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Advantages of Combining Solar Greenhouse System and Trombe Wall in Hot and Dry Climate and Housing Design: The Case of Isfahan

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***Abstract*—**Nowadays over-consumption of fossil energy in buildings especially in residential buildings and also considering the increase in populations, the crisis of energy shortage in a near future is predictable. The recent performance of developed countries in construction with the aim of decreasing fossil energies shows that these countries have understood the incoming crisis and has taken reasonable and basic actions in this regard. However, Iranian architecture, with several thousands years of history, has acquired and executed invaluable experiences in designing, adapting and coordinating with the nature.

Architectural studies during the recent decades show that imitating modern western architecture results in high energy wastage beside the fact that it not reasonably adaptable and corresponded with the habits and customs of people unlike the architecture in the past which was compatible and adaptable with the climatic conditions and this necessitates optimal using of renewable energies more than ever. This paper studies problems of design, execution and living in today's houses and reviews the characteristics of climatic elements paying special attention to the performance of trombe wall and solar greenhouse in traditional houses and offers some suggestions for combining these two elements and a climatic strategy.

***Keywords*—**Climatic Designing, Housing in Hot & Dry Area, Solar Greenhouse, Trombe Wall.

I. Introduction

DURINGthe history, human has always tried to provide a residence corresponded with his environment to have better living conditions. In fact, the geographical and climatic conditions have direct effects on formation of this environment. As there are four types of climatic conditions in Iran including hot & humid; hot & dry; temperate & humid and cold, there are different architectures especially in local housing designing according to the climate.

Studies about traditional architecture and urban design in Iran show that they have always been corresponded with the nature, using of renewable energies and constructing buildings with lower energy consumption.

Housing for today's human should be designed according to his current needs taking into consideration the changes in lifestyle and the quality of housing should be considered as one of the main objectives in housing plans beside the quantitative dimensions. In a country like Iran that experiences rapid modernization process, the quality of housing is one of the serious challenges in housing plans and policies.

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It is important to consider the climatic conditions and their effects on buildings, especially residential buildings, in terms of increasing the useful life of buildings, quality and hygiene in internal spaces and energy saving in order to control the environmental conditions of these spaces. The patterns of projects designed according to special climatic conditions can provide the required natural and non-fossil fuels in the environment according to climatic conditions of the place and type of the building without any changes in today's accepted patters and extra expenses in design or execution of buildings. The building with climatic design can provide proper heating conditions for the residents in all seasons of the year without any need for fossil fuel and mechanical controlling devices in most regions of Iran. The changes in temperature, humidity and air current and continuous changes in lighting of internal spaces in such buildings provide a desirable, different and pleasant environment for the residents in all seasons of the year [1].

According to the samples of traditional architecture in Iran and new experiences in different parts of the world, we can concluded that if urban developers and architects recognize the importance of coordination in construction especially in residential places and climatic conditions in terms of quality and quantity and have access to proper tools for climatic design, they will be able to coordinate their projects according to geographic and climatic conditions of the place and take advantages of its benefits without damaging other objectives of their project.

II. Climatic Conditions of Project

Climate, as established relations with welfare of human, is the result of factors like sunshine, temperature, humidity, wind and precipitation. Creating healthy and comfortable spaces for working and life is one of the main and known objectives of modern architecture. Undoubtedly, creating such spaces in buildings which are based on nature and climatic conditions is possible with lower expenses for energy, is very important in terms in increasing the mental and physical efficiency of persons, decreasing the risk of diseases and also decreasing the consumption rate of non-renewable and polluting fuels [2].

Special location and natural geographical situation of Iran with a difference of 15' of latitude between the northern and southern parts of urban points, difference of more than 2500m between the highest and lowest points, existence of high and continuous range of Alborz mountains in the north, high range of Zagros mountains from northwest to southeast, Mazandaran Sea in northern borderline and Persian Gulf and Omman Sea in southern borderline have created a different climatic conditions in different parts of this country.

It is natural that this climatic variation requires the necessity of anticipating special form of human-made environments for different climatic regions [3].

According to climatic categorization Isfahan is in hot& dry and semi-desert category and according to Coupon categorization, taking into consideration the rate of precipitation and temperature fluctuations, Isfahan is in "B" category, that is, hot and dry.

A. Sunshine

As Isfahan is located in northern 32' it receives a high rate of sunshine (first factor) and as it is far from sea, it has low absolute humidity and hence it has relatively clear and cloudless sky (second factor). These two factors result in highs sunshine in this city and considering high temperature in Isfahan during the day, passive solar heating is a strategy which can be considered in this case. Considering the above-mentioned cases, as the temperature is higher than easing level in the summer, entering of direct sunshine should be prevented and as the temperature is lower than easing level in the winter, direct sunshine should be highly used.

B. Temperature

As in Fig. 1, The temperature of this city in winter is about 6ºC and it reaches to 14ºC in the warmest days and it reaches to -4.6ºC in the coldest days of winter. As we can see, the temperature in winter is lower than easing level.[1]

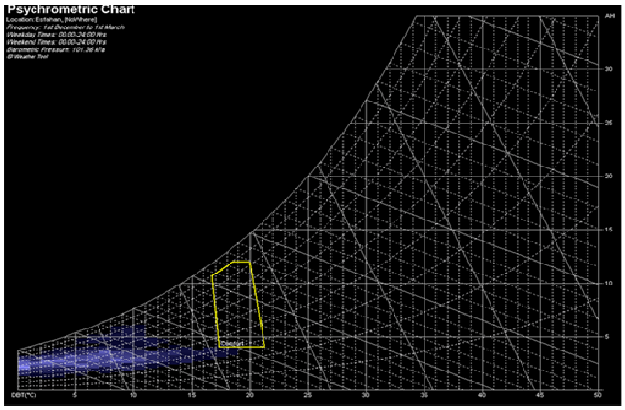

Fig. 1Psychrometric chart,Winter

As in Fig. 2, In spring, the average temperature to 21ºC and it reaches to 29ºC in the warmest days of spring and to 9ºC in the coldest days and it has warm and moderate temperature in this season.

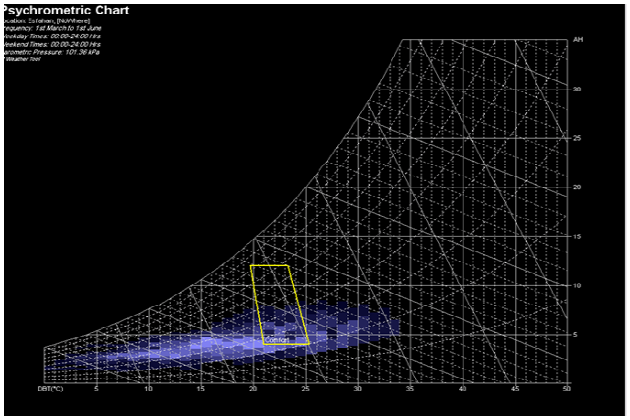

Fig. 2 Psychrometric chart, Spring

As in Fig. 3, In summer, the average temperature is 27ºC and it reaches to 36ºC in the hottest days and to average of 16ºC in cool days. So, summer is mainly hot and it becomes moderate in the last days of summer.

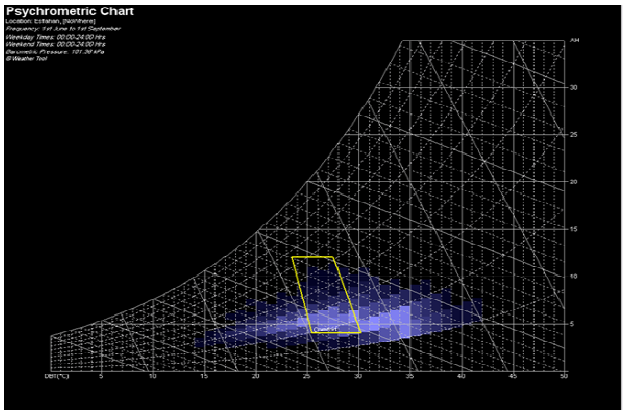

Fig. 3 Psychrometric chart, Summer

As in Fig. 4, In autumn, the average temperature is 10 ºC and it reaches to the average of 21ºC in warmest days and the lowest temperature in autumn reaches to 1ºC. This season is mainly cold with a temperature lower than easing level.

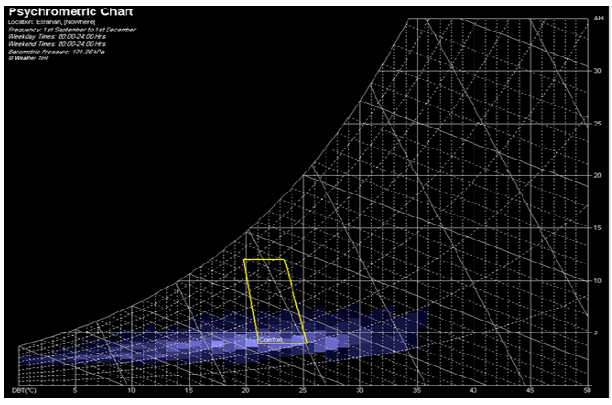

Fig. 4 Psychrometric chart, Autumn

[1]Psychrometric chart, Weathertools Software [4].

C. Humidity

The relative humidity of this region in spring is average of 24% at 09:00am and 18% at 15:00 pm; in summer it is the average of 21% at 09:00am and 15% at 15:00 pm; in autumn it is the average of 38% at 09:00am and 21% at 15:00 pm and in winter is the average of 46% at 09:00am, 34% at 15:00 pm.

D. Wind

According to the statistics, in windy hours (frequency) the wind is mostly blown from south and southwest and the speed of wind is 30-10 km/h in most hours, which is a relatively proper speed and the temperature of this wind is 10-25◦C and humidity is 40-60%.

Considering the cases mentioned regarding the factors effective on climate of Isfahan, taking advantages of these factors specially sunlight in this region can have an important role in energy saving and increasing the quality of housing, so studying and identifying the traditional patterns in this region including trombe wall and the effect of other solar climatic elements such as solar greenhouse and using the modern technology, we can promote their performance and use them in recent designs.

III. Climatic Design & The Role of Trombe Wall & Solar Greenhouse

Climatic design is a method to decrease the expenses in a building. Design of the building is the first defensive system against outside climatic factors. In all types of climates, the buildings designed according to climatic principles, will minimize the need for mechanical hearing and cooling and will use natural energy around the building instead. The money saved in long term will prove that execution of climatic designing techniques is the best type of investment for the owners of buildings. Most of these techniques don't have any expenses and they required only being informed about climatic design [5].

Climatic design will provide good easing conditions for the building and the building constructed based on climatic design have not only good performance against undesirable weathers, but also they provide healthy and beautiful environment and establish a balance between us and our world around.

Introducing trombe wall and solar greenhouse system as climatic elements in traditional houses in this section, we will try to describe their advantages, remove their disadvantages and combine these two systems to reach a new element in climatic design section.

A. Trombe Wall

Trombe wall, as a passive solar system, is a heating storage of building that absorbs sunshine using its outer surface and then transfers this heat from its wall through conduction.

In this system, some part of southern wall, which is made of materials with high thermal mass like concrete, is covered with glass with the distance of 5cm from the wall surface. Sunshine enters the space between the glass and wall and the heat is trapped by glass and it helps the wall absorbing the heat.

The openings in the upper and lower parts of the wall transfer the heat from the wall and glass to internal space and at night when the openings are closed, the radiance of heat from wall heats the house [6]. Trombe wall also doesn't need ventilation because the aim of this system is circulation of heat and receiving heat through radiance from the wall.

One of the disadvantages of this system is that it occupies a large area of southern façade and prevents from receiving daylight and sunlight and also disturbs the outside view. Here we will try to remove these disadvantages.

B. Solar Greenhouse

All solar heating systems use greenhouse phenomena. In this system, the solar energy is absorbed by greenhouse and injected into the house and hereby the ventilatory circulation is done. In most cases, a greenhouse should have an internal thermal mass to reduce heating fluctuations and the space of greenhouse should be well ventilated and shaded in order to prevent from excessive absorption of heat in summer [7].

One of the disadvantages of this system is that it should be placed in southern side opposite the trombe wall and as a result it will occupy a large area in the building.

IV. Hypotheses of Research and General and Technical Characteristics of Project

The idea of design for today's life is planned based on some traditional concepts and using of simple and inexpensive technology. The main hypotheses of this research include optimal design of building according to present needs of human providing his ease and comfort.

After making studies and researches on climate of Isfahan and its effect on traditional and modern houses, we found a deep gap between two fields of climate and design in today's housing and increasing of expenses and here the necessity of climatic design to reduce the expenses and protect the environment which have attracted the attention of the world because of ever-increasing reduction of non-renewable and fossil resources.

Considering the history of using climatic elements in traditional houses of this region, we can study about positive and negative aspects and take advantages of them using the technology of the day to reach a modern plan according to the needs of residents. As in Fig. 5, The system suggested in this research is a combination of the performance of solar greenhouse and trombe wall.

This system includes to glass layer separated by an air space. This air space plays the role of insulation against temperature fluctuations, wind and sound. There are openings in the upper and lower parts of this system for entering of air from outside to the space between the two layers. The fresh air enters the space between the two layers through these openings and is diffused to the internal space through a canal installed in the floor as a result of heated greenhouse effect. This system also traps the solar heat and converts it to electrical energy using the Venetian blind containing photovoltaic cells and keeps the house cool in summer and during winter this space receives solar heat and transfers it to internal space through opening the internal glass wall during the day and opening the openings of wall at night.

The space between the two walls can be equipped with a series of louvered shading elements made of aluminum with the width of 80 to 90mm which can produce electricity and absorb the heat and play the role of thermal mass of trombe wall in this system and protect the internal space from sun and dazzling radiation and help absorbing, reflecting or eliminating the heat.

One of the other advantages of this system is that it provides natural daylight and ventilation for the house; unlike trombe walls which occupy a large area of the façade and disturb receiving daylight and ventilation.[2]

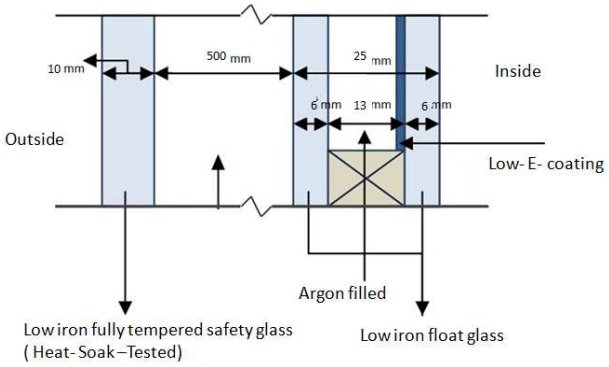

Fig. 5 Cross-Section of Suggested System

V. Conclusion

Paying attention to climate and weather conditions of any region and designing and constructing residential spaces taking into consideration the ease and comfort, will result in saving of energy and expenses.

Therefore, applying the modern technology of the world and using new energies in buildings and construction in accordance with the climate, we can save energy and prevent from environment pollution. Besides, it is important to use the valuable patterns of Iranian traditional architecture. As it was observed in local investigations, optimal use of renewable energies like sunlight, air current and other cases were considered by constructors and it has been tried to minimize negative effects on environment.

So, correct using of local patterns and integrating them with new conditions of construction and taking advantages of the experiences of competent experts in the field of energy we can use renewable energies like solar energy and wind for cooling, heating and ventilation of building and this required providing the background for cooperation of architects and energy experts to take advantages of new technologies to create a modern architecture according with the climatic conditions of any region.

[2] - Enameled coating for reducing light absorption and reducing heat transfer to internal space
- Glass with low light absorbing capacity (this glass is not ground glass and passes more light through it)
- High-resistance glass, resistant against temperature changes, shock and other factors.

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