37
Bu-Ali Sina University
Iranian Scientific Archaeological Association
PAZHOHESH-HA-YE BASTANSHENASI IRAN
P. ISSN: 2345-5225 & E. ISSN: 2345-5500
Homepage: https://nbsh.basu.ac.ir/
Vol. 13, No. 37, Summer 2023

Building Orientation; Climatic Adaptation Technique in The Vernacular Architecture of Cold Regions of Iran (Case Study: Vernacular Houses in Hamadan)

Alitajer, S.[1]; Shahabi, S.[2]

https://dx.doi.org/10.22084/NB.2023.27359.2546
Received: 2023/01/14; Accepted: 2023/04/10
Type of Article: **Research**
Pp: 333-361

Abstract

In recent years, the importance of energy conservation has increased due to the lack of energy resources and environmental problems caused by the use of non-renewable energy. Energy efficiency in the housing sector is very high and consumption is expected to increase as the world's population grows. Creating comfort in buildings against climate problems is allocated to high energy consumption. It is appropriate to study the solutions employed in vernacular housing to deal with climatic problems and provide comfort for residents. Buildings consistent with the climate can reduce energy consumption. The vernacular architecture reflects the harmony between architecture and climate and has been providing comfort for the residents with passive solar techniques. This article addresses several vernacular houses in Hamadan with a cold mountain climate in the west of Iran in order to identify effective factors in reducing energy consumption. This study is aimed to find the most important factor in the formation of climate-adaptive vernacular houses in Hamadan. In this article, effective climatic factors are initially extracted for vernacular houses through previous studies and a variety of factors are then analyzed by an investigation into vernacular houses in Hamadan and simulation of some factors. The orientation was noticed as an important factor in previous studies, which is quantitatively investigated in this article by simulating vernacular houses. The houses are simulated by Design Builder software based on two factors: orientation and the window-to-wall ratio. It is concluded that although various factors contribute to the reduction of energy consumption in vernacular architecture, the most important factor is the orientation of houses toward the sun. The orientation particularly affects the area of openings on a facade and the energy consumption for heating. The results show that other protective factors against cold climate depend on the orientation of houses towards the sun and are formed based on it.

Keywords: Vernacular Architecture, Hamadan Vernacular Houses, Climatic Architecture, Climatic Passive Techniques, Orientation.

1. Associate professor, Department of Architecture, Faculty of Art and Architecture, Bu-Ali Sina University, Hamadan, Iran (Corresponding Author).
Email: Alitajer@basu.ac.ir
2. Ms in Architecture, Department of Architecture, Faculty of Art and Architecture, Bu-Ali Sina University, Hamadan, Iran.

Citations: Alitajer, S. & Shahabi, S., (2023). "Building Orientation; Climatic Adaptation Technique in The Vernacular Architecture of Cold Regions of Iran (Case Study: Vernacular Houses in Hamadan)". *Pazhoheshha-ye Bastan Shenasi Iran,* 13(37): 361-333. https://dx.doi.org/10.22084/NB.2023.27359.2546
Homepage of this Article: https://nbsh.basu.ac.ir/article_5321.html?lang=en

PAZHOHESH-HA-YE BASTANSHENASI IRAN
Archaeological Researches of Iran
Journal of Department of Archaeology, Faculty of Art and Architecture, Bu-Ali Sina University, Hamadan, Iran.

Introduction

The building sector is one of the biggest economic activities throughout the world. The energy consumption in the buildings sector is very high and is expected to increase further because of the improvements in living.... standards and the increase in the world's population (Kumar Singh et al., 2011; Bee, 2010; Singh et al., 2009a). With the current trend of urbanization and increasing living standards, the energy demand for residential buildings is increasing more than ever before (Gou et al., 2015).The solar passive building design techniques were practiced for thousands of years, by necessity, before the advent of mechanical heating and cooling (Chandel and Aggarwal, 2008). Vernacular architecture is considered as an architecture which is compatible with the climatic conditions. Climate-responsive strategies, which are widely concealed in the traditional vernacular dwellings all over the world, are typical passive designs (Gou et al., 2015).

Climate-responsive buildings seem to be the most appropriate solutions to meet the increasing energy needs, particularly in developing and less developing countries (Kumar et al., 1994). Vernacular architecture sets an example of harmony between dwellings, dwellers, and the physical environment (Singh et al., 2009b). Given the cold mountain climate, the cold is the main factor in climatic problems in Hamadan. Buildings require heating for about 3 to 5 months, on which vast sums and high amounts of energy are spent annually. In Hamadan, vernacular houses provide comfort for the residents with no need for detailed heating systems. It is necessary to study the vernacular houses of Hamadan in this research due to their valuable features. The focus of this research is on the direction of building design in Hamedan trying to investigate its effect among other climatic factors. The orientation of buildings based on the principles and conditions of the native climate in each region can determine the amount of solar radiation absorption. While the architects have to choose the direction of the building by calculating the amount of solar radiation at different hours of the day and on different days of the year, the maximum amount of solar energy absorption occurs in the cold period of the year. Studies show that 77.8 percent over year, the temperature in Hamedan is less than 21 degrees, and this period is the time when the sun and solar energy are most needed, which is known as the cold period of the year. Considering the special geographical location of Hamedan city and its location on the relatively cold slopes of the Alvand mountain range, the orientation of the buildings should be such that in order to save energy consumption in the cold period, the buildings receive the maximum amount of solar energy. In order to achieve this goal, the present study tries to investigate the architectural climate conditions of Hamadan with regard to the amount of solar radiation and determine the optimal orientation of the buildings. The effect of urban geometry and orientation on solar access and shading conditions for different latitude conditions has been studied by researchers while other studies have examined the relationship between urban density, orientation and solar access issues, in an effort to investigate urban design options. This study is conducted on several vernacular houses in Hamadan to indicate the importance of vernacular dwellings as a model for today's architecture and identify the most significant factor of climatic adaptation.

These houses date back to more than 70 years ago when fossil fuels were not commonly used. In Hamadan, most of the vernacular houses have been destroyed and disappeared over years and only a few have remained, of which only about 55 houses can be surveyed because they have been registered by the Cultural Heritage, Handicrafts, and Tourism Organization of Iran and their documents and drawings are available.

These houses are divided into 3 categories: 1. garden houses with large areas, which are not investigated here because they are not affordable as today's dwellings and involve huge spaces and gardens; 2. large houses where living spaces are arranged around the courtyard and separated in accordance with warm and cold seasons, they are not investigated here because today it is not possible to build such houses; 3. four houses registered by Cultural Heritage, Handicrafts and Tourism Organization of Iran, where the spaces are located on one side of the courtyard and less area is occupied, they are climate-adaptive and more compatible with modern construction. 3 houses are selected from these 4 houses and analyzed due to their similarity in terms of formal structure and interior spaces. The difference between these houses that matters to us is their rotation towards the southeast. Another reason for choosing these houses is their different locations in Hamadan. Each house is located in a different neighborhood; so it can be claimed that constant principles are noticed regarding the building orientation despite different locations (Fig. 3).

The research questions are as follows: Which features are important in the vernacular architecture of Hamadan? Which features are superior to the other and form the basis of the vernacular architecture of Hamadan? The purpose of this research is to find climate-compatible features in the traditional houses of Hamadan. Features that can be used even in today's architecture.

Literature review

- Importance of vernacular architecture in energy efficiency

Achieving thermal comfort has always been one of the goals of building design and construction. This topic includes all types of functions such as residential, office, commercial, etc. The residents always try to address constraints (Kumar Singh et al., 2011). One of the main goals of building design is to provide a comfortable space for living (Shanthi Priya et al., 2012). Of the various factors that affect architectural design, climate control is of prime importance for maintaining comfortable conditions inside the buildings (Vural et al., 2007). Any good building should relate and respond to the climate (Shanthi Priya et al., 2012). Climatic issues have always been a problem for the people, over thousands of years people have tried to find solutions for the problem (Tavasoli, 1981) [6].

The term, environmental architecture, means the architecture adjusted to its surroundings or in harmony with nature creating a healthy environment for human beings by maximizing the utilization of natural energies (Dili et al., 2010a). The vernacular building construction technique and specifications are more based on knowledge achieved by trial and error rather than conventional practices. This art is more often transferred by traditions and handed down through the generations (Kumar Singh et al., 2011; Singh et al., 2009b). These solutions represent the perfect balance between naturally built environment and limited technical resources (Zhai & Previtiali, 2010). Climatic design involves a series of applied and scientific principles.

It seems that there are two very important issues, the first is the search for sources of energy and the second is its preservation and saving. In an era when energy efficiency is an important area of concern, studying vernacular architecture has still something new to explore (Al. Azzawi, 1994). Typically, more than 80% of total energy consumption in the buildings sector occurs during the operation of the buildings and around 20% during the construction of the buildings (Liu J et al., 2010). Buildings account for 45% of worldwide energy use and hence significant amount of greenhouse gas emissions to the environment is related to this energy use (Singh et al., 2009a).

If energy efficiency measures are incorporated in the building judiciously, then the potential for energy savings could be 40–50% in these buildings (Bee, 2010; Kumar Singh et al.; 2011).

Energy savings can be achieved in different ways, of which the most effective one is the design with careful attention to available energy resources in the given region and making the building compatible with the climatic and environmental conditions in terms of location, form and so on to benefit those energies. (Koch-Nielsen, 2002). Incorporating appropriate solar passive features in climate-responsive buildings is a good option for energy conservation (Kumar Singh et al., 2011). A solar passive house/structure is designed such that it makes effective use of solar radiation to warm up indoors in winter for heating and to block out this radiation in summer for cooling (Nayak and Prajapati, 2006). The design of solar houses/structures requires a detailed understanding of the complex relationship between architectural textures, human behaviors, culture, and climatic factors (Nahar et al., 2003). Issues related to energy saving and environmental problems have increased interest in traditional architecture in recent years. A style of architecture that is famous for attention and precision in saving energy.

Vernacular architecture is widely recognized as a practical, effective and popular solution (Tuan Nguyen et al., 2011). Vernacular architecture can be therefore described as a genuine climate-responsive and environmentally-friendly architecture (Philokyprou et al., 2017). Traditional buildings use passive methods to respond to their local climate and improve the indoor thermal environments (Huang et al., 2016). This architecture is a source of great wealth for the new architecture (Dili et al., 2010b; Kumar Singh et al., 2011). The principles which were used in traditional buildings can very well be implemented in modern buildings so as to produce energy-fewer consuming buildings (Shanthi Priya et al., 2012).

- Accomplished studies

Previous studies should be investigated to understand the important factors in the climate-adaptation of the vernacular architecture described in this article. The main factors derived from previous studies and used in this research are orientation, spaces, openings, facade materials, etc. There are various studies about the capabilities of vernacular architecture for modeling; so some of these studies are mentioned here, which are carried out in different regions and climates around the world and partly resemble this research in terms of the classification of factors. According to a field study on a number of vernacular houses in the northeast of India for identification of passive solar systems in the buildings with the aim of reducing energy consumption, Singh (2011) concluded that these systems depended on building form, orientation, facades, openings, shading, natural ventilation and arrangement of interior spaces [1]. This area was mainly divided into 3 microclimates, i.e. warm and humid, cold and humid, and cold and cloudy. In the warm and humid zone, the building form which was adapted to the wind direction for more ventilation had priority over other factors. In the other two zones, the orientation aimed at receiving maximum solar radiation was the most important. In the cold climates, the openings were small and fewer in number in comparison with the warm zone.

According to qualitative and field investigation and analysis of passive systems in vernacular residential architecture in Kerala (India), Dili (2010a) showed that the indoor environment was formed by the building orientation, arrangement of interior spaces, inner courtyard, existing local materials, openings, and construction techniques [8]. In an area with a warm and humid climate, the building orientation is a major factor to benefit from the wind and to protect against sunlight.

A study on the features of traditional architecture was carried out by Oikonomou and Bougiatioti (2011) in Florina in the northwest of Greece with a cold and humid climate [24]. Given the qualitative and quantitative analysis of various architectural aspects such as the building typology, form, orientation, openings, and construction techniques, it was concluded that the orientation for receiving solar radiation affects other parameters, e.g. the window-to-wall ratio, and the rooms were also oriented towards the sun.

Shanthi Priya (2012) conducted quantitative and qualitative research on the vernacular architecture of the Nagapattinam and Tamilnadu coastal regions with a hot and humid climate in India [7]. Qualitative studies were conducted on the building orientation, inner courtyard, openings, and thickness of walls, while quantitative studies addressed the moisture content and temperature of rooms in the summer. The buildings had an extended form facing the sea breeze and were less exposed to the sun, which indicates the importance of orientation.

Examining a specific type of vernacular architecture in Greece, known as "Sernikaki", which was located in a mountainous region with a cold and temperate climate, Vissilia (2009) revealed that the local buildings were formed according to the orientation principle and wind direction [25]. The buildings had a cubic compact form. The windows were embedded on the sun-facing facade, while there were fewer windows on other facades. This study illustrated climate techniques, such as orientation, spaces, openings, facades, etc. that make a relationship between location, building, and weather and can be used for optimization of modern architecture.

The results of these studies are presented in Table 1. The table shows that orientation is considered the most important factor in all these studies. In this study, orientation is also noticed as the main factor and it is attempted to highlight its importance because it is not addressed quantitatively in the previous studies. Hence this study aims to accurately examine the orientation and also the window-to-wall ratio that is highly dependent on it. Other factors are briefly discussed. As seen in the table, the roofs of buildings are not investigated in the previous studies, but the form of roofs is also important and briefly explained here because "the roof of a building is directly exposed to the solar radiation and heat and its form is of great importance in each climate" (Koch-Nielsen, 2002) [12].

Table 1: A summary of previous studies and investigated factors (Authors, 2022). ▼

Researcher	Orientation	Form	Courtyard	Arrangement of interior spaces	Openings	Facade
Singh et al., 2011	×	×		×	×	×
Dili et al., 2010	×		×	×	×	×
Oikonomou, 2011	×	×			×	
Shanthi et al., 2012	×		×		×	×
Vissilia, 2009	×			×	×	×

Mountainous area of Hamadan

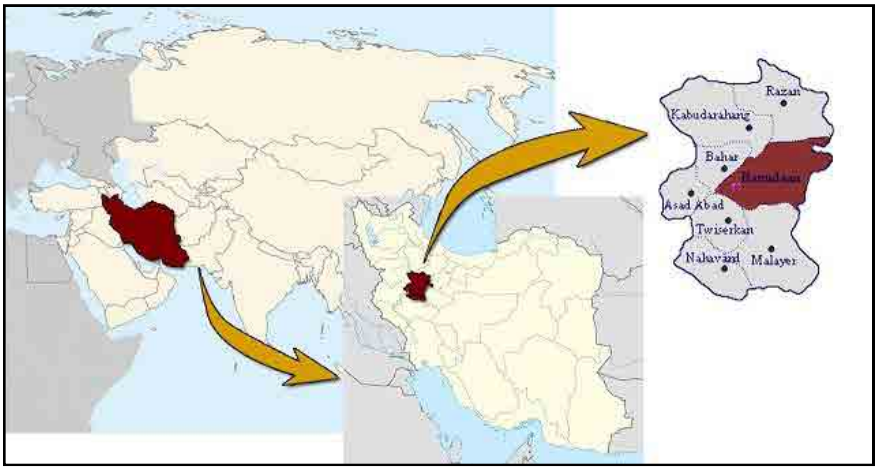
- Topography

Hamadan city is located on the high foothills of the Alvand mountainous area in the west of Iran (relatively cold winters and hot summers) (Fig. 1) (Tahbaz and Jalilian, 1998) [26]. The city has an altitude of 1741.5 meters above sea level, located at a latitude of 34° 52' N and a longitude of 48° 32' E (www.hamadanshahrionline.ir) [27].

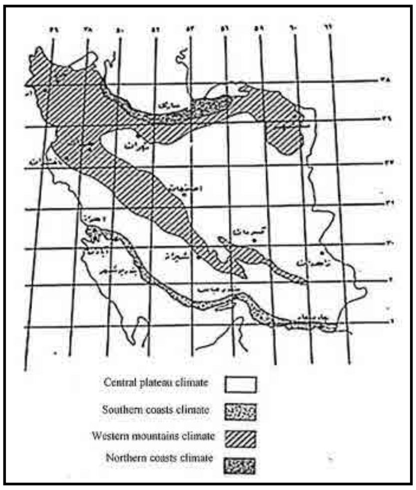
- Introduction to the climate of Hamadan city

Hamadan is located in a cold mountainous region. The Zagros Mountain Range acts as a barrier to the penetration of Mediterranean moist airflow into the Iranian Plateau. So Hamadan has cold and long winters which begin in early November and last until mid-March. The coldest months of the year are December and January. The winter turns into a relatively hot summer through a short-term spring. According to the climate classification in Iran, Hamadan is classified as a cold mountain climate (Fig. 2) (Statistical Calendar of Hamadan Province).

According to climate studies conducted by the US National Weather



◀ **Figure 1. Location of Hamadan in Iran (Authors, 2022).**



▲ **Fig. 2: Climate classification (Kasmai, 2002).**

Service in 2021, the climatic characteristics of Hamadan are listed below. The average annual temperature is 11.2 °C and the average maximum temperature is 31.4 °C during the warmest summer days. The average minimum temperature is -1 °C during the coldest winter nights. The temperature fluctuation during a month (difference between the minimum and maximum temperature) is often more than 4 °C and even reaches 13.2 °C (8.2 °C on average).

◀ **Table 2: Temperature of Hamadan city in 2021 (source: US National Weather Service, Iranian typical meteorological year (ITMY) data).**

Temperature (centigrade)	January	February	March	April	May	June	July	August	September	October	November	December
Average of maximum temperature	1	4.9	10.1	12.2	20.4	26	31.8	30.6	24.8	18	8.6	4.4
Average of minimum temperature	-3	2.7	3.9	5.6	12	13.8	19	17.4	12	7.4	3	0.8
Average of temperature	-1	3.8	7	8.9	16.2	19.9	25.4	24	18.4	12.7	5.8	2.6
Average of temperature fluctuation	4	2.2	6.2	6.6	8.4	12.2	12.8	13.2	12.8	10.6	5.6	3.6

The average relative humidity for the winter night is 48% and the average relative humidity for the summer day is 55%. Humidity is normal in Hamadan. The prevailing wind blows from the southwest at a speed of 4.9 m/s. The disturbing cold wind also blows from the southwest in cold seasons. The pleasant wind blows from the southeast in August and September (Table 3).

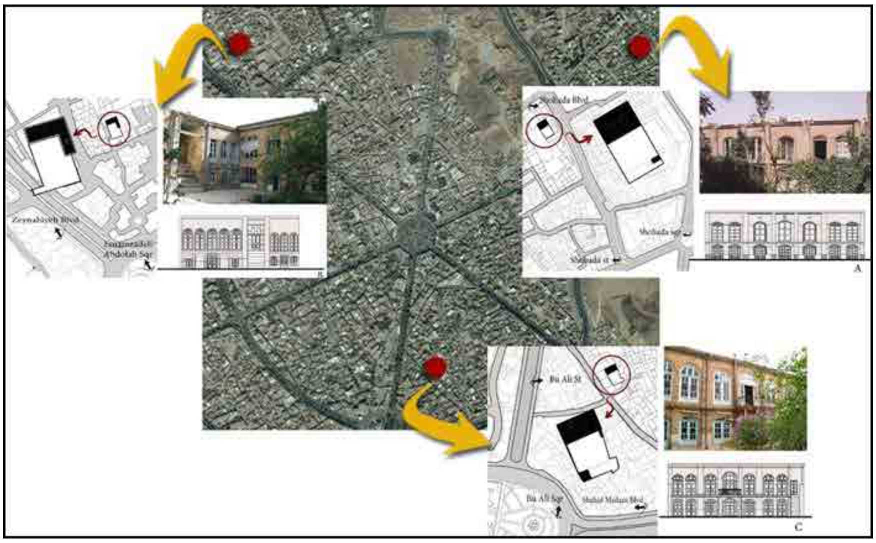
◀ **Table 3: Wind direction and average speed in Hamadan city in 2021 (source: US National Weather Service, Iranian typical meteorological year (ITMY) data).**

	January	February	March	April	May	June	July	August	September	October	November	December
Average High spped of wind(m/s)	5.3	6.6	8	6.2	5.2	4.2	3.7	3.4	5.2	2.9	5.6	3.4
direction of prevailing winds	→	↗	↗	↗	↗	↗	←	↗←	↗	↗	↗	↗

Table 2 indicates the low temperature and the need for heating. Table 3 also shows the flow of disturbing winds from the southwest in most months. Heating appliances are required in the building for about 7-8 months a year. It is essential to minimize the consumption of fossil fuels and thus maximize the use of solar thermal energy in these months. “The climatic conditions of Hamadan include severe cold winter and mild summer, significant difference between the night and day temperature, mild humidity, cold winds in winter and snowfall (Tahbaz, 2008) [29]. In Hamadan, the construction principles obtained from climatic research are as follows: (1) maximum solar radiation heat gain; (2) minimum heat loss; (3) prevention from winter cold; (4) resistance to frost; (5) protection of building against cold winter winds (southwest). This indicates the importance of solar radiation heat gain.

An overview of case studies according to the theoretical framework of research

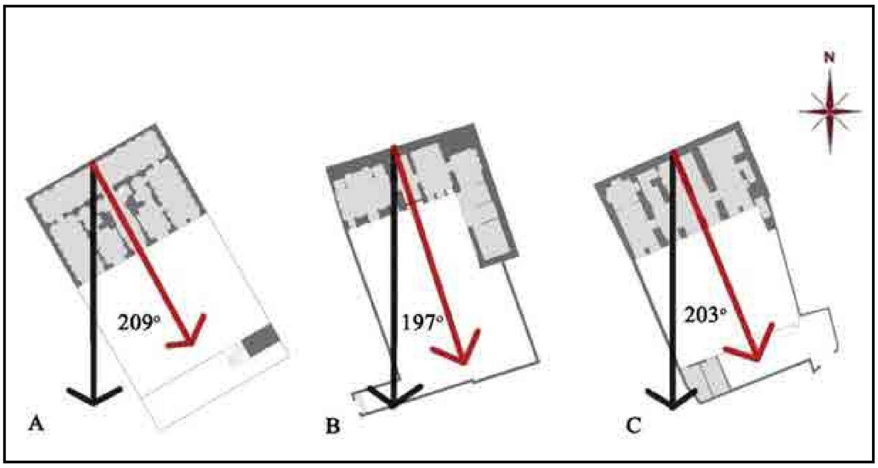
Vernacular buildings of Hamadan are located in a cold area where heating is the main factor in buildings. In a cold climate, design principles are based on reducing the cold, increasing the solar radiation heat gain and protecting against disturbing winds (Tahbaz, 2008) [29]. 3 houses are selected and assessed as representatives of other houses in order to understand different aspects of design in the vernacular architecture of Hamadan. In Hamadan, vernacular houses possess a configuration that best adapts to the climatic conditions. Their layout is based on a courtyard. The vernacular houses have small courtyards which are often square or rectangular and aligned with the northwest-southeast axis, making the building orientated toward the southeast. The houses are located within a dense urban fabric where they adjoin adjacent buildings, having a rectangular dense form orientated towards the southeast. House A (Sharafi House) is located in Jolan neighborhood at 48° 32’ E and 34° 58’ N. In this house, the spaces are arranged across each other on both sides of the courtyard, with the living spaces placed on north side of the courtyard. House B (Entezam House) is located in Ghasaban neighborhood at 48° 29’ E and 34° 58’ N. It has an L-shaped form where the main parts of building are placed in the north of the courtyard and the warehouse and service spaces are embedded on the east side of the courtyard. House C (Samavat House) is located in Aghajani-Beik neighborhood at 48° 30’ E and 34° 57’ N. All these 3 houses have two stories (Fig. 3).



◀ **Fig. 3: The urban location of vernacular houses in Hamadan (Authors, 2022).**

Building orientation

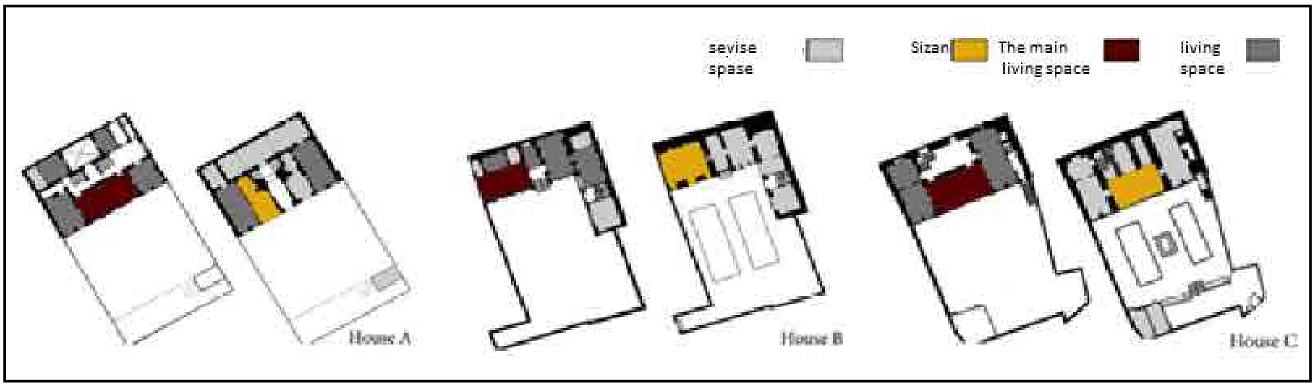
In the construction of houses in this area, the proper orientation and rotation to get more solar heat and protection against cold winter winds are the major concerns. As shown in Fig. 4, House A is rotated towards the southeast (29 degrees upon the south); so the main spaces located in the north of the courtyard face the sun. House B is divided into two sections: the main part is in the north of the courtyard (17 degrees towards the southeast) and the second part is located in the east of the courtyard, including the service spaces and warehouse. House C gains the maximum solar energy due to the rotation by 53 degrees towards the east. In all three houses, the main parts face the sun. The houses are rotated to the southeast and the walls are constructed on the southwest and west sides of buildings; the rotation protects the houses against disturbing cold winter winds blowing from of the west (according to Table 3).



◀ **Fig. 4: Orientation of vernacular houses in Hamadan (Authors, 2022).**

Arrangement of interior spaces

In Hamadan, vernacular buildings are located in the north of the courtyard and turned toward the southeast, facing the sun. Inside the building, living spaces are located on the front side of it, facing the courtyard, while circulating spaces and lobbies are placed at the rear of the building where there is no sunlight. Service spaces are often located at the rear of the upper and lower floors. On the top floor, there is a living space larger than the other. This room is the main space of the house, which is most used and located approximately in the center of the building (Fig. 5). About 1/4 of the floor area is dedicated to the main room which has the most openings compared to other rooms. It has a rectangular shape with a width of approximately half of the length. The main room is about 3.5 m high and has a false ceiling (Fig. 6). The specifications and dimensions of the main room in the three houses are listed in Tables 4 and 5.

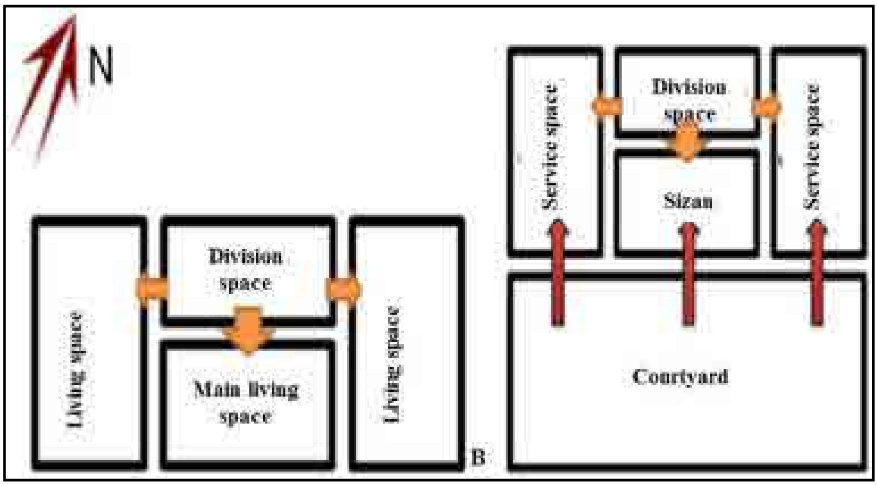


▲ **Fig. 5. Spaces in vernacular houses in Hamadan (Authors, 2022).**

Fig. 6. Main living spaces in houses (Authors, 2022).▶

In these houses, the lower floors include spaces such as kitchens, warehouses, and winter living spaces (Zemestan-Neshin[1]) that are called "Sizan" (Fig. 5 and 7). The Sizan was a living-service space for hard winters using low height, thick walls, and a few openings. As an appropriate winter space, the Sizan was placed next to the kitchen, warehouse, and sometimes the Howz-Khaneh[2] (for easy access to water). Fig. 8 represents a pattern for spaces on the floors.

◀ Fig. 7: Sizan in vernacular houses (Authors, 2022).



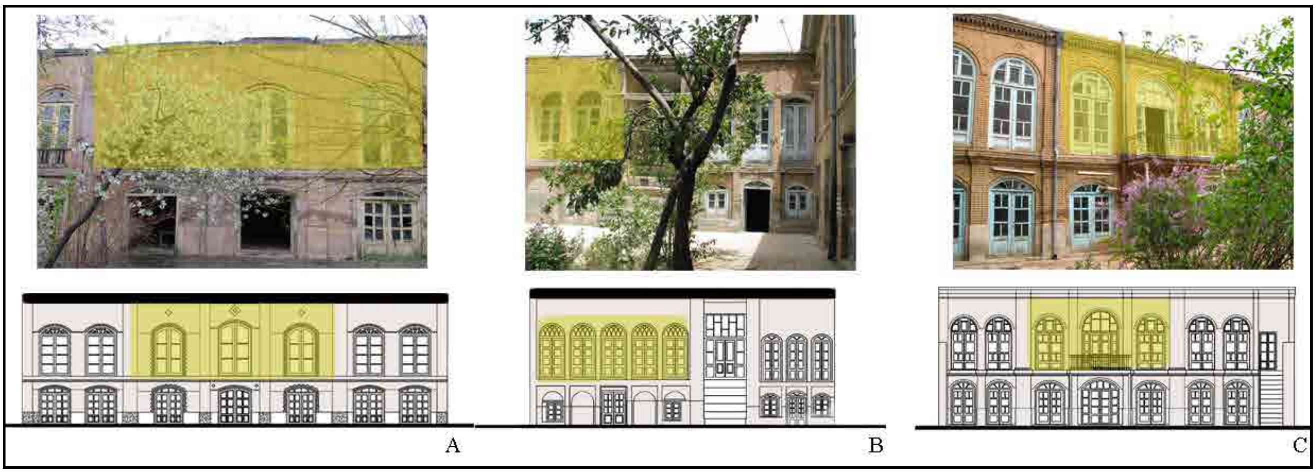
◀ Fig. 8: Arrangement of spaces on floors in vernacular houses in Hamadan: (a) ground floor; (b) first floor (Authors, 2022).

Openings

Living spaces face the courtyard and the southeast, where the openings (windows) are embedded. On the southeast side, the window-to-wall ratio is about 50%. On the other side, openings are eliminated or minimized in number and area, if necessary. On the west side, the absence of openings makes the building impervious to disturbing winter winds blowing from the west. In these houses, windows are rectangular with a width of approximately half of the height. As an example, Table 5 presents the dimensions of openings in the main room in each of the 3 houses. In the main room, windows account for almost half of the wall surface. There are 3 or 5 openings in these rooms. The window frames are made of wood and small size glass pieces are used. The glazing account for about 2/3 to 3/4 of the window area (Fig. 9 and 10). On the main (southeast) facade, windows are protected against the summer solar radiation by withdrawal from the outer wall, which is a characteristic of most traditional buildings in Hamadan.

Materials

Materials used in the vernacular houses of Hamadan include adobe, brick, wood, and cob. The walls are 40-60 cm thick, with about a 10-15 cm bricklayer used for the facade. The rest of the wall thickness is made of



▲ **Fig. 9: Position of windows on the main facade and main room of the building (Authors, 2022).**

Fig. 10: Form of windows (Authors, 2022). ▶

adobe molded like a brick. The interior walls are coated by gypsum or clay-gypsum plaster. Arched roofs are made of adobes coated by cob as moisture insulation. The roof is 40-60 cm thick. Under the main roof, a wooden false ceiling is installed at a distance of 40 cm.

Form of roof

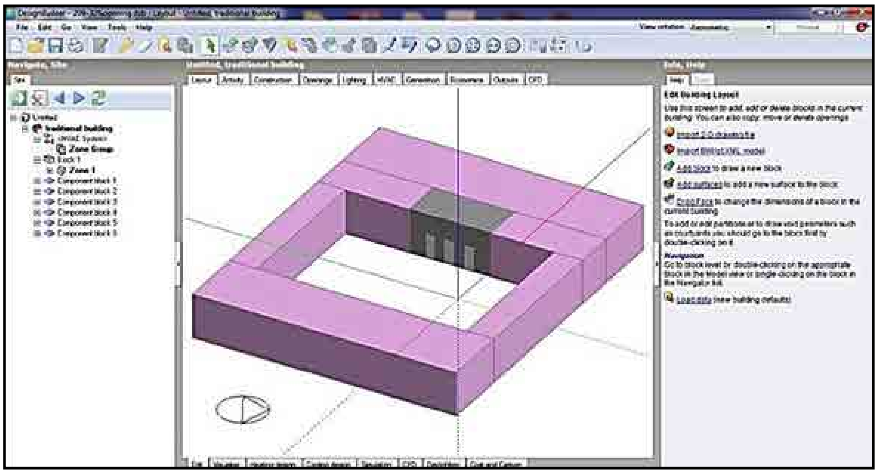
The roofs of the houses are flat and directly exposed to solar radiation and heat (Fig. 9). False ceilings are used in the living spaces. The roofs are constructed without parapets, with 10 cm eaves above the southeast wall. A general survey of houses in Hamadan demonstrates that various factors are in accordance with orientation in order to receive more solar radiation, e.g. building elongation, interior layout, window-to-wall ratio, etc.

In this study, the building orientation is assessed by simulation due to its importance. On the other hand, the openings are also investigated because the window-to-wall ratio controls the rate of heat transfer and is more dependent on the orientation than other factors.

Research methodology

General issues

At first, influential climatic factors are determined in vernacular houses using library studies and previous research, according to Table 1, and the houses are then analyzed briefly based on existing documents such as photographs and drafts as well as meteorological reports. It is observed that orientation is the most important factor to gain maximum solar radiation and protect the building against disturbing winds. A quantitative and numerical study should be conducted through simulation to surely determine the importance of climatic orientation and its impact on energy consumption. A sample room is initially made and assessed by Design Builder for this purpose (Fig. 11). In simulation steps, the analysis is done based on the air temperature; so that the output is not in accordance with individual comfort and conditions. In the simulation, the south is chosen as a control direction (180°), which faces the sun, in order to evaluate the effect of building rotation versus energy consumption. The rotation angle of the 3 houses (i.e. 197°, 203°, and 209°) are selected to test the building rotation. When the best building orientation is determined, the window-to-wall ratio is examined. The window-to-wall ratio affects the heat transfer between the indoors and outdoors. Hence the window-to-wall ratio is changed in the sample room and the results are assessed for each change. The mean window-to-wall ratio in the main room is selected as a control value in each house, equivalent to 50%. The window-to-wall ratios of 30%, 40%, 60, 70%, and 90% are also investigated. The results of the software are presented as findings.



◀ Fig. 11: Simulation of sample room (Authors, 2022).

To investigate both factors of orientation and window-to-wall ratio, it is necessary to simulate a room reflecting the properties of houses in Hamadan. Thus, the main rooms are firstly selected in each of the 3 houses as the main living space and the most important part of life within the houses. The position and characteristics of the sample room are designed based on the main rooms in each of the 3 houses, according to the descriptions of the main living space given in sections 3.3.2 and 3.3.3. The characteristics of main rooms, e.g. dimensions, the form of openings, etc., are reviewed in each of the 3 houses, as listed in Tables 4 and 5. To determine the specific dimensions and characteristics of the sample room, the mean value of numbers listed in Tables 4 and 5 is obtained and presented in Tables 6 and 7. Given the both tables and average dimensions of the spaces, the area of the main space is considered 25.6 m2, and the sample room is then made (Fig. 11). The sample room is placed within a building protected against the disturbing west wind. The sample is analyzed by Design Builder software to examine the factors of orientation and window-to-wall ratio.

Table 4: Dimensions of main rooms in studied houses (Authors, 2022). ▼

Name of house	Physical features of the building		Physical features of the main room											
	The angle of the rotation from the south	The house area (occupied area) m^2	The space area (m^2)	The ratio of main space area to the total area	The height of room (m)	The height of dropped ceiling (m)	length (m)	Width (m)	form	The ratio of width to length	The ratio of height to width	Materials features: Materials and thickness of ceiling	Materials features: Materials and thickness of wall
A (Sharafi)	29	291.5	61.7	0.21	3.7	0.5	9.8	4.5	Horizontal rectangular	0.46	0.82	0.45 adobe	0.65 adobe
B (Entezam)	33	83.7	22.7	0.27	3.5	0.4	5.25	3.03	Horizontal rectangular	0.56	1.2	0.4 adobe	0.4 adobe
C (Samavat)	17	127	32	0.25	3.9	0.4	6.11	3.28	Horizontal rectangular	0.52	1.2	0.63 adobe	0.5 adobe

Table 5: Characteristics of openings of main rooms in studied houses (Authors, 2022). ▼

Name of house	the features of the openings of the main space												
	The wall area (m2)	The opening area (m2)	The ratio of opening area to the wall area (%)	The ratio of the glass area to the total area of the window (%)		The number of openings	The ratio of the part which can be opened to the total window (%)		Materials of window frame	Dimensions of window: The ratio of width to height		Dimensions of window: The opening form	
				small	large		small	large		small	large	small	large
A (Sharafi)	35.9	14.4	0.4	0.56	0.59	3	0.91	0.91	wood	0.6	0.6	vertical rectangular	vertical rectangular
B (Entezam)	18.9	12.3	0.65	0.35		5	0.63		wood	0.5		vertical rectangular	
C (Samavat)	23.8	13.1	0.55	0.43	0.46	3	0.64	0.56	wood	0.5	0.6	vertical rectangular	vertical rectangular

Table 6: Dimensions of sample room (Authors, 2022). ▼

The average of data for the sample room	Physical features of the building	Physical features of the main space										
	The house area (occupied area) m^2	The space area (m^2)	The ratio of the main space area to the total area	The room height (m)	The height of dropped ceiling (m)	Length (m)	Width (m)	form	The ratio of length to width	The ratio of height to width	Materials features: Materials and thickness of ceiling	Materials features: Materials and thickness of wall
	106.7	25.6	0.24	3.7	0.43	7.1	3.6	Horizontal rectangular	0.51	1.07	0.5 adobe	0.52 adobe

Table 7: Characteristics of openings of sample room (Authors, 2022). ▼

The average of data for the sample room	the features of the main space opening								
	The wall area (m2)	The opening area (m2)	The ratio of opening area to the wall area (%)	The ratio of the glass area to the total area of the window (%)	The number of openings	The ratio of the part which can be opened to the total window (%)	Materials of window frame	Dimensions of window: The ratio of width to height	Dimensions of window: The opening form
	26.2	13.2	0.53	0.48	3	0.73	wooden	0.56	rectangular

- Introduction to DesignBuilder software

Design Builder software is used to model buildings in terms of building physics (construction materials), architecture, cooling and heating systems, lighting systems, etc. It is capable of modeling all aspects of a building. Design Builder modeling software precisely calculates the energy gain, loss, and consumption based on climatic conditions of the site using valid weather files of cities. So the production and validation of new climate data in energy modeling are one of the main and most effective applications of the previous climate data.

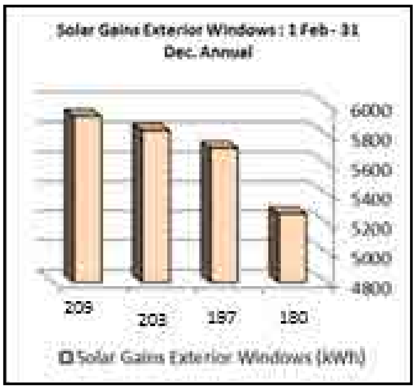
In this study, the weather file of Hamadan city is produced using weather file-generating programs, interpolation of existing files, and climate data of nearby stations. The temperature is generated based on the average value in 2021 and solar radiation is determined based on the average value in 1986-2005. In the end, the data is converted to EPW format by Energy Plus. Then the information available in existing meteorological databases is assessed and validated.

In this software, when small or large changes are applied to the design, their effects are reflected in the amount of energy consumption or energy savings within the building or each space. The simulation results are displayed in different charts on an annual, monthly, daily, hourly, and sub-hourly basis. This software employs the Energy Plus modeling engine.

Findings

The following table summarizes the results of the annual investigation of the sample room by Design Builder software.

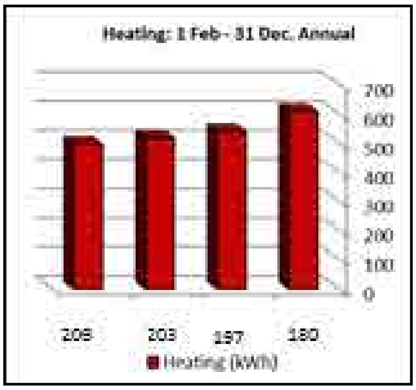
The following charts are obtained according to the results above. Chart 1 shows the amount of solar energy gain in the sample room for 4 geographic orientations. The chart indicates that as the building turns toward the



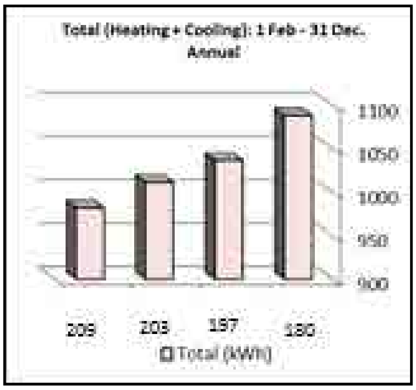
▲ **Chart 1: Annual solar energy gains in the sample room (Authors, 2022).**

Table 8. Annual results of simulation (Authors, 2022). ▶

Temperatures & Energy consumption (1 Feb - 31 Dec. Annual)	180º	197º	203º	209º
Heating (Electricity) (KWh)	607.94	540.51	517.86	495.76
Cooling (Electricity) (KWh)	480.27	496.12	493.60	486.53
Outside dry-Bulb Temperature (ºC)	13.37	13.37	13.37	13.37
Occupancy (KWh)	74.32	73.85	73.71	73.58
Solar Gains Exterior Windows (KWh)	5260.95	5707.35	5825.62	5921.34



▲ Chart 2. Annual energy consumption for heating in sample room (Authors, 2022).

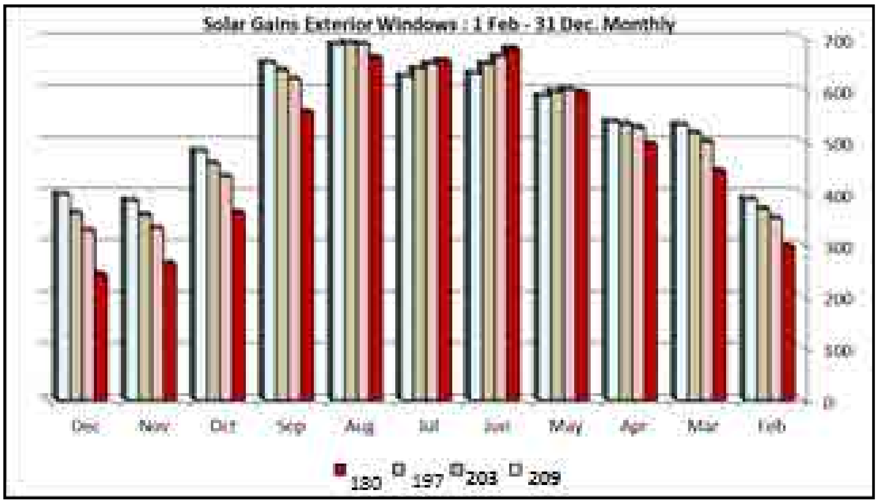


▲ Chart 3. Total annual energy consumption (heating and cooling) in the sample room (Authors, 2022).

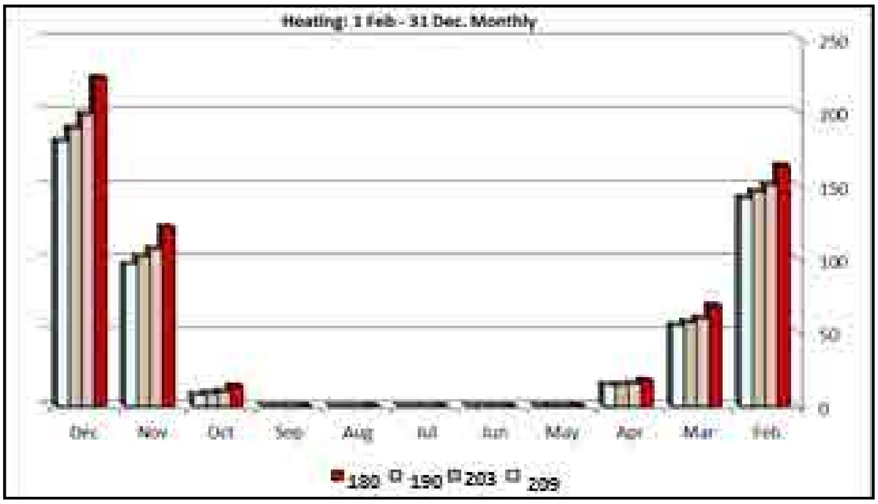
southeast, the solar energy gain increases in the room. Chart 2, which indicates the amount of energy consumed for heating over a year, suggests that the energy consumption is reduced by rotation toward the southeast, with the lowest consumption at an angle of 209 degrees. The minimum energy consumption for cooling is observed at an angle of 180 degrees; this value increases initially by turning the building to the southeast, then it decreases as the angle rises from 197 degrees to 209 degrees (Table 8). However, the total annual energy consumption (heating and cooling) reaches its minimum at an angle of 209 degrees (Chart 3).

Chart 4 illustrates the amount of solar radiation gain in different months of the year. The chart shows that at an angle of 209 degrees, the solar energy gain reaches its maximum in most cold months of the year and has a lower value in warm months. The study on energy consumption for heating in different months suggests that the lowest consumption in cold months is associated with an angle of 209 degrees (Chart 5). This is also true for the total energy consumption required for cooling and heating and it decreases in different months as the building turns more to the southeast.

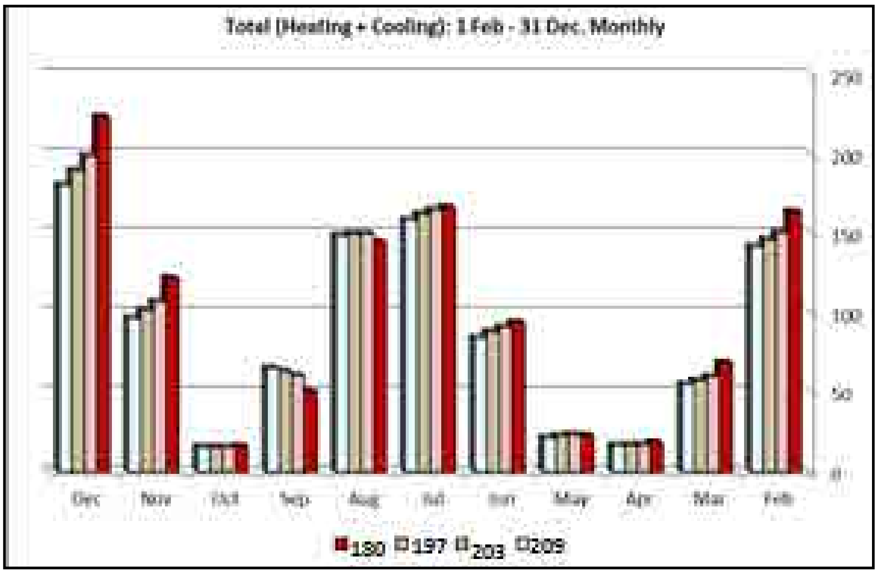
Chart 4: Monthly solar energy gains in the sample room (Authors, 2022). ▶



The last investigation into the effect of orientation is done at different hours on July 15 (solar solstice). The result used to determine the amount

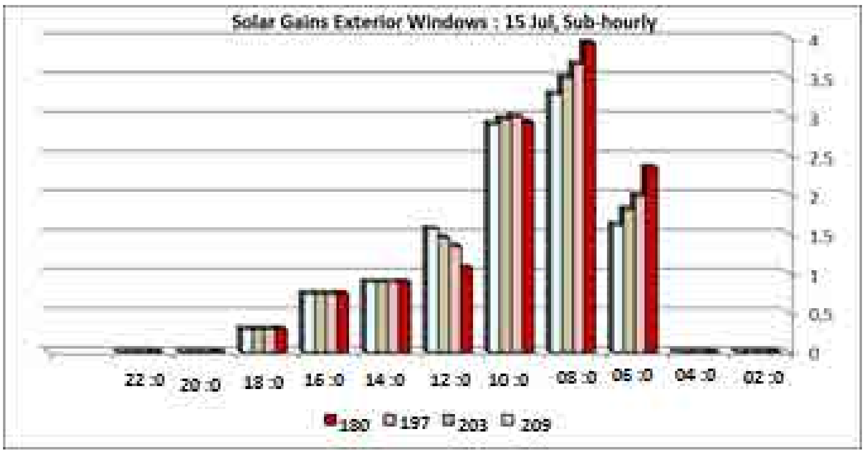


◀ **Chart 5: Monthly energy consumption for heating in the sample room (Authors, 2022).**



◀ **Chart 6: Monthly total energy consumption (heating and cooling) over a year in the sample room (Authors, 2022).**

of solar radiation gain and the relative room temperature at all hours in different directions are listed in Charts 7 and 8, respectively.



◀ **Chart 7: Solar energy gains at different hours on July 15 (Authors, 2022).**

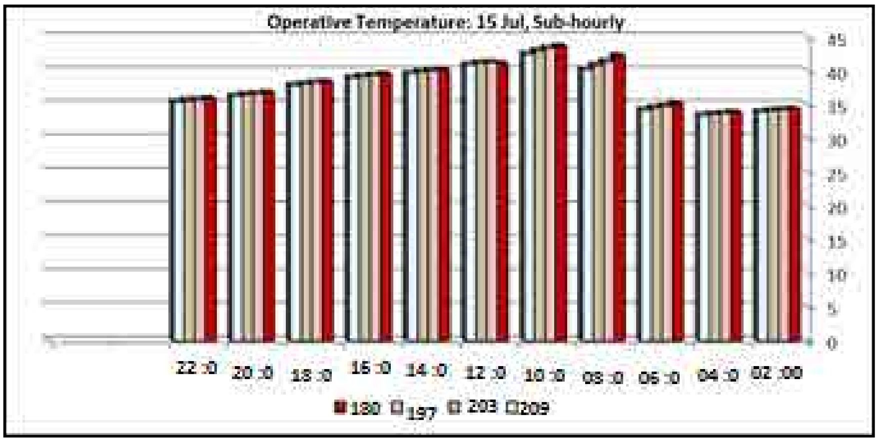


Chart 8: The relative temperature in sample room at different hours on July 15. ▶

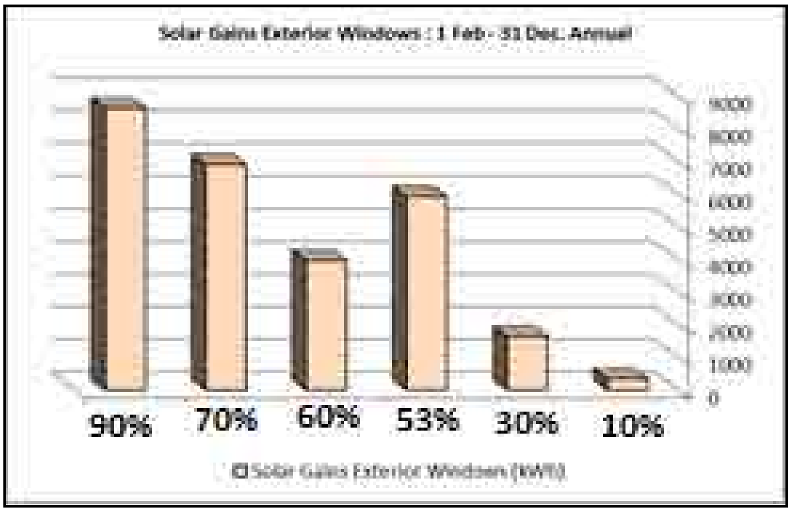
According to the investigations into orientation, it is found that the angle of 209 degrees provides the best direction for lower energy consumption. As the building is rotated from the south to the southeast and approaches this angle, the annual energy consumption declines, especially the energy needed for heating. Given the fact and the purpose of the study for energy saving, the angle of 209 degrees is considered as a reference angle for the study on the window-to-wall ratio, and the factors are measured for the main (southeast) facade of the building.

According to Table 7, the window-to-wall ratio of 53% is considered a control value (based on the mean dimensions of openings in the vernacular houses). Then, the window-to-wall ratio is changed (increased or decreased) in the sample room and compared with the control value. An example of the results obtained from the software is presented in Table 9.

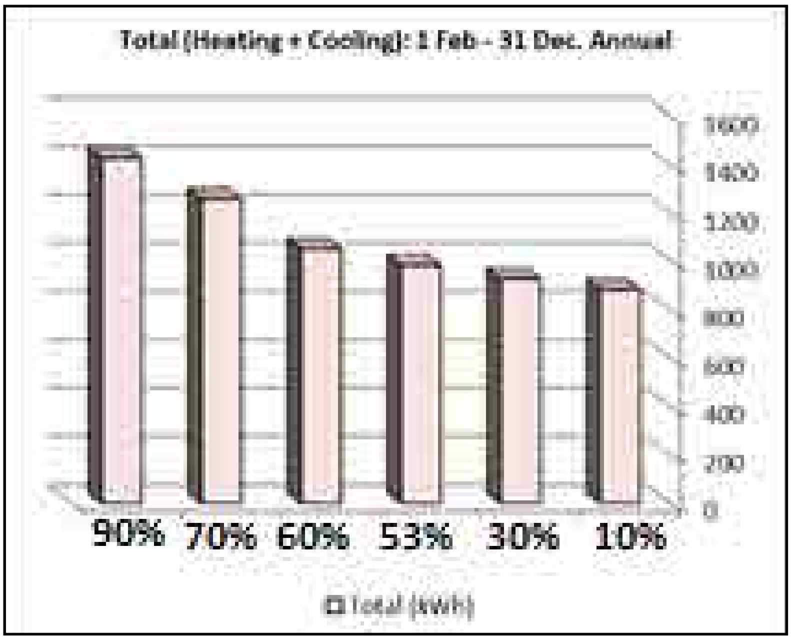
Table 9: Simulation results for openings (Authors, 2022). ▶

Temperatures & Energy consumption (1 Feb - 31 Dec. Annual)	10%	30%	53%	60%	70%	90%
Heating (Electricity) (KWh)	813.20	789.40	495.76	763.07	766.92	825.76
Cooling (Electricity) (KWh)	68.78	137.54	486.53	286.80	490.29	599.94
Outside dry-Bulb Temperature (°C)	12.12	12.12	13.37	12.12	12.12	12.12
Occupancy (KWh)	86.50	84.90	73.58	83.07	81.59	81.12
Solar Gains Exterior Windows (KWh)	340.14	1631.70	5921.34	3965.27	6909.78	8635.65

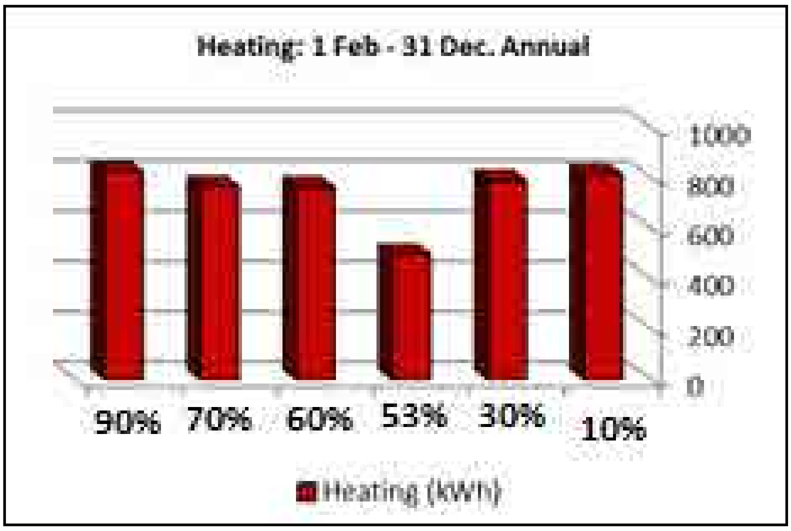
Fig. 9 shows the amount of solar radiation gain during a year for windows of different dimensions. As the window area increases, the amount of solar radiation gain rises, except for the value of 60% where the solar radiation declines by increasing the window area. As the window area increases, the total annual energy consumption rises (Chart 10). But Chart 11 shows that the annual energy consumption for heating is almost the same in all cases, with a considerable difference for the value of 53% which indicates the lowest consumption.



◀ **Chart 9: Annual solar energy gain for openings of different dimensions (Authors, 2022).**



◀ **Chart 10: Total annual energy consumption (heating and cooling) for openings of different dimensions (Authors, 2022).**



◀ **Chart 11: Annual energy consumption for heating for openings of different dimensions (Authors, 2022).**

The amount of solar radiation gained for openings of different dimensions and the energy consumption for heating in different months of the year are shown in Charts 12 and 13, respectively.

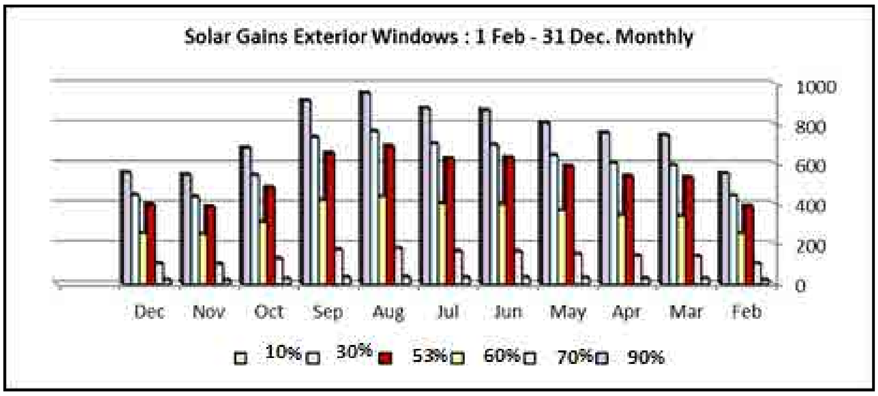


Chart 12: Monthly solar energy gain for openings of different dimensions (Authors, 2022). ▶

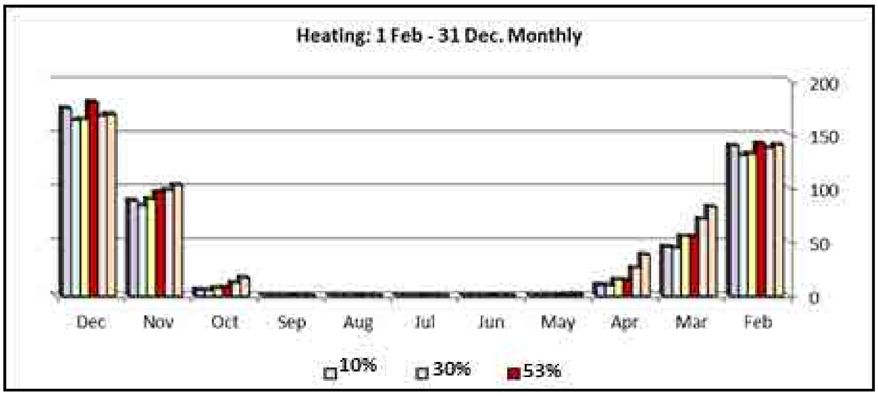


Chart 13: Monthly energy consumption for heating for openings of different dimensions (Authors, 2022). ▶

Charts 14 and 15 show the amount of solar radiation gain and the relative room temperature at all hours on July 15 (solar solstice) for openings of different dimensions

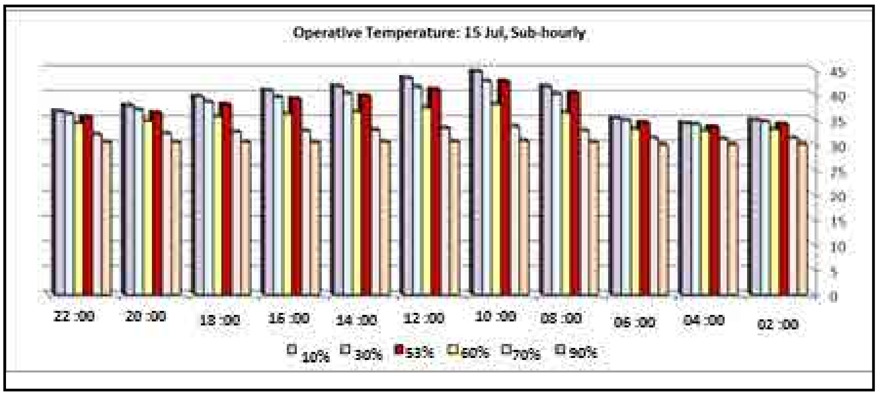
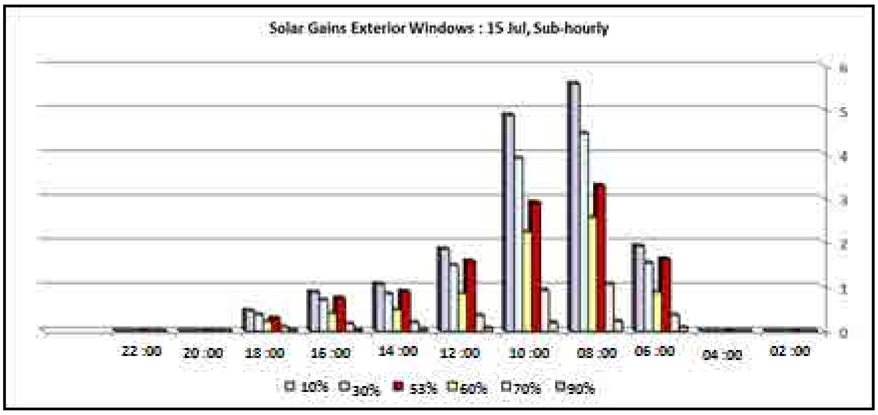


Chart 14: Relative temperature of sample room at different hours on July 15 for openings of different dimensions (Authors, 2022). ▶

Discussion and assessment

Effective factors in climatic adaptation within vernacular houses are determined using previous studies on the vernacular architecture of different regions. In this study, factors influencing the vernacular architecture are



◀ **Chart 15: Solar energy gain at different hours on July 15 for openings of different dimensions (Authors, 2022).**

addressed through the studies and examination of documents of vernacular houses in Hamadan. The simulation shows that the building orientation towards the sun is the most important factor among all factors introduced in this study and previous researches and also the most significant factor in the formation of vernacular houses in Hamadan.

There are many items in vernacular houses of Hamadan, which are important for design. Vernacular Houses of Hamadan are located within a dense urban fabric and adjoin their adjacent buildings, which can block the flow of disturbing west and southwest winds, protect the buildings from disturbing cold winds and lead to less heat transfer to the air.

The courtyard is small in the vernacular houses, which may be an advantage for protection against the disturbing wind. The courtyard is useful to benefit from the south light. The spaces are located in the north of courtyard; the living spaces are placed in front of the building overlooking the courtyard, so that they are oriented to the southeast or the sun along with the courtyard. These spaces can gain maximum solar radiation. The longest facade of the building is elongated toward the southeast, so that the larger side faces the sun path and gain more solar radiation. The roof is flat, which can lead to the least shading on itself and the highest absorption of solar radiation. If the roof was sloping, a part of it might be shaded and would not receive half the solar radiation in winters. The roof is constructed without any parapet; the installation of parapets may prevent some parts of the roof being exposed to solar radiation, creating a shadow and causing frost; that is why parapets are not observed on the roof of vernacular houses in Hamadan.

But the orientation is the most important factor in the houses of Hamadan. The houses are turned to the southeast to receive the most solar radiation; gaining maximum solar radiation is the most important factor in the area.

As shown in Chart 1, as the buildings turn to the southeast and approach the angle of 209 degrees, the amount of solar radiation gain increases. This can cause the room to get warmer by receiving more solar radiation and reducing the energy consumption required for heating (Chart 2). Moreover, pleasant winds blow from the southeast in the warm months of the year (Table 3), which lower the indoor temperature in summers and help reduce the use of cooling appliances. In general, the proper rotation of building reduces the total energy consumption during the year, so that about 100 kWh is saved for annual energy consumption by rotating the building by about 30 degrees from the south to the east (Chart 3). This is also seen in different months of the year, i.e. the monthly energy consumption is reduced in most months of the year by turning the building to the southeast.

On July 15 (solar solstice), the solar radiation gain at different hours is the lowest at an angle of 209 degrees, but it increases at noon. However, the relative temperature of the room is lower at other angles at all hours, which may be due to the pleasant wind blowing from the east that can reduce the need for cooling (Chart 8). In cold climates, the most suitable direction of the main facade is generally the direction that gains the lowest heat in hot weather and the highest heat in cold weather; this is clearly observed for the orientation to the southeast, especially at an angle of 209 degrees.

In Hamadan, the north facades are not suitable due to the lack of solar radiation, but they are protected against cold winds. The west facades are not suitable due to the lack of solar energy gain and the flow of cold winds. The south facades are suitable both for solar energy gain and protection against cold winds. The east facades are somewhat suitable in terms of solar energy gain, but certainly not as good as the south facades. An investigation into the houses of Hamadan indicates that the best building orientation is along the southeast at an angle of 10 to 30 degrees from the south, due to the solar radiation gain in different months.

The next important issue is the position and size of openings. In cold areas, openings should be exposed to sunlight and, on the other hand, protected from disturbing cold winds; hence their position is so important (Tahbaz, 2008) [29]. In the vernacular houses of Hamadan, the living spaces are oriented to the southeast, facing the courtyard; so most of the openings are located on this side to provide south solar radiation for the living spaces. On the other side, the openings are eliminated probably due to the reduction of the number of living spaces, inappropriate light, and disturbing winds.

As shown in Fig. 10, the glass panes are small in size. The glazing accounts for about 2/3 to 3/4 of the window surface; it seems that the small number and size of glass panes are important to decrease heat transfer. Reduction of heat transfer is very important in buildings in cold climates; in cold areas, it should be attempted to reduce the building surface exposure to the cold outside in order to minimize heat loss (Ghobadian, 1998) [30].

According to the evaluation of the simulation in the openings section, the solar radiation rises as the window-to-wall ratio increases. However, the total annual energy consumption (cooling and heating) also rises as the window-to-wall ratio increases (Chart 10). But the energy consumption for heating has a slightly different trend; the minimum annual energy consumption for heating occurs when the window area accounts for 53% of the wall surface, i.e. the window-to-wall ratio specified in the vernacular houses. This reduction in energy consumption is about 150 KWh (Chart 11) so a significant amount of energy can be saved by considering the window-to-wall ratio. This can be acceptable for the climate of Hamadan because it is cold in most months of the year and heating is more required than cooling. Hence it is more important to save energy needed for heating. The window-to-wall ratio may be considered between 45% and 55% in the houses of Hamadan. But further study on more samples is required to achieve specific dimensions. The form of openings and window-to-wall ratio on other sides of buildings may also be other subjects for study because it is necessary to insert openings on other facades according to different design conditions.

Conclusion

The studies show that the characteristics of vernacular houses, especially the proper orientation in accordance with climate, help to save energy and can be effective in new designs. This study only examines a brief aspect of the impact of building orientation and there are plenty of more subjects for further research, which are not addressed in this article. The subjects for further research may include the range of rotation in different directions, studies on more houses, the form of openings, etc.

In general, this study describes the following:

• In vernacular buildings, there is a good balance between climatic constraints and construction techniques, which indicates the importance of the study of vernacular architecture and its modeling.

• Vernacular houses of Hamadan have been able to adapt to the climate in different ways and a variety of factors are effective in such adaptation.

• The building’s orientation toward the sun is the most important factor in the construction of houses in Hamadan.

• The rotation toward the southeast (about 209 degrees) provides maximum solar radiation for the building in winter, which reduces the amount of energy consumed for heating.

• The building orientation affects the amount of solar radiation gained by windows.

• The window-to-wall ratio is so important in a room. The investigations show that if windows account for about half the wall surface, it properly affects the amount of energy used for heating.

• Utilizing the principles of vernacular architecture in the design of new buildings helps to reduce energy consumption.

• The orientation of buildings naturally affects the orientation of streets and the correct climate-adaptive orientation of streets can, in turn, create an appropriate structure within the cities, of which the first and most important consequence is to preserve and save energy on a global scale.

Endnotes

1. Spaces which are used in winters and located in the north part of courtyard in traditional Iranian architecture to gain more solar radiation
2. A summer chamber in traditional Iranian architecture, with a pond in the middle

References

- Al-Azzawi, S., (1994). "Indigenous courtyard houses: a comparative checklist for identifying, analysis and appraising their passive solar design characteristics, region of the hot-dry climates". *Renewable Energy*, 5 (II): 1099–1123.

- BEE, Bureau of Energy Efficiency, (2010). <http://www.bee india.nic.in/ ecbc.php> (accessed 21.02.10.).

- Chandel, S. S. & Aggarwal, R. K., (2008). "Performance evaluation of a passive solar building in western Himalayas". *Renewable Energy,* 33 (10): 2166 – 2173.

- Bourbia, F. & Awbi, H. B., (2004). "Building cluster and shading in urban canyon for hot dry climate part 2: shading simulations". *Renew Energy,* 29: 291-301

- Capeluto, I. G.; Yezioro, A.; Bleiberg, T. & Shaviv, E., (2005). "From computer models to simple design tools: solar rights in the design of urban streets". Montreal, Canada: IBPSA, *The Ninth*

International Building Performance Simulation Association: 131e8.

- Dili, A. S.; Naseer, M. A.; Varghese, T. & Zacharia, V. T., (2010a). “Passive environment control system of Kerala vernacular residential architecture for a comfortable indoor environment: A qualitative and quantitative analyses”. *Energy and Buildings*, 42: 917–927.

- Dili, A. S.; Naser, M. A. & Zacharia, V. T., (2010b). “Passive control methods of Kerala traditional architecture for a comfortable indoor environment: a comparative investigation during winter and summer”. *Building and Environment*, 45 (5): 1134–1143.

- Ghobadian, V., (1377). *Climatic investigation of traditional buildings in Iran.* Tehran: Tehran university.

- Helena, C., (1998). “Bioclimatism in vernacular architecture”. *Renewable and Sustainable Energy Reviews*, 2(1-2): 67–87.

- http:// www.hamadanshahrionline.ir

- http:// www.irimet.net

- Koch-Nielsen, H., (2002). *Stay Cool, A Design Guide for the Built Environment in Hot Climates.* James & James Science Publishers.

- Kumar Singh, M., Mahapatra, S. & Atreya, S. K., (2011). “Solar passive features in vernacular architecture of North-East India”. *Journal of Solar Energy*, 85: 2011–2022.

- Lee, K-H.; Han, D-W. & Lim, H-J., (1996). “Passive design principles and techniques for folk houses in Cheju Island and Ullng Island of Korea”. *Energy and Buildings*, 23: 207–216.

- Liu, J.; Zhang, T. & Zhai, Z., (2010). “Considering building energy from environment perspective”. *Energy and Buildings*, 42 (1): 1.

- Milne, M. & Givoni, B., (1997). “Architectural design based on climate”. In: Watson, D. (Ed.), *Energy conservation Through Building Design.* McGraw Hill, Newyork.

- Nahar, N. M.; Sharma, P. & Purohit, M. M., “Performance of different passive techniques for cooling of buildings in arid regions”. *Building and Environment,* 38: 109-116.

- Nayak, J. K. & Prajapati, J. A. (2006). *Handbook on Energy Conscious Buildings.* New Delhi, India: Solar Energy centre, Ministry of Non-Conventional Energy Sources, Government of India.

- Oikonomou, A. & Bougiatioti, F., (2011). “Architectural structure and environmental performance of the traditional buildings in Florina, NW Greece”. *Building and Environment*, 46: 669-689.

- Ratti, C.; Reydan, D. & Steemers, K., (2002). “Building form and environmental performance Archetypes, analysis and an arid climate”. *Energy Build*, 1495: 1-11

- Rohinton, E., (1993). “A hypothetical shadow umbrella for thermal comfort enhancement in the equatorial urban outdoors”. *Archit Sci Rev*, 36: 173-184.

- Sayigh, A. & Marafia, H., (1998). “Vernacular and contemporary buildings in Qatar”. *Renewable and Sustainable Energy Review*, 2(1-2): 25–37.

- Shanthi Priya, R.; Sundarraja, M. C.; Radhakrishnan, S. & Vijayalakshmi L., (2012). “Solar passive techniques in the vernacular buildings of coastal regions in Nagapattinam, TamilNadu-India – a qualitative and quantitative analysis”. *Energy and Buildings*, 49: 50–61.

- Singh, M. K.; Mahapatra, S. & Atreya, S.K., (2009a). “Thermal performance study and evaluation of comfort temperatures in vernacular buildings of North-East India”. *Building and Environment,* 45 (2): 320–329.

- Singh, M. K.; Mahapatra, S. & Atreya, S. K., (2009b). “Bioclimatism and vernacular architecture of North-East India”. *Building and Environment*, 44 (5): 878–888.

- Sozen, M.S. & Gedik, G. Z., (2007). “Evaluation of traditional architecture in terms of building physics: old Diyarbakir houses”. *Building and Environment,* 42(4): 1810–6.

- Tahbaz, M., (1387). *The principles of architecture design compatible with climate in Iran with an approach to mosque architecture.* Tehran. Shahid Beheshti University.

- Tahbaz, M. & Jalilan, S., (1377). *Regulations and criteria of design and implementation of building type*. first volume, Climate and building features, budgeting and planning organization, Tehran.

- Tassiopoulou, T., (1996). “Thermal behavior of an eighteenth-century Athenian dwelling”. *Applied Energy,* 53 (4): 383–398.

- Tavasoli, M., (1360). *Architecture and city construction in arid and warm climate of Iran.* Tehran: Fine arts college, university of Tehran.

- Tuan, N., (2011). “Quoc-Bao T, Duc-Quang T, Sigrid R. An investigation on climate responsive design strategies of vernacular housing in Vietnam”. *Building and Environment*, 46: 2088-2106.

- Vissilia, A. M., (2009). “Evaluation of a sustainable Greek vernacular settlement and its landscape: Architectural typology and building physics”. *Building and Environment,* 44: 1095–1106.

- Vural, N.; Vural, S.; Engin, N. & Su¨merkan, M. R., (2007). “Eastern Black Sea Region – a sample of modular design in the vernacular architecture”. *Building and Environment,* 42(7): 2746–61.

- Zhai, Z. & Previtali, J. M., (2010). “Ancient vernacular architecture: characteristics categorization and energy performance evaluation”. *Energy and Buildings*, 42 (3): 357–365.

فصلنامهٔ علمی پژوهش‌های باستان‌شناسی ایران
P. ISSN: 2345-5225 & E. ISSN: 2345-5500
نشانی پایگاه نشریه: https://nbsh.basu.ac.ir
شمارهٔ ۳۷، دورهٔ سیزدهم، تابستان ۱۴۰۲

جهت‌گیری ساختمان؛ تکنیک سازگاری اقلیمی در معماری بومی مناطق سردسیر ایران
(مطالعهٔ موردی: خانه‌های بومی شهر همدان)

سعید علیتاجر[I]، صفورا شهابی[II]

شناسهٔ دیجیتال (DOI): https://dx.doi.org/10.22084/NB.2023.27359.2546
تاریخ دریافت: ۱۴۰۱/۱۰/۲۴، تاریخ پذیرش: ۱۴۰۲/۰۱/۲۱
نوع مقاله: پژوهشی
صص: ۳۶۱-۳۳۳

چکیده
در سال‌های اخیر اهمیت صرفه‌جویی در انرژی به‌دلیل کمبود منابع انرژی و مشکلات زیست‌محیطی ناشی از استفاده از انرژی‌های تجدیدناپذیر افزایش یافته است. مصرف انرژی در بخش مسکن بسیار بالا است و انتظار می‌رود با افزایش جمعیت جهان افزایش یابد. ایجاد آسایش در ساختمان‌ها در برابر مشکلات اقلیمی به مصرف بالای انرژی نیاز دارد. مطالعهٔ راه‌حل‌های به‌کار رفته در مسکن بومی، برای مقابله با مشکلات اقلیمی و ایجاد آسایش برای ساکنین مناسب است و ساختمان‌های سازگار با اقلیم می‌توانند مصرف انرژی را کاهش دهند. معماری بومی منعکس‌کنندهٔ هماهنگی بین معماری و اقلیم است و با تکنیک‌های خورشیدی غیرفعال، آسایش ساکنین را فراهم کرده است. این پژوهش به مطالعهٔ چند خانهٔ بومی همدان با آب‌وهوای سرد کوهستانی در غرب ایران می‌پردازد تا عوامل مؤثر در کاهش مصرف انرژی را در آن‌ها شناسایی کند. مطالعه با هدف یافتن مهم‌ترین عامل در شکل‌گیری خانه‌های بومی هم‌ساز با اقلیم در همدان انجام شده است. این مطالعه در ابتدا با بررسی مطالعات پیشین، عوامل مؤثر اقلیمی در خانه‌های بومی را استخراج نموده و سپس با بررسی خانه‌های بومی شهر همدان و شبیه‌سازی برخی عوامل، به تحلیل آن عوامل مختلف پرداخته است. در مطالعات پیشین جهت‌گیری عامل مهمی ذکر شده بود که در این مطالعه با شبیه‌سازی خانه‌های بومی به‌صورت کمّی بررسی شد. شبیه‌سازی خانه‌ها با نرم‌افزار Design Builder و برروی دو عامل جهت‌گیری و میزان سطح بازشوها صورت گرفت. نتایج نشان می‌دهد که با وجود این‌که عوامل مختلفی در کاهش مصرف انرژی در معماری بومی مؤثرند، اما مهم‌ترین آن‌ها جهت‌گیری مناسب این خانه‌ها نسبت به خورشید است. جهت‌گیری به‌خصوص برروی میزان سطوح بازشوها در یک جبهه مؤثر بوده و در مصرف انرژی برای گرم کردن اثر می‌گذارد. نتایج تحقیق نشان می‌دهد سایر عوامل حفاظت در برابر اقلیم سرد، وابسته به جهت‌گیری خانه‌ها نسبت به خورشید بوده و براساس آن شکل می‌گیرند.

کلیدواژگان: معماری بومی، خانه‌های بومی همدان، معماری اقلیمی، روش‌های غیرفعال اقلیمی، جهت‌گیری.

I. دانشیار گروه معماری، دانشکدهٔ هنر و معماری، دانشگاه بوعلی‌سینا، همدان، ایران (نویسندهٔ مسئول).
Email: Alitajer@basu.ac.ir
II. کارشناسی‌ارشد گروه معماری، دانشکدهٔ هنر و معماری، دانشگاه بوعلی‌سینا، همدان، ایران

ارجاع به مقاله: علیتاجر، سعید؛ و شهابی، صفورا، (۱۴۰۲). «جهت‌گیری ساختمان؛ تکنیک سازگاری اقلیمی در معماری بومی مناطق سردسیر ایران (مطالعهٔ موردی: خانه‌های بومی شهر همدان)». پژوهش‌های باستان شناسی ایران، ۱۳(۳۷): ۳۶۱-۳۳۳. https://dx.doi.org/10.22084/NB.2023.27359.2546
صفحهٔ اصلی مقاله در سامانهٔ نشریه:
https://nbsh.basu.ac.ir/article_5321.html?lang=fa

فصلنامهٔ علمی گروه باستان‌شناسی دانشکدهٔ هنر و معماری، دانشگاه بوعلی‌سینا، همدان، ایران.