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Application of Climate in Architecture with Compatible of Benefit economic in Save of Energy in Esfahan (Iran).

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Azadeh Arbabi Sabzevari, Gholamreza Miri; Application of Climate in Architecture with Compatible of Benefit economic in Save of Energy in Esfahan (Iran)

ABSTRACT

Nowadays, consideration of weather conditions in the design of buildings and specifically traditional design of buildings is quite clear. This research is conducted to study the quality of application of climate conditions in architecture and construction of houses in Esfahan city. In this study, metrological data of synoptic station in Esfahan has been used. In order to use the climate in architecture, the structural bioclimatic conditions in Esfahan have been used on a monthly basis and by the use of a 30-year mean (1980-2010). In this evaluation, the climatic components of solar radiation angel and direction for every month at 12 o'clock and the quality of wind behavior in urban environment and its changes have been overviewed. The results of the research show that with regard to the sun radiation angel and direction in Esfahan city, the best directions for the establishment of openings to make the optimal use of sun radiation include southeast, southwest and somehow south. In Esfahan city the favorable heat resistance of materials in ordinary and small buildings in the walls is 1.17 and in the ceilings is 1.28 (m2×h×degc×kcal).

Key words: Architecture climate, comfort climate, energy consumption, Esfahan city.

Introduction

Communities' emphasis on the proper management of resources and development of human rational and optimal utilization of these resources, make the scientists obligated to use all human sciences as the main routes to achieve this goal. Since the human environment is surrounded by the atmosphere and the major parts of his activities is done in this area, so the weather condition plays a major role in his life and activities[1].

Today consideration of weather conditions in the design of buildings and specifically traditional design of buildings is quite clear. The buildings and houses are places for the human's security and comfort by transformation of the outdoor environment. Architecture and climate association is more like a baby's embrace, like the proportion of any herb to the soil; an evolutionary dependence, inspirational and of course not limiting. In this sense, embrace, soil and climate are the relation between life and liveliness and their absence are the symbols of death [2]. Among other studies with the subject of architectural climate and climatic comfort includes:

Kasmaei, [2]. Climate and architecture of Karaj city, Mohammadnia [3]. applied metrology and climatology; Kasmaei, [2]. climate and Architecture book, Kasmaei [4], design of rural settlements compatible with the climate, Spagnolo, [5]. climatic study and application of solar radiation to decrease the fuel consumption in building, lovei, [6]. regionalization of effective temperature in the country, Deng [7]. Climatic design techniques in the traditional architecture in Iran, Tian *et al* [8]. have studied the dynamic assessment of environmental thermal comfort in the buildings equipped with the air conditioner and recommended the momentary thermal index based on the concept of Fanger thermal comfort. Tian and Love [8] have done a field study with the subject of thermal comfort of the inhabitants with radiant cooling system, Sakoy *et al* [9] on thermal comfort study, skin temperature distribution and sensible heat loss distribution in the sitting posture, Spangolo & Dier [10] also did a field study on thermal comfort in the open and semi-open areas in Sydney, Australia. The present research is also investigates the application of some of the climatic conditions in the architecture of Esfahan city in order to make the optimal utilization from the natural resources.

Research Methodology:

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The metrological data effective on the architecture compatible with the natural resources have been applied to perform the research. The respective data have been extracted from Esfahan metrology station and for a 40 year study period (from 1970 to 2010). In this research the main emphasis is on the effective impact of components such as radiation angel, radiation direction and also the climatic conditions such as wind flow in the direction of houses patterns appropriate with these climatic components in order to take the advantage of the proper conditions of these components and determine the quality of these constructional materials.

Research Results:

1.1. Elevation and Direction of the Solar Radiation:

By solar radiation elevation we mean that the angel between the direction of the sun's apparent disk and the horizon. Spherical position of the earth made the situation in which in every moment only one point of the earth receives the sun light in a vertical angel. Radiation direction is the angel between the Norths with a determined direction in the horizon. Solar radiation is really important in the architectural construction and especially traditional architecture and has so many applications. In the cold climates the basic principle of architectural climate application is the further penetration of solar radiation into the building. In the warm climates the building is constructed in a way that the least radiation will penetrate into the building. The solar radiation angel for winter and summer is resulted from 1 and 2 relations [11]:

Relation 1: $a_{s=90-\varphi+\delta}$ (1)

Relation 2: $a_{s=90-\varphi+\delta}$ (2)

φ is the local latitude, δ is the current sun declination (23 degrees and 27 minutes), a_s is the solar elevation angle at the local noon in the summer solstice and a_w is the solar elevation angle at the local noon in the winter solstice. With regard to the fact that Esfahan is located in the latitude: 32 North. The highest solar elevation occurs in January 21 and during summer and the lowest solar elevation is in the winter and December 21. In Esfahan, on December 21 at 12 o'clock, the sun angel is 34 degrees from the horizon and on January 21, which is simultaneous with the highest elevation of the sun in this city, the sun is 82 degrees above the horizon. During September 21 and March 21, that is simultaneous with the Equinox in the northern hemisphere, the solar angel is 62 degrees at the noon. Solar elevation range during the year is 48 degrees. Regarding the radiation direction the sun rises at the approximate 62 angel (around the north east) on January 21 and it sets at the 297 degrees. On September 21that the sun is in its lowest elevation overhead the observer, it rises at the 116 degrees and it sets at the 243 degrees. In Equinox (September 21 and March 21) the sun rises exactly from the east (90 degrees) and sets in the west (270 degrees). The figures 1 and 2 respectively show the solar elevation and solar radiation direction during the year for every month.

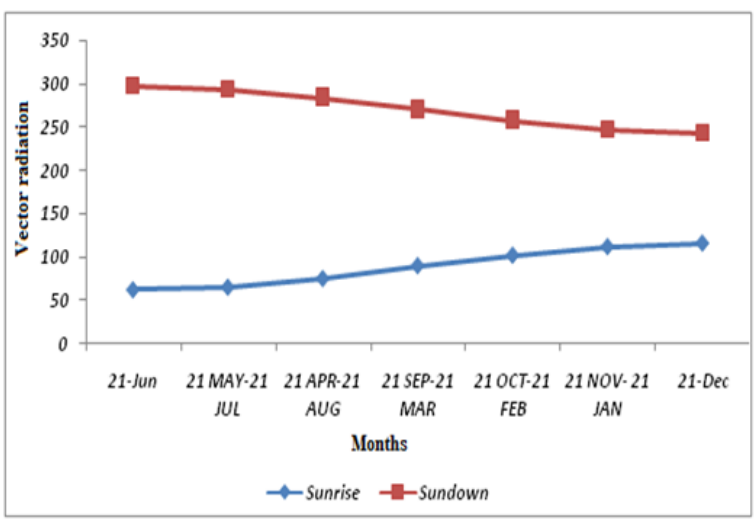

Fig. 1: Sun elevation at 12.

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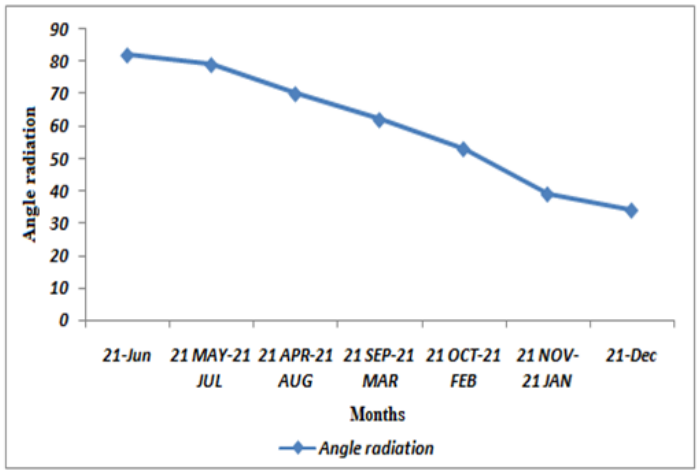

Fig. 2: Solar radiation direction in Esfahan.

Considering the solar radiation we can say that the south east and south west are the best directions in Esfahan to have the more solar radiation to heat the houses. During the summer with regard to the environment temperature drop it is very important to make use of the solar radiation to heat the houses. Since during the winter the sun rises from south east and sets in the south west, so the preparation of large size windows in this direction can lead the maximum level of radiation to the houses. Due to the low solar elevation in this season, the construction of houses toward the south is recommended. During the warm season, with regard to the increase in the solar elevation and radiation direction, the south east and south west directions receives the least radiation and it can be effective to create the thermal balance inside and outside of the building. The opening toward the west and the east in this season can direct high energy into the structure. Therefore, creation of large openings in these directions is not recommended and in the case that there are openings, we should reduce the level of solar radiation penetration into the building.

1.2. Type of constructional materials:

With regard to the fact from bioclimatic aspect during some of the months In Esfahan city, there is essential need to the usage of heating devices and controlling the penetration of the outside air into the building. Therefore, type of constructional materials is selected in the cold weather group. In order to select the type of constructional materials in cold areas we should consider two points: noticing the turbulent condition of the outside air and favorable environmental temperature. By turbulent condition of outside air we mean thermal temperature that is presented as the minimum temperature in calculations. This temperature indicates the most critical of weather temperature. In order to calculate the thermal resistance of the materials the relation 3 has been used:

Relation 3: $\mathrm{Rdes} = \frac{\mathrm{Ti-t(o)min}}{\mathrm{hi\times\Delta ti}}$(m2×h×degc/kcal)

Rdes in this relation is the thermal resistance o f the walls
Ti is the indoor temperature
T(o) min is outdoor critical temperature of the
Hi is the coefficient of the inside surface
Δ ti is the difference between temperature and inside surface

In this relation the Ti is considered to be 20 c degrees. As said about t(o) min (critical outdoor temperature) the average of the minimum air temperature is considered. About ti it is said that the maximum temperature difference between internal surface and indoor air is about 3 c degrees (the favorable degree) and maximum 5 c degrees (the maximum acceptable degree). The coefficient of the internal surface is also regarded to be 7 meters. The above mentioned relation is true for the materials such as big block constructions. In order to obtain the thermal resistance for the small buildings we should add an amount equal to 10 percent of the calculated number to the vertical walls and 20 percent to the roofs.

Since, In Esfahan city the average minimum temperature in the coldest month is -2/5, thermal resistance of the walls and the roofs of the large constructional blocks is as follows:

$$\boldsymbol{Rdes} = \frac{\boldsymbol{Ti-t(o)min}}{\boldsymbol{hi\times\Delta ti}} = \frac{\mathbf{20-(-2/5)}}{\mathbf{7\times3}} = \mathbf{1/07}$$

(m2×h×degc/kcal)

$$\boldsymbol{Rmin} = \frac{\boldsymbol{Ti-t(o)min}}{\boldsymbol{hi\times\Delta ti}} = \frac{\mathbf{20-(-2/5)}}{\mathbf{7\times5}} = \mathbf{/64}$$ (m2×h×degc/kcal)

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With regard to the above-mentioned relation in Esfahan, the optimal level resistance of constructional materials in large blocks is 1.07 and the maximum favorable level is 0.64. Considering the thermal resistance, the desirable weight of the houses' walls is about 100 kg per meter. This amount for the roofs, since they reflect the high ground waves more to the sky, will increase. In table1 the amounts of materials resistance in small blocks and roofs are shown.

Table 1: Thermal resistance in small constructional materials.

Roofs	Walls	Thermal resistance
1.28	1.17	Rdes(m2×h×degc/kcal)
0.77	0.70	Rmin(m2×h×degc/kcal)

1.3. Considering the wind as a factor in architecture:

Wind is one of the important climatic elements which is considered in architecture and other environmental programming. The reason for Devoting special attention the wind in architecture is from the natural ventilation aspect in building. The natural air ventilation is due to the pressure difference that the wind creates in the external walls of the structure. Only the wind can create the natural air ventilation and the comfort for the inhabitants of the buildings.

In Esfahan city, the wind direction in most of the months of the year is from the west (270 c). during the cold weather, with regard to the fact that climatic conditions is not appropriate for the people and there is essential need to the mechanical devices for heating, the penetration of air flow into the building cause the existence of cooler air. So in January, February and December it is a serious matter to prevent the penetration of outside air into the building and the exit of the inside air to the outside environment. With regard to the bioclimatic conditions In Esfahan city, usage of air flow for the air ventilation and draft is recommended to create desirable comfort condition during the warm months. Since the wind blows from east and west during the cold months of the year, the windows and openings could also direct the air flow into the building. In these directions and during the warm season of the year it is essential to remove barriers to have greater penetration of air. During the warm months of the year, wind speed also rises and it will improve the better air draft in the buildings. Table 2 shows the wind speed and direction in Esfahan city.

Table 2: Wind speed and direction in Esfahan city (Nut per hour).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elevation	2.8	4.4	5.9	6	5.4	4.6	4.4	3.9	3.2	3	2.5	2.4
Angle	270	270	270	270	270	270	270	90	90	90	270	270

In urban environments and with regard to the typography with man-made features, the barriers reduce the wind speed. Actually the urban typography creates friction and wind speed reduction. At the time of construction of the buildings in which the climate has been regarded, the way and elevation of the openings placement to let the outside air flow into the building and create natural ventilation must be studied.

In order to investigate the process of wind speed changes in different levels we can use the relation 4:

$$V = V_r (X / V)^k \qquad (6)$$

In this relation, V_x is the wind speed in X altitude, V_y is the wind speed in a determined altitude and K is the power of the most appropriate curve with the following values:

For the open plains 0.16, for forest areas 0.28 and for urban areas0.40, V is the standard altitude of measuring V wind speed. In Esfahan city, with regard to the existence of urban typography the wind speed in 5 meter altitude is considerably reduced. This wind speed reduction can be effective in the quality of air draft and ventilation in the buildings and monuments. For the better and optimum use of airflow in the Esfahan city, the openings should be placed in a determined altitude and far away from any barriers on the way to wind penetration.

Wind speed reduction in the low altitude buildings can have negative effect on the natural ventilation of air. In this condition the windows of the high altitude cad direct the air flow into the building and so the air draft is occurred with regard to the pressure difference created between the wind direction and wind back. Fig 3 shows the rate of air speed reduction in Esfahan city.

Conclusion:

Nowadays, the human bioclimatic studies as the basis of many of the civil planning especially in the area of urban and housing issues and the results of such studies is operated in the human settlement in new areas and the expansion of existing settlements. The present research is done for the purpose of investigation and application of climate in the architecture of Esfahan city. Actually the studies of architectural climate make efforts to establish settlements compatible with the climate in order to create favorable conditions for human comfort. Considering the direction of solar radiation, the south

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east and south west are the best directions for the optimum usage of light to heat the houses. With regard to the fact that during the winter, the sun rises in south east and sets in the south west, so the placement of the large size windows in this direction can lead the maximum light into the houses. With regard to the reflection of the high ground waves by walls and roofs, investigation of thermal resistance and the type of constructional materials is of great importance. In Esfahan city, the favorable thermal resistance of the constructional materials in the large blocks 1.07 and the maximum favorable level is about 0.64. With regard to the thermal resistance, the favorable weight of the houses walls is about 100 km per meter. In Esfahan city, due to the urban typography, the wind speed in the house will reduce and since the wind is an important factor in the draft and natural ventilation of the buildings, attention to the quality of the wind behavior is an important factor. In the cold season of the year, the dominant wind direction in Esfahan is west (270 degrees) and with regard to the bioclimatic condition of the construction, further prevention of the penetration the outside air into the building is recommended.

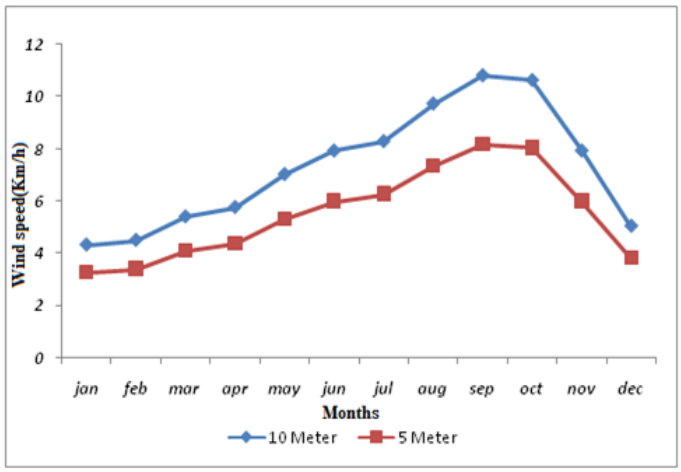

Fig. 3: Wind speed change in Esfahan city (km per hour).

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