Climatic Design of Iranian Traditional Buildings

Case Study: Tabriz

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Abstract

Today, the environment, saving fossil energy and sustainable development have become important and common discussions at the international level. So that energy sources' conservation, avoiding contaminating the land and the environment, reducing the amount of fossil energy consumption and coexistence with natural and climate conditions have become one of the most important measures in architecture and urbanism. In modern discussions of sustainable architecture, the use of passive systems for cooling and heating of buildings is a way of saving energy consumption. On the other hand, Iran's traditional architecture in the residential sector and in the non-residential sector, as well as the integration of these two broadly in the name of the city has unique features that while considering aesthetic issues and the environment conservation has also been responsive to climate needs of each region. Techniques and rules used in this architecture have many new concepts in the field of sustainable architecture in itself clearly that the paper examined these concepts in Tabriz residential architecture located in cold regions of Iran. The method of the present paper is descriptive-analytic and data collection method is library and field. In this paper, the traditional solutions for cooling and heating in traditional architecture were classified in the form of passive cooling and heating methods and finally the result was that most of proposed methods have been considered in passive systems of traditional architecture and by detailed study of Iran architecture, urban development and modernization intelligent solutions can be found matching local architecture of regions.

Keywords: Passive Solar Design, energy, climate, Tabriz, Iran

1.Introduction

In discussing sustainable development and consequently sustainable architecture, this issue that each building should interact with its substrate and surrounding natural environment has become obvious. The controversial part of the discussion is how to build this type of given interaction and measures. This is the same thing that many years ago the inhabitants of this land have benefited from it with special skills and have used it by the implementation of specific techniques and rules in the field of optimized use of natural energy and resources especially sun, wind and harmony with the climate, today, with negligence it has been brought into an abyss of oblivion. These measures are obvious not only in environmental fields but also in other aspects of social and economic sustainability as well. In this paper, traditional residential architecture in Tabriz, located in cold regions of Iran has been studied. First, Tabriz climate conditions have been examined, as statistics of weather stations for several years, then Qajar and Pahlavi buildings in Tabriz with a history of 100-200 years have been analyzed in terms of the climate and providing climate solutions in design and construction. Finally, the methods used in traditional architecture have been classified based on three-step process of Passive[1] design of cooling and heating of buildings. The method used in this paper is descriptive-analytic and data were obtained from field and library studies. The research question was whether traditional methods of cooling and heating of buildings can be classified in accordance with the process of designing passive systems.

2.Sustainable architecture

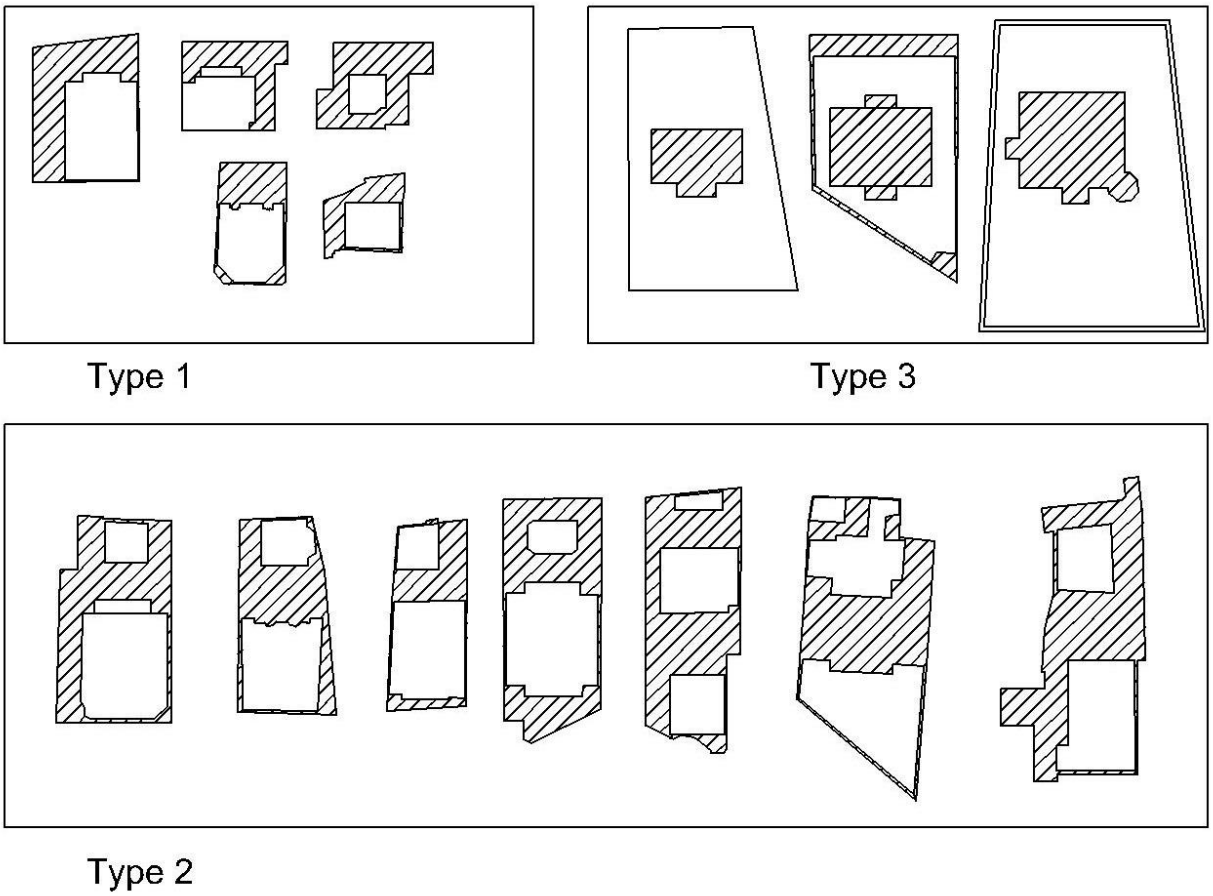
Sustainable architecture challenge is related with finding a comprehensive solution for environmental consideration, meanwhile it is to achieve life quality and cultural; socioeconomic and comfort values[1]. we may search on objectives of sustainable architecture in relation to

environment and energy: sensitive buildings to vernacular needs must be created; energy consumption must be reduced to the minimum level; indeed we must necessarily consider vernacular sociocultural content for implementation of environmental technology. Sustainability needs a continues progressive effort. It is impossible to improve and modify constructed environment without peoples' participation. Sustainability requires compatible rules and regulations; consequently, it needs participation of communities through effective management of resources by focusing on equity[2].

Concept of sustainable development is the result of increased awareness of global connections; increasing environmental problems, socioeconomic issues; poverty; inequality; and concerns about a healthy future for mankind. Sustainable development links socioeconomic and environmental issues strongly[3].

Sustainable development emphasizes on environmental issues that is one of the three important domains. The task of architects is very serious and sensitive because they are up to 75% responsible for climate change either directly or indirectly[4,5]. Therefor, the architects must encroach the environment very cautiously. sustainable architecture is proceeding for decades; and the architects have developed and proposed many solutions for crises and problems of sustainable architecture[6]. thus, it is necessary to study old sustainable residential complexes.

Figure 1. shows the plan of a number of traditional houses in Tabriz.



3.Climatic conditions in Tabriz

Tabriz is located in northwestern Iran, in cold climate and mountainous region. In this climate, the amount and intensity of radiation is higher in summer and in winter is very low. Winter is long, cold and hard and several months of the year are icy. Throughout the climate winter is very cold and cold starts from early December and continues to late April more or less [7]. Tabriz wind is also considered as one of the most significant factors affecting so that the climate of this city is achieved from the results of the review of airflow in ten years. Directions of East, Northeast and Southwest and West constitute the most important wind directions in Tabriz and have the highest amount of annual wind flow. Among these four important wind

directions, flow in the mutual direction, and wind from the East and northeast has annual high flow [8]. East and northeast wind is continuous air flow with significant amount all year in the plain of Tabriz. Meanwhile, the east wind in autumn and northeast wind in winter also dominate wind with other directions. The two air flows only in spring with a relatively high amount and very little distance from southwest wind is dominated by southwest wind. In general, the results of this study indicate that the air flow from regions of Siberia and the eastern and northeastern regions of Siberia and in the plain of Tabriz is the prevailing Tabriz air flow [7]. Examining the amount of rainfall in Tabriz also indicates that totally March to May is Tabriz plain rainy period. After this period, ten-year rainfall period in Tabriz in terms of different months shows that April and May respectively were the rainiest months of the year and July and August, respectively had the least rainfall during the last ten years [9].

4.Traditional Buildings in Tabriz

Most Tabriz historic buildings' history dated back to Qajar era. Tabriz is the second great city in the country in terms of historic buildings [10]. All monuments in Tabriz were destroyed in 1193 AH last night and in the early Qajar period, due to the terrible earthquake and Tabriz was ruined [10]. After the earthquake in 1193 AD, and in the early years of Qajar period, construction boomed in Tabriz and people on the ruins built a new city with beautiful and interesting buildings. Today, also the old buildings dating back to Qajar period, are seen in the central parts of the city. Today, in the city more than 600 historic buildings have been identified and it is estimated that the number will search more than 800 buildings in the coming years by exploration [11].

Tabriz traditional buildings can be divided into three general types: 1. Introvert with a central courtyard 2. Introvert with two or three central courtyard, owned by wealthy people. 3. Koushki, shaped extrovert in the yard or garden, The examples were spread during Pahlavi era and the number is less than previous examples

5.Examples of environmental sustainability in traditional buildings in Tabriz

5.1. Proper orientation of buildings

One of the principles of construction in Iran traditional complexes is proper orientation of buildings according to the movement of the sun in the sky and efficient use of solar thermal energy in different seasons of the year. In Iran traditional buildings, three directions Raste (northeast - southwest), Isfahani (northwest-southeast) and Kermani (East - West) were the best for building construction in different climates[12]. Ignoring this problem in some regions caused major problems in the city and/ or residents always had problems with light and energy absorption and effective use of wind. In Tabriz in order to establish buildings there was Raste (North East South West). Tabriz meteorological statistics show that the city has very cold winter and hot summer. So make maximum use of sunlight in winter for heating living spaces is essential.

Iran, which is located in the northern half of the planet, the east – west orientation is best direction for building. This means that length and width of buildings must be located in east – west and north-south directions, respectively, because the south wall absorbs most of the energy in winter and this wall can be protected using canopies in summer. East-west walls, which absorb enormous amounts of energy in the summer, should have a lower surface if possible. It is also better to build western walls under the shade of trees or buildings[13]. Since the ambient

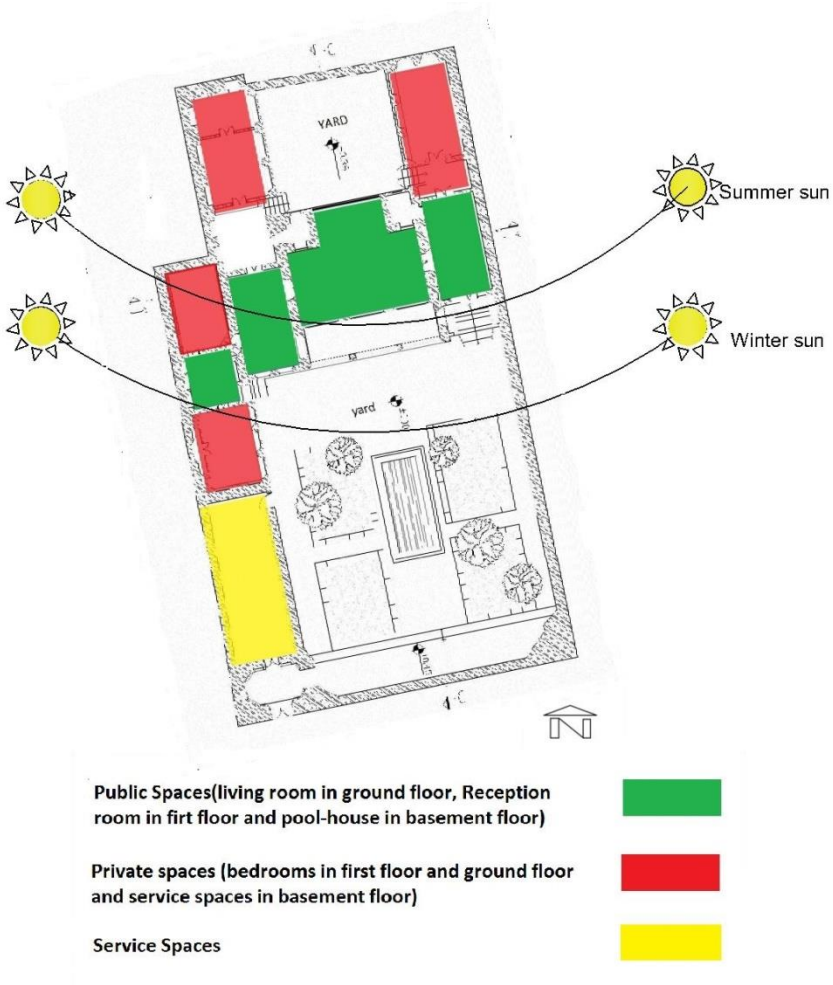
temperature rises during the day due to sun radiation and in the afternoon the air and surroundings of buildings is warmer than the morning so it is best to construct the building toward East so that summer sun shines somewhat less directly to Western levels of the building [13]. This orientation is exactly proportional to the traditional orientation in Tabriz meaning R that the ancients were fully aware of it.

With reviewing plans' details it can be concluded that all introverted buildings have a front facing south, meaning a part of the plan where there are the main living spaces and private living rooms is east-west and south-facing to use south light. In addition, in these buildings some parts are north to south-facing and use East or West light, the parts usually are kitchen and storage in the basement floor, and in upper floors are used as bedrooms. Usually there is an Ivan in south-facing side with the main living spaces with a proper depth preventing summer sun radiation but not in winter. But in type III i.e. extrovert Koushki buildings, with windows on all sides, the most important rooms requiring light are facing south. In the buildings common in Pahlavi period, Ivan became sunshade with dimensions smaller than introverted buildings. Of course, windows' dimensions also became smaller in south for less light in internal spaces in summer in the lack of Ivan.

5.2.Yard: It plays an important role in organizing traditional buildings. Yard in cold climates is usually smaller than warm and dry climates. Because cold season is long [13] in most buildings of Tabriz, the main courtyard is located on the south side and pool is in the middle of the yard, to soften the air, creating perfect view and sometimes create water sound using fountains and a sense of calm and cool in summer. Proper use of water and plants together in order to create a pleasant environment and good air and view is the most important principle of Iranian architecture. In addition to create a heavenly space, these factors' role is important in

regulating the environmental conditions inside the building and soften ambient and regional air. Planting plants matching the local climate and planting of evergreen and deciduous trees according to the need of shade or sun light in different seasons and the diversity and color in space prove ancestors' intelligence in using plants

Fig.2. Nikdel House plan in Tabriz, Sort of applications based on maximum use of sunlight.[14]



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5.3.Pool-house: Located in the basement, where there was a pool, in fact, a summer building where there is a pool with fountain. In cities like Tabriz with no summer building, pool-house is built under the main space with door and window. In an Iranian building, constructing a pool under dome chamber has features such as cooling, moisture and reflecting various images, the space is called pool-house and this space is for living people on hot summer days. Tabriz prevailing wind is from the southwest and northeast in warm seasons, pool-house is from the south and north with window[15]. The air flow passing through the pool-house helps displacement of the air and cooling, the pood-house has windows to other basement rooms through which cool air moves to other rooms. On the other hand, since the pool-house is located in the basement, the land cooling property is another factor in its cooling.(Fig.3)

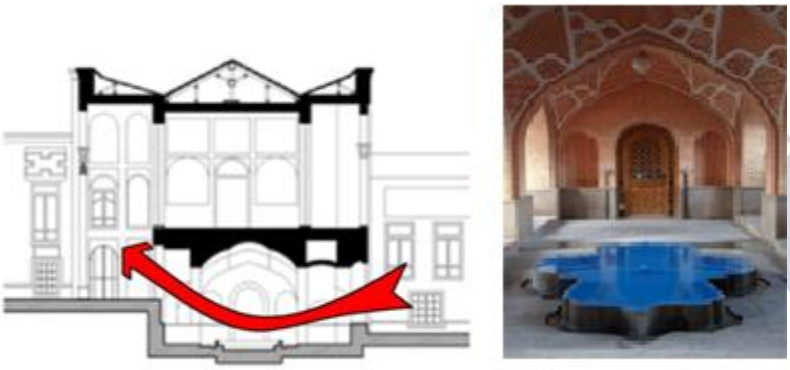


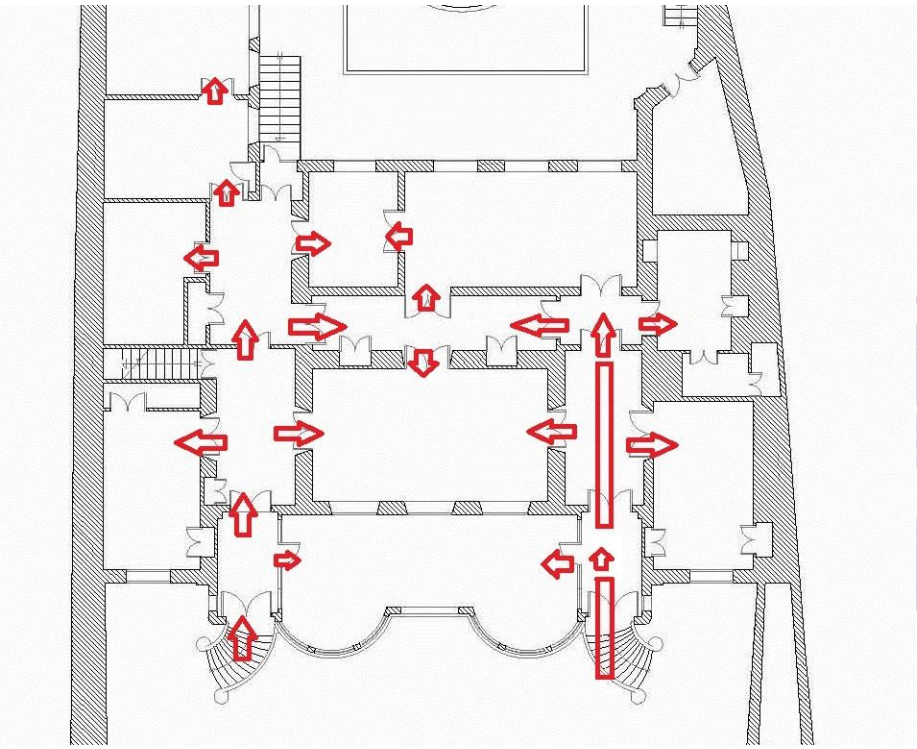
Fig.3. The pool-house of Gadaki house, Tabriz

5.4.The use of local materials compatible with the climate in each region: It not only emphasizes on reducing transportation costs and saving energy consumption but also the

materials are compatible with environmental climate and are flexible against environmental factors. In constructing Tabriz local buildings, local materials have been used i.e. stone and mud-brick, with high thermal storage capacity that pass heat with time lag. Two-cover roofs, flat or curved and sloping in addition to lighting the roof helped control sun received heat by a kind of insulation by trapping air between the two covers.[16]

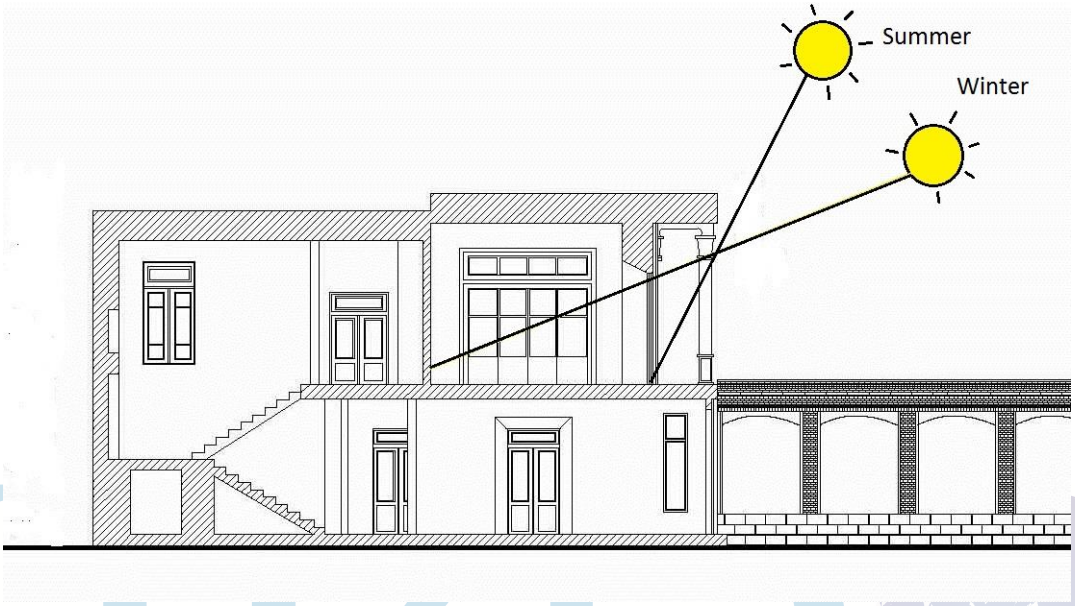
5.5.Spatial hierarchy: In Tabriz traditional architecture, there is spatial hierarchy in different parts of the building. For example, to enter the building or yard, no one enters the main spaces directly, but first entering a space called porch, then yard and other spaces. To enter the main spaces, such as living halls from the yard there is also such a hierarchy, entering the yard and then connectivity spaces and then the main spaces. In some buildings, to reach some spaces one should pass several connectivity spaces[17]. This prevents heat dissipation of spaces in winter and the entry of heat into space in summer. (Fig.4)

Fig.4. Hierarchy in company house plan, Tabriz



5.6.Ivan and shed: Half-open spaces with pillar in different shapes beside rooms are called Ivan and horizontal raised parts on windows are called shed. Both are essential elements of controlling sun radiation[18]. Using them, along with the use of vertical or horizontal blade of sunlight control, curtains, and windows with colored glass is a way to control the depth and the amount of sunlight into the building in summer and winter in terms of the need of residents to solar energy. Ivan depth in different regions was selected according to latitude so that it prevented summer sunlight and allowing winter sunlight.(Fig.5)

Fig.5. Ivan is an essential element of controlling sun radiation in summer and winter.



6.Methods of creating thermal comfort

Inside environmental condition of building must be even for physical and mental comfort of residents. Namely, thermal comfort (heating and cooling) and lighting require energy consumption. Extensive warm climate of Iran requires space cooling and it is the most important objective of the architects. A glance on old architecture in Iran reveals indicator elements in architecture structure of the buildings mainly used to satisfy thermal needs. They are main structure and configuration of the building. Although used elements in traditional architecture for cooling are not implemented in contemporary architecture; whereas principles of thermal physics are the same as those in the designing process of current passive system, sometimes , structure of the traditional elements is the same as that of current systems [19]. Heating three-step approach includes: 1. heat retention, 2 passive solar heating 3. mechanical heating. The first step is to minimize heat dissipation through building's wall through insulation, orientation and

appropriate surface-to-volume ratios. The second stage consists of collecting solar energy using passive methods. In the third stage, only a small amount of fossil energy is required for heating, which is not happen in Stages 1 and 2 [20]. Cooling requirements of buildings are best estimated by implementing a three stage design approach including: 1. Avoiding heat, 2. Passive cooling

3. Mechanical cooling.Passive solar systems use renewable natural resources of energy for heating, cooling and lighting and physical comfort in the building, only a small amount of mechanical devices are used for energy transfer. Designing process of these systems is directly dependent to the decisions of architect for conformability of other elements of architecture design.

Table1. Three steps of Passive heating in traditional buildings of Tabriz

three-stage of Passive heating design	**Solutions used in traditional buildings of Tabriz**
Keep heat inside the building	The proper orientation of the building help to maximum solar energy gain of the buiding
	Create the interface space between the external environment and the main living spaces to minimize heat loss(Fig.4)
	.Thick brick walls prevent heat transfer to outside of the building
	The use of double-glazed windows to prevent heat loss
Passive Solar Heating	The establishment of the main spaces on the south side, causing the absorption of solar energy in walls with high thermal mass and the generated heat during day in these materials returns to the environment in the night and evening with time lag.
Fossil heating	The use of fireplaces, Korsi, Firewood heaters and eventually the use of oil for heating spaces

three-stage of Passive cooling design	Solutions used in traditional buildings of Tabriz
Avoiding heat	The proper orientation of the building help to minimum solar energy gain of the buiding
	Create the interface space between the external environment and the main living spaces to minimize heat entrance to the building
	The use of double-glazed windows to prevent heat entrance,
	canopies in front of the building in the south side, prevent the sun light entrance to the inside
Passive cooling	Thick brick walls with high termal mass absorb solar and transfer it into the building with time lag in the evening and night and prevent over heating inside the building during the day,
	pool- houses in the basement floor are summer buildings which are cooled with evaporative cooling and ventilation,
	evaporative cooling of the building via the water of the pool in the yard
Mechanical cooling	In the traditional houses of Tabriz mechanical cooling were not used

Conclusion

Tabriz historic buildings are mostly related to Qajar and Pahlavi periods. By a careful study of the city's monuments and comparing construction methods, cooling and heating of buildings and comparing them with the principles of sustainable design that today are widely considered, we concluded that Tabriz local architecture is in accordance with the principles of environmental

sustainability. In the construction of the buildings, local materials fully compatible with the climate of the region are used. For cooling and heating of buildings, passive three-step approach has been implemented step by step. The first step in passive cooling system is avoiding heat and in passive heating system is conserving heat in the building. This step has been implemented with the correct orientation of the building, materials compatible with the climate and proper design measures. In the second step, we had passive cooling and heating, and maximum use of renewable energy. A proper design of sun energy has been used for the building heating in winter and summer nights and wind power and evaporative cooling of water have been used for cooling in summer. Also the effect of the earth heating has been used in winter and its cooling effect has been used in summer to create comfort conditions. Finally, in very cold days of winter that the first and second steps of passive heating had no power to control winter cold, fossil fuel, fireplace and/ or wood heaters have been used for heating the spaces.

Postscript

[1]Passive Design do not use mechanical energy and fossil fuels for heating and cooling. (Leckner,2006)

References

[1] [WGSC], (2004), Working Group Sustainable Construction Methods and Techniques Final Report.

[2]Munier, Nolberto (2005), Introduction to Sustainability: Road to a Better Future, The Netherlands: Springer.

[3]Hopwood,et al. 2005: 38-39) Hopwood, Bill, Mary, Mellor and Geoff, O'Brien (2005), Sustainable Development: Mapping Different

[4]Rogers, Richard (2005), Action for Sustainability, JA (Japanese Architecture), No. 60, p.129.

[5]Rogers, Richard (2007), Sustainability, www.richardrogers.co.uk.

[6]Yousef Gorji Mahlabani,(2010) scientific- research Journal, Iranian architectural and urbanism association, no.1 , autumn.

[7] Kasaei, Morteza, Climatic zoning in Iran: housing and residential environments of Tehran: Building and housing research center, 1993o.5, Spring & Summer.

[8]Meteorological annual report, 1933

[9] Saburi.R, Shukuhi Tabrizi.P, Analytical review of climate architecture in historic houses Tabriz, Architecture and Urbanism and Sustainable Development National conference,

[10]Shakib Mehr.L, Home Magazine, Style of historic houses in Tabriz, of the Constitution to today 2015

[11] Introduction to Tabriz, Old houses of Tabriz, Website Tabriz University

[12] Pirnia, mohammad karim,Introduction to Iranian Architecture , Science and Technology Publications, 2003:p 29

[13]Qobadian. Vahid, (2006), Climatic Analysis of the Traditional Iranian Buildings.university of Tehran, press 2344, 7, 42

[14] http://www.eachto.org/index.php/miras/banaha

[15]Neghabi.M,(2015) Pool- Houses – The Most Effective Elements of Traditional Passive Cooling, Current World Enviroment Journal, Volume 11, no.2

[16]Purdeihimi.Sh, Instruments shadow effect on the rate of heat gain through windows, Soffe Journal, no3-4, 1991

[17]Abdolhoseyni, Javad, Adaptability of Design of Residential Houses in Tabriz and Baku with the Native Culture and Climate , Vol.8/No.18/Autumn 2011,

[18] Zandie.M, Parvari Neghad.S, Sustainable development and its concepts in housing construction in Iran, Housing rural environment Journal,2010

[19]Vakili Nejad, R, Mahdizadeh, F and Mofidi Shemirani, (2013) M, Principles of passive cooling systems in vernacular Iranian elements , *scientific and research Journal of Iranian society of architecture and urban planning*,

[20] Leckner, N, Architects' design approaches for Heating, Cooling, and lighting, translated by Keynejad. M & Azari. R, Islamic Art University of Tabriz.(2006)