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ORIGINAL ARTICLE

Determining the Thermal Comfort Range in the Climate of the City of Yazd using the Olegy Model

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ABSTRACT
Urbanization and urban development is associated with a rapid increase in population, development of industrial activities, the irregular use of fossil fuels, and serious damage to the environment. Harmony between architecture and climate of different areas causes increasing the heating or cooling energy use in buildings, which has a negative impact on both economic and environment. Hence, it is necessary to determine the thermal comfort of area by identifying features of each area. This research using statistics for 10 years from the synoptic stations of Yazd and calculating the monthly and annual mean of relative humidity and monthly mean of dry temperatures in Yazd during 1997-2006 has investigated the study and comparison of thermal comfort in Yazd city using Olegy method, evaluation of climatic conditions in different months, and drawing up the bio-climatic graph of Yazd city with software "Climat Consultant". According to the Olegy graph and upper and lower ranges of thermal comfort in summer and winter in Yazd city, the results showed that only three months (April, May, October) were in the range of thermal comfort, as well as four months (June, July, August and September) were in a position where is not possible for people to feel comfort without air flow and cooling due to evaporation of particles. In five months (January, February, March, November and December), it cannot feel comfort without exposure to the heat of sunlight or artificial heating sources. The results of this study can be used in the maximum use of environmental potential to save the energy consumption, enhance the quality of comfort in residential environments, and make a healthy environment.
***Keywords**: climate, architecture, thermal comfort, Olegy Model, Climate Consultant*

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INTRODUCTION

One of the important achievements of the traditional architecture of Iran in dry areas without water is as follows:

Very dense urban fabric, urban spaces with high degrees of coverage, narrow and irregular streets, and partly covered with the arch of buildings joined together, how they have been establish based on direction of the sun and wind, and in general all living spaces in these areas are protected against atmospheric agents [1].

Unfortunately, related to climate issues many of the lessons about past architecture in Iran have been forgotten to design new buildings, and in the warm seasons except closed environments with the electric coolers in other parts of these modern cities comfort conditions for human are not provided [2].

The climate design is a design that in addition to harmony with the its surrounding natural environment and a greater utilization of natural resources in the area can make an appropriate natural environment for users to the extent possible [3]. The sunlight is always required for lighting in a building. As the light is finally converted to heat,the amount of radiation needed for each building should be determined based on the type of building and the climatic conditions of area [4].

Intensity of solar radiations and its heat at one point on the ground depends on a distance where the sun's rays have to pass, the thickness of clouds, and air pollution level. Therefore, the intensity of solar radiations in a place is proportional to the height of area from the sea level so that in high places solar radiations pass lower distance of atmosphere, it generates more heat. Also at noon, the distance is low. As a result, the intensity solar radiation is more than morning and evening when the sun is the most crooked to the desired location. Given the above, it is concluded that intensity of sunlight at each point of the ground depends on the position of sun to that point [5].

BACKGROUND STUDIES AND SCIENTIFIC ACTIVITIES CONDUCTED

In 1975, Viktor and Eldar Olegy proposed moisture and thermal conditions scientifically in relation to the needs of human and climate design, and draw a bioclimatic table. Following Olegy's work, Parouch Giyouvni in 1976 completed it, determined the effect of construction practices in the comfort needs of human bioclimatic, and provides a table "climate-environment of building" [6]. In 1971 Karl Mahani also prepared a series of tables to evaluate the conditions of environment building bio-climate in more detail [7]. In 2007 M. Kasmaei has provided a variety of actions in Iran using the tables of building bio-climate and stats43 of synoptic stations. Also in 1994, he provided the first climate zoning in Iran related to residential environment with Mahani,s method using climate data from 591 weather stations .On this basis, the climate of country is divided into 23 climate groups. M. Razjouyan also provided appropriate guidelines for the optimal use of potential of climate in a book "comfort by architecture in harmony with the climate" in 1994 [8]. In practical, evaluations associated with the construction and architecture in harmony with the climate can be investigated in Alijani's findings, which has described the role of climate in the housing according to the angle of sunlight and various methods about the survey on housing consistent with the climate [9]. Papeli Yazdi studid the traditional housing in the turkmen tribes [10].

Practically, the climatic design defined as special construction methods of which the aim is reducing heating and cooling costs using natural energy flows to develop the comfort in buildings [11]. To accomplish this goal, buildings should be studied according to the features of the regional climate. To do this work, two steps should be taken:

1- Study on the climate conditions in the area of human comfort.
2- Designing the body of building (the body of building namely dimensions and its surface, the type of walls) , which are evidence of climate design.

Since 64.66% of the country's land with an area of 1,046,446 sq km is located in a hot, dry, ultra-dry climate [12], determining the size thermal comfort range in this climate became a priority. Yazd with hot and dry summer, cold and dry winter, the longitude 31 degrees 54 minutes, latitude 54 degrees 24 minutes and the height of 1230 meters above sea level is an obvious example of this climate. In this area, sometimes the temperature difference is 28 degrees C at night and day (Figure 1).The Yazd city in Iran is without a wet month (Graph 1).Obviously, this climate makes many problems for residents. The people of this area have long experienced different ways of dealing with this condition such as to build houses side by side, high walls, using materials like adobe, the use of thatch cover, the design and construction of dome arch, undergrounds ,and windwards. Among these cases, designing windwards has high efficiency. This sentence "cities and villages in the desert villages breathe with windwards" confirms the efficiency and effectiveness of windward design. The windward has affected the architecture of Yazd to the extent that the city is known as "the city of windwards" [13]. According to the definition, the thermal comfort condition is a range of humidity and temperature in which mechanisms regulating body temperature is at least an activity [14].

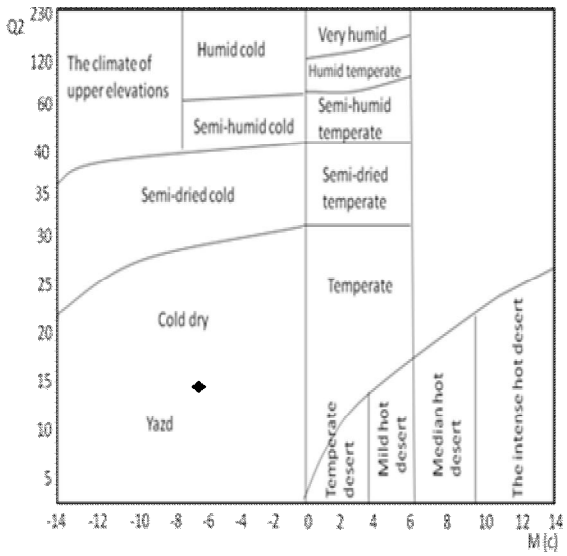

Figure 1 | The climate condition of Yazd city based on climate patterns of amberje during the years 2006 - 1977

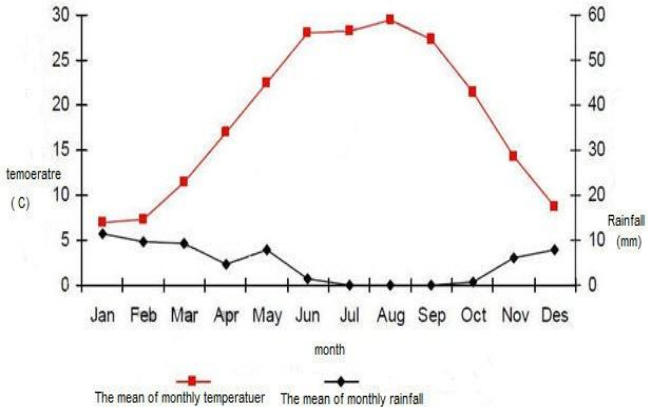

Figure 1 | The climate graph of Yazd synoptic stations during 2006 – 1977

MATERIALS AND METHODS

In this study, in order to achieve the thermal comfort range in the city of Yazd ,where is located in central Iran, for the study and comparison of the thermal comfort range the Olegy method is used ,in which is predicted ability to adapt to latitudes below 40 degrees(Figure 1)[15]. As well as climate factors such as relative humidity, rainfall, and temperatures were extracted to evaluate the climate condition, estimate the thermal comfort condition in different months, and draw the environment-climate graph using the Statistics of 10 years collected from synoptic stations in Yazd [16]. The climate design determines the impact of climate condition. It should simultaneously consider four climate variables in the loss of body heat. According to features of comfort area, available in the comfort index, human comfort conditions is thermal conditions suitable for at least 80% of people[4].Among the elements of climate , the temperature and humidity have a greater impact on human comfort. Therefore, most models of comfort measurement are based on two elements [17].

RESULTS AND DISCUSSION

Calculating the monthly and annual mean of relative humidity and the mean of monthly dry temperature in Yazd station during the 10 year period (2006-1997) (graph-1),and determining monthly and annual conditions of this station on the graph of thermal comfort ,points 1 to 13 are achieved according to Olegy as upper and lower ranges of thermal comfort range in summer [15]. Considering the graph of Olegy (Figure 3), the upper and lower ranges of thermal comfort are respectively 28 and 21.2 degrees in Yazd.

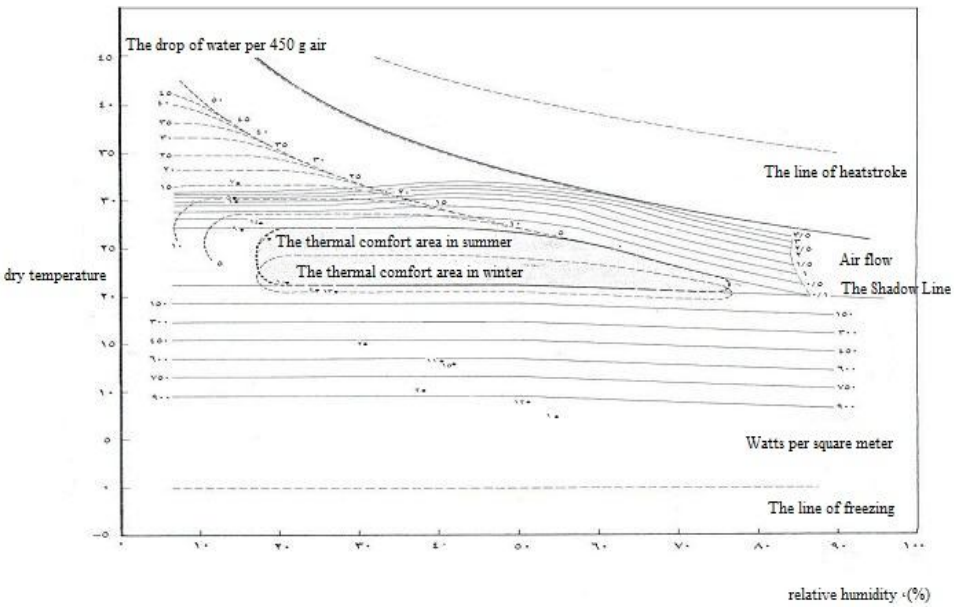

Figure 3 | The graph of Environment – Climate of Olegy, 1973, thermal comfort conditions in Yazd station on a monthly basis Conclusion

Five climatic factors such as the temperature, humidity, water vapor pressure, air flow velocity (wind) and radiation from the internal walls are consider in determining the thermal comfort range. Also other factors like the types of activity, coverage (clothing), and age and gender are assumed constant because they are not controlled [8]. Calculating the monthly and annual mean of dry temperature and relative humidity according to Olegy model, and transmitting estimated data on the environment-climate graph, thermal comfort conditions in the Yazd station were measured and evaluated on a monthly basis .Finally, considering the field observations, monthly statistical information , the environment- climate graph of Olegy, and climatic conditions of the city , thermal comfort ranges were determined to reduce the energy consumption.

Figure 3 | The graph of Environment – Climate of Olegy, 1973, thermal comfort conditions in Yazd station on a monthly basis.

The position of Yazd on the olegy graph showed that upper and lower ranges of the thermal comfort in summer and winter were respectively 6 warm months of year (April 11 to October 11) and 6 cold month of year (October12 to April 10). Thus, the environment-climate graph was created as follows. These results showed only three months (namely April, May, October) points 4,5,10 were in the range of thermal comfort and the four months(namely June, July, August, September) points 6, 7, 8,9 were in a situation where without air flow and cooling due to evaporation of particles, comfort feeling is not possible for people. In five months (January, February, March, November and December) points 1, 2, 3, 11, 12 were in a position where without exposure to the heat of sun or artificial heating sources comfort feeling is not possible. According to the Olegy model, in addition to temperature, relative humidity should also be determined to show the ranges of thermal comfort. Based on the Olegy model, relative humidity ranges are ideally 65% - 30%. The annual mean of relative humidity in Yazd is 26.9%.The highest mean of relative humidity is respectively 50.6% and 52.8% in temperatures of December. Also, the least mean of relative humidity created the thermal comfort is 18.9% in a month. So, the upper limit of relative humidity is 53% and its lower limit is 18%.This finding is less than comfort threshold of relative humidity in the city of Yazd.

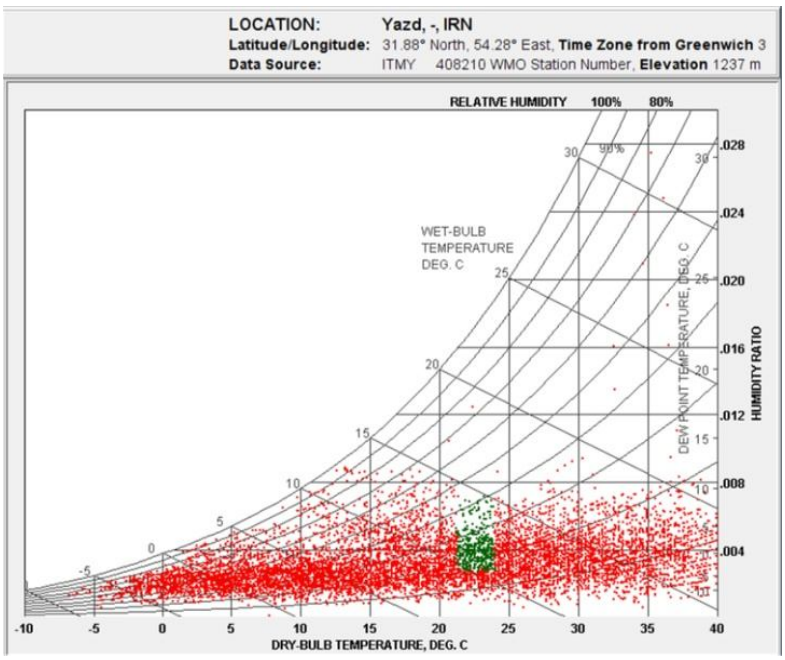

Figure 4 | The graph of thermal comfort in the Iranian city of Yazd. Humidity and dry temperatures, Climate Consultant

Heat exchange occurs according to four principles *physical, conduction, displacement, radiation, and transpiration*. It can be observed that the sun, wind, rain fall and their temperatures in air stored in the ground make natural energy sources in form of heating and cooling [11].

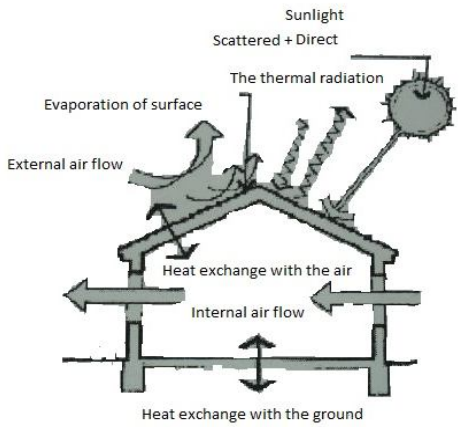

Figure 5 | Pathways of thermal energy exchange in buildings

These results can cause the maximum use of the environmental potential to save the energy consumption, enhance comfort quality in residential environments, and make healthy environment. In this regard, considering the angle of radiation, the direction of solar radiation, the direction of beneficial and harmful winds, and the importance of shadow in the summer, appropriate strategies for efficiency can be presented to create better environment conditions using standard materials and consistent with the nature and native environment. However, it is important that the traditional technology, resources and forms are suitable and stable although now some of them is not applicable due to cultural changes and environmental conditions. We go back to the traditional architectural structures and should design the environment using planning and management of applying appropriate strategies because they have been designed for other cultural situations .The main concern of the architects in 21st century is the technology and traditional vernacular architecture in the past to find ways for modern plans and designs. Buildings should be designed to provide the necessary energy from new sources. Buildings in ground should be constructed to be compatible with its surrounding environment .That is seen in dry and hot areas where have been tried in saving the energy and optimal consumption. Techniques used in traditional buildings are naturally consistent with climate. Therefore, we can use them with modern technologies and methods [18].

The Glass, which has ability to pass electromagnetic waves, prevents passing the amount of energy by reflection and absorption. Even the most transparent and colorless glass do not allow to pass a major part of ultraviolet and infrared waves. One of the most important references is American Energy Organization (us),where in addition to discussion about the glass with spectral selection has paid to their role in preventing the increase of cooling load in building to develop a deep relation between the environment, nature ,and human as well as take action for stable architecture.

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