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The Effect of Iranian Traditional Architectural Forms on Reducing Energy Consumption; Comparison of Two Types of Buildings in Hot-Dry and Cold Climates (Case study: Afsharian House and Ganjei Zadeh House)

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ABSTRACT: In different parts of Iran, the traditional form of buildings are significantly subordinate to the climate of the region in which they are located. How much traditional Iranian housing forms have been effective in thermal behavior is an issue that is discussed in this paper. The research method in this paper is analytic-deductive analysis, which is done by modeling and analysis of the case study of two climates and comparing them in different situations with appropriate soft wears. The results of energy simulations and their comparison with each other indicate that the form and geometry chosen by the Iranian architect for each climate show a very good behavior to meet the climatic conditions. And if these two forms of housing are displaced together, this efficiency decreases. As a result, the housing form of each climate is an optimal response to the same climate. Traditional architects have been aware of the impact of geometry and forms on the thermal performance of buildings, and they have been able to respond appropriately to environmental conditions by using different geometric proportions and forms.

Keywords: Iran's Traditional Housing, Thermal-Climate Behavior, Energy Efficient, Energy Consumption

INTRODUCTION

Shelter is a basic necessity for human beings to protect themselves from the extremes of climate. Climate influences the building forms. It partly explains why built forms vary according to the region (Moradchelleh and Rashid, 2011). Other important influencing factors are the culture of people, their religion, the availability of materials and construction technology. One factor may be more dominant relatively to another, depending on the context and people's preferences (Rapoport, 1969). Making an effort to understand how built environment is shaped. Due to the interaction between people and their surroundings has been a fascination for many researchers. People usually react to the alterations and changes caused by the environmental elements through behavioral adaptation, physiological and psychological adaptation to meet comfort requirements (De Dear and Brager, 1998). To gain desirable environment, people have a tendency to adjust their clothing change and relocate their activities to gain the desired comfort level (Roaf et al., 2009). Environmental controlling features such as a mechanism to open and close doors, windows, and blinds increase the range of acceptable temperature of comfort in buildings (Darby and White, 2005). Therefore, thermal comfort in a building is gained through the physical elements as well as through the adaptive behaviors of the occupants (Roaf et al., 2009).

Iran experiences four types of climate conditions namely, moderate and humid, cold, hot-dry and hot-humid climates in various regions of the country. As a result, there is a diversity of vernacular architecture that could be found in different parts of the country. In general, Iranian traditional houses are classified into two recognizable types: the introverted type (with internal courtyard) and the extroverted type (without central courtyard) (Mokhtarshahi Sani, 2013). The courtyard type is widely used in the central part of Iran with hot and dry climatic condition (Heidari, 2010). However, this unique architectural feature can be found in other regions with modifications in terms of form and configuration (Amadouni, 1995). In the traditional architecture of Iran, using many natural and constructed elements, including topography, elevation, water, land cover, and surrounding environments formation and architecture design techniques to protect residents from the adverse effects of climate on comfort has led to the formation of Iranian housing. For this reason, the housing of each climate is highly consistent and adaptable to the native conditions in which it is located (Saljoughinejad and Rashidi Sharifabad, 2015).

Many studies have been conducted in the field of traditional Iranian housing, among which the studies of Professor Pirnia in the form of reference books are taught in Iran's universities. The basics mentioned in this article are mainly derived from these books, including the book of Persian architectural methods by Gholam Hossein Memarian in 2002. In the book of Residential Architecture of Iran, Memarian also addresses the typology of the introverted and extraterrestrial form of traditional Iranian housing, which has occurred through the formulation of housing for each region. Mohammad Tavassoli, in a book entitled Building a City and Architecture in the Dry Climate in 2012, explores the climate impact on the formation of housing and even urbanization in that climate. Other books on building elements of Iranian traditional architecture for ventilation and climate in the dry climate have been compiled including the publication of the book of natural cooling in traditional buildings of Iran, by Mehdi Bahadirinejad.

MATERIAL AND METHOD

At first, a brief explanation of the theoretical foundations includes the concepts and key elements of the climate of traditional Iranian buildings will be explained. Then a variety of dominant buildings in different climates of Iran are introduced. And then the buildings of Ganje zadeh in the city of Tabriz as the dominant form of the building in a cold climate and the Afsharian building in Shiraz is introduced as the dominant form in warm and dry climate. Then these two buildings are examined for thermal performance. Energy simulations have been done using Honeybee that is a weather and energy analysis tool for grasshopper 3D package and connects grasshopper to Energy Plus simulation engine. Simulations are done in two parts. Simulations are performed for each month of the year. Each building once was modeled in its own climate and once again in a different climate and the results are compared.

Theoretical bases considering climate change around the world and increasing fossil fuel consumption, it is important to control and manage optimal fuel consumption. Although Iran is a land of four seasons with a lot of climate variations However, Iran is located in a semi-arid climatic zone relative to its latitude and distance from the equator, has vast desert plains in the central area It has very hot summers and cold winters.

On the other hand, in the cold and dry climate of the Alborz and Zagros mountains in the western and northwest regions, it creates cold winters for the inhabitants of this region. Traditional Iranian houses have always been one of the most important sections of Iranian architecture and have great popularity among its inhabitants .Because most of the time spent in the lives of the people and all of the activities that can take place in the open and semi-open spaces are formed in it (Asefi and Imani, 2017) Housing as the most fundamental architectural building in Iran has a significant contribution to determining fuel and energy consumption. On the other hand, traditional Iranian architecture has used designing techniques in traditional houses to answer those issues (Najafgholi Pour Kalantari et al., 2015).

Each climate is proportional to its climate zone, and it is considering measures to build housing in that region that is responsive to the same climate. Building form is one of the most important strategies for optimizing fuel consumption. In the following, introducing and describing the traditional form of Iranian housing in two hot and cold regions and cities of Iran, we examine and analyze this claim

Types of houses

Buildings are divided into several categories according to the location of spaces in different parts of the yard:

1. With spaces on one side of the yard
2. With spaces on both sides of the yard and facing each other
3. With spaces on the courtyard side, L-shaped
4. With spaces on the three sides of the yard. U shape
5. With spaces around the yard:

In this species, the organization of spaces with regard to domestic migration has taken place in different seasons. In this way parts facing sun has used during the winter, and parts that placed back to sun used in summers (Memarian and Pirnia, 2007)

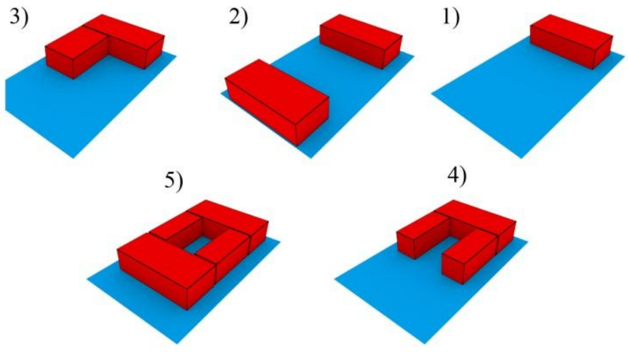

Figure 1. The shape of the spaces in different parts of the yard

Gangei zadeh House of Tabriz

The GanjeiZadeh House has a mix of architectural styles from the Qajar and Pahlavi periods. The house is about three thousand square meters in size, and its land is composed of three floors of rooms in a row without an interior and exterior. The use of sharp angles in the construction of a treasure house and a rectangular window without curvature in the building reveals that the building consists of two parts. The eastern part is constructed during the Qajar period, and the western part of the Pahlavi period has been added to the former building. The main core of this building is the lounge chamber, which is located on both sides of the entrance hall and at the edges of the rooms. The porch contains five spans covered with semi-circular arches. In the northern part of the living room there was also a veranda with three openings facing the courtyard. The northern interior courtyard is destroyed and the northern side of the living room is walled the back of both parts of the building is protected and decorated with stone plates, and the exterior and basements are brick. Materials used in the building of stone, brick, plaster, lime and wood Architectural plans, combining two planes, porches, two-way staircases and optimal brick application are the hallmarks of this building.

Figure 2. Gangei zadeh House of Tabriz

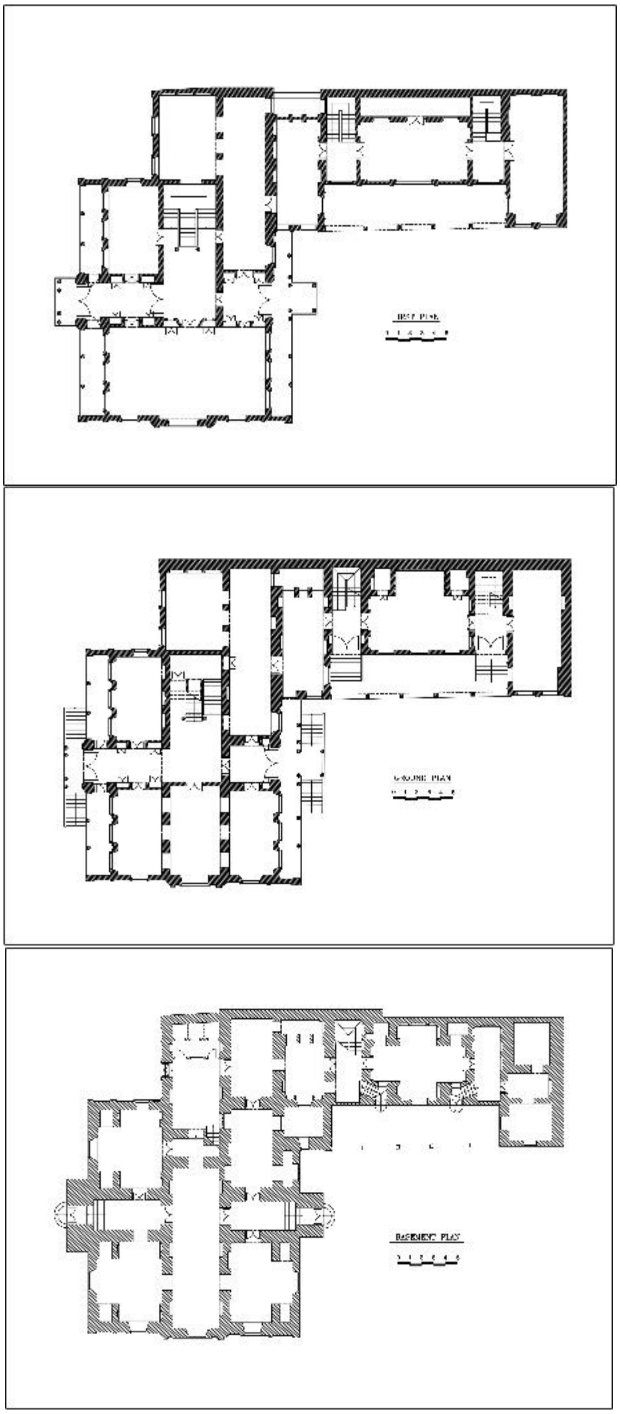

Figure 3. Gangei zadeh House of Tabriz

Afsharian house in Shiraz:

The house of Afsharian with an area of 380 square meters is a combination of two species with and without the traditional window. The building has a central courtyard and on three fronts there is a room, two corridors and two double rooms. The type of structure is the barrier wall, the arched vault and the arc. Most of the materials used in the construction of the building include brick, stone, plaster mortar, wood. Also, the decorations used in the building include carvings, wood decoration, tile, brickwork, painting, mirroring, and painting. This house was built during the Qajar era.

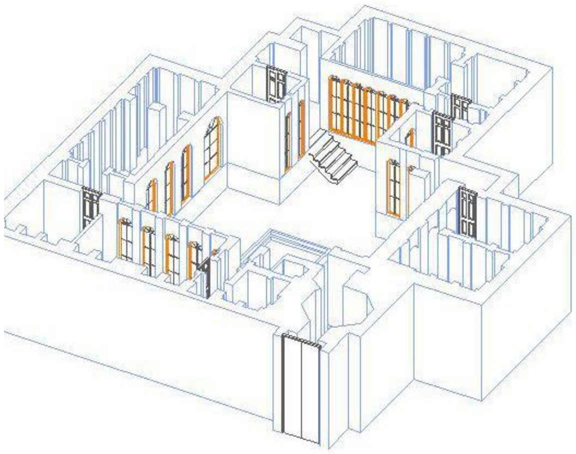

Figure 4. Afsharian house in Shiraz

RESULTS

Gangei Zadeh house in Tabriz & Shiraz climates

Energy use of Ganjei Zadeh house in Tabriz climate is: 26256.652 kWh for cooling, and 27377.517 kWh for heating over a year, also total energy demand for thermal load in 28.825 kWh/M2 in a year (Charts 1-3). In the second part of experience the building tested in Shiraz climate and result is as follows: 84625.107 kWh for cooling, and 943.924 kWh for heating over a year, also total energy demand for thermal load in 41.202 kWh/M2 in a year (Charts 4-6).

Comparing the result shows that energy demand for cooling in Ganjei Zadeh house in Shiraz Climate in a year raised 222.3 percent and energy demand for heating is dropped 28.394 percent because the Shiraz has hot and dry weather that has no significant need for heating. Finally total thermal energy demand for Ganjei Zadeh house in Shiraz climate raised by 51.543 percent (kWh/m2) that shows this geometry is not optimal chose for Shiraz climate.

Afsharian house in Shiraz and Tabriz climates

The total energy consumption of the entire Afsharian house for one year is 1869.66 kWh for heating, and for cooling it is 12719.817 kWh, and energy consumption per square meter for the whole year is 54.924 kWh hours in the climate of Shiraz (Charts 7-9). The energy consumption of Afsharian house in the Tabriz city is as follows: Heating during the year is 1439.337 kWh. Cooling during the year was 3778,732 kWh. And the amount of energy consumed per square meter during the year is 68,403 kWh (Charts 10-12).

Comparison of the results shows that if the form and geometry of the Afsharian building used in Tabriz's climate, the energy consumption for heating will decrease by 29.897 percent. And this is due to the closure of the form and the central courtyard of the Afsharian building, which indicates that this form is optimal for cold seasons. Also, the amount of energy used for cooling is increased by 197 percent that shows, the form of the Afsharian house in the climate of Tabriz is not optimal for cooling loads. Eventually, the amount of energy consumed by Afsharian house increased by 24.541 percent per square meter. Which indicates the lack of optimality of this form and geometry for this climate.

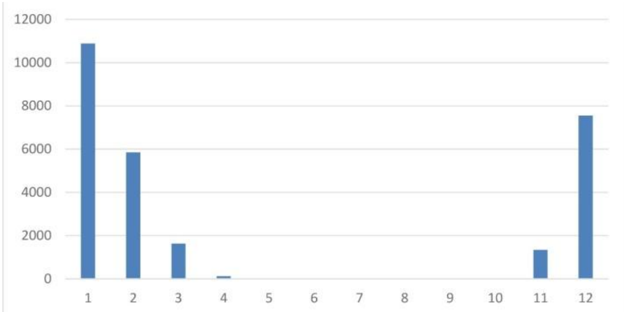

Chart 1. Heating energy demand of Gangei Zadeh house in Tabriz

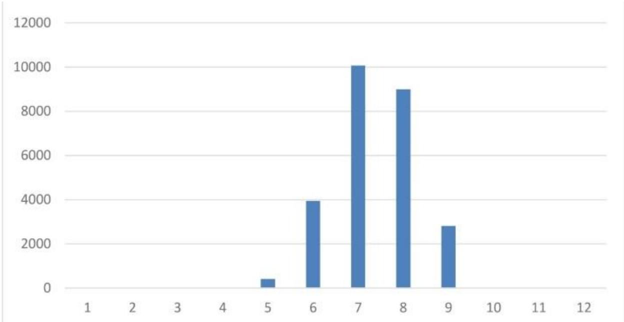

Chart 2. Cooling energy demand of g Gangei zadeh house in Tabriz

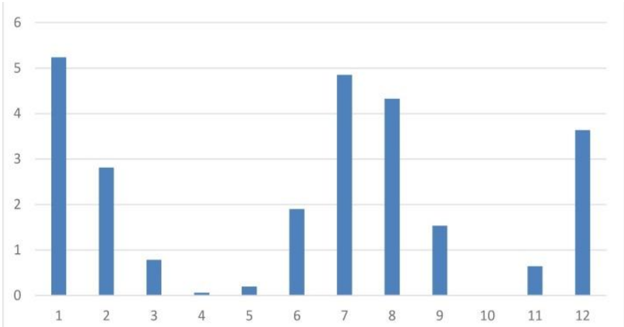

Chart 3. Total energy demand of Gangei zadeh house in Tabriz kWh/m2

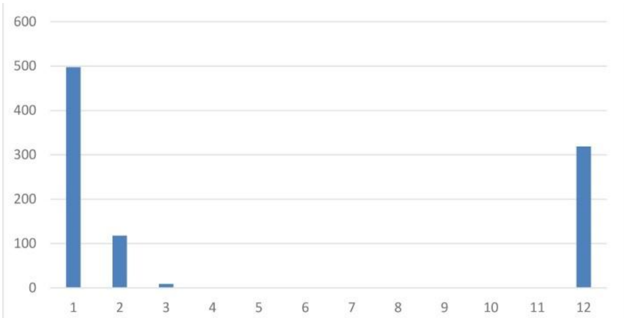

Chart 4. Heating energy demand of Gangei zadeh house in Shiraz climate

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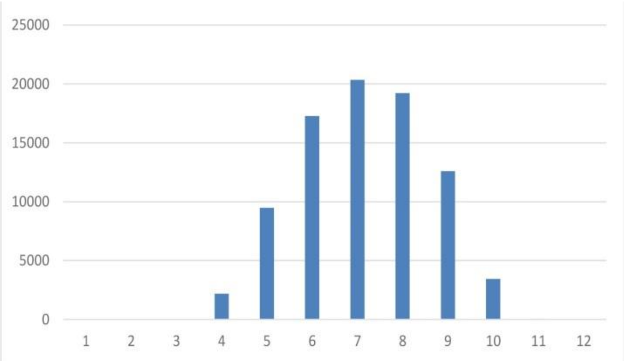


Chart 5. Cooling energy demand of Gangei zadeh house in Shiraz climate

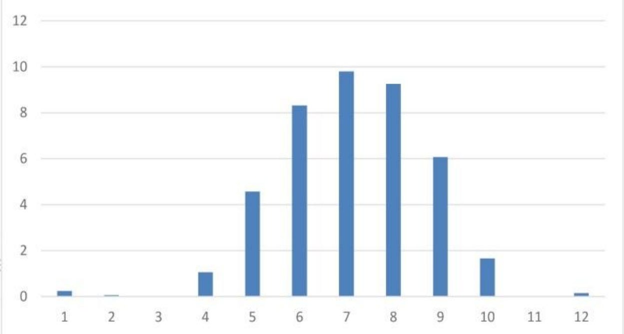
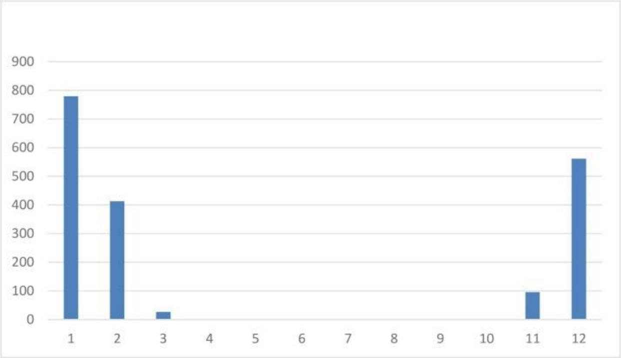
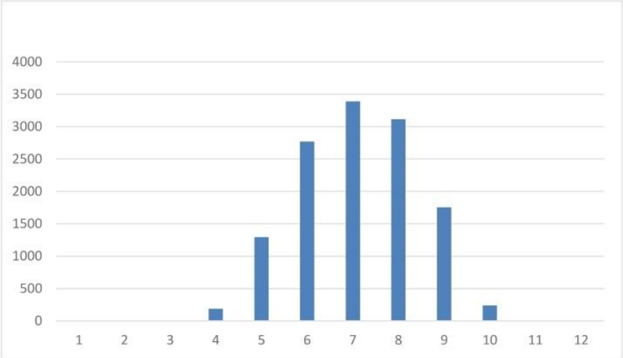


Chart 6. Total energy demand of Gangei zadeh house in Shiraz climate, kWh/m2



Char 7. Heating energy demand of Afsharian house in Shiraz climate



Char 8. Cooling energy demand of Afsharian house in Shiraz climate

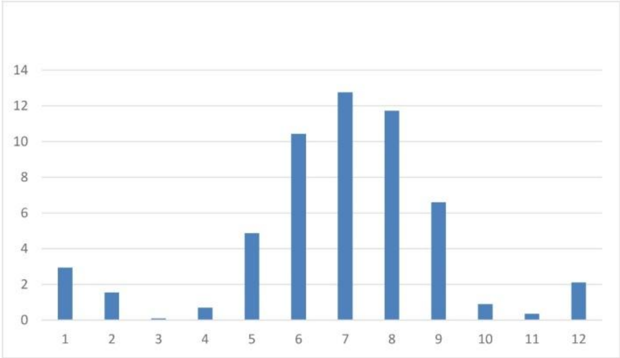
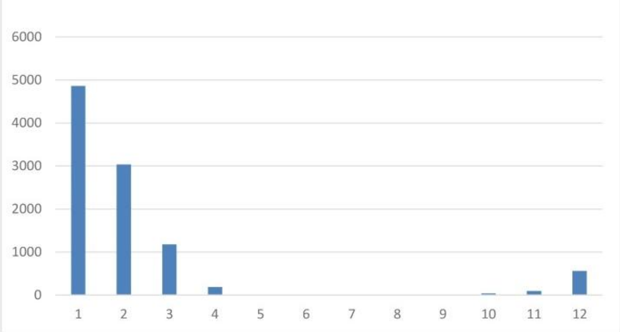
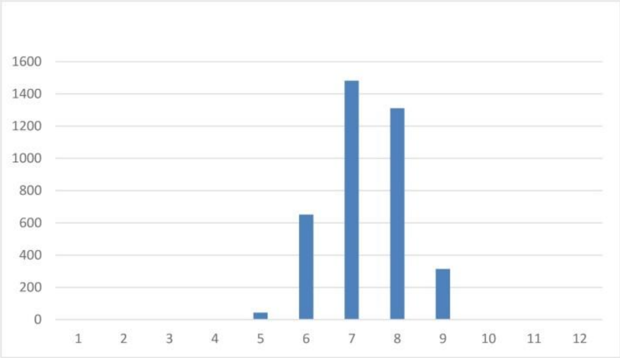


Chart 9. Total energy demand of Afsharian house in Shiraz climate, kWh/m2



Char 10. Heating energy demand of Afsharian house in Tabriz climate



Char 11. Cooling energy demand of Afsharian house in Tabriz climate

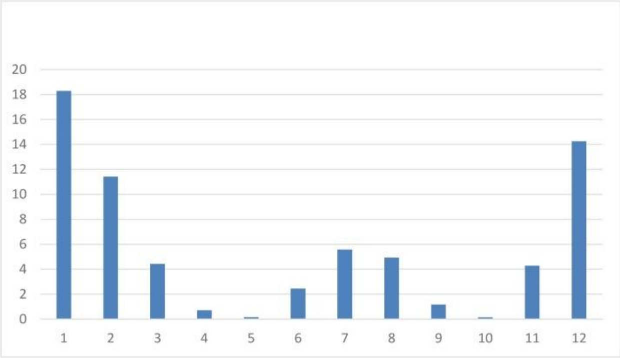


Chart 12. Total energy demand of Afsharian house in Tabriz climate, kWh/m2

CONCLUSION

The results show that the Iranian architect, with the detailed knowledge of the appropriate forms and geometries of each climate, was able to respond appropriately to the climate conditions and optimize energy consumption with respect to the climate. In such a way that a special form that was suitable for cold climate was not optimized for hot climates and vice versa. as the results of climate simulations prove this. Although the Afsharian house has been able to show good results in the cold climate of Tabriz this is due to the central courtyard and the closed form of the building, but finally the total energy consumption has increased in total.

DECLARATIONS

Authors' contributions

All authors contributed equally to this work.

Competing interests

The authors declare that they have no competing interests.

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