of climate on the traditional and modern architecture of Arak city. Amayesh Geographical Journal, No. ١١, pp. ١٣٣-١٥٥. (٢٠١٠)