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Optimization of Energy Consumption in Buildings with Architectural Design Compatible with Environment and Climate

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ABSTRACT: Extremely valuable fossil fuels and huge national investment in the recovery of fuel costs highlight the need to improve the structure and patterns, energy efficiency necessary to use. Damaging effects of fossil fuels on the environment and the nature have created risks in the lives of citizens, especially in today's metropolises. Thus, considering the use of native and adaptive knowledge in today architecture is crucial. Therefore, the present paper aims to investigate the environmental and climate effects on sustainable construction and constrains with the environments in hot and dry regions and its effect on optimization of energy consumption in the green architecture compatible with nature in city Damghan. Accordingly, besides use of library resources, required information was collected through field and descriptive –analytical methods in order to different aspects of climate effects on architecture and building in the studied region were considered. The obtained result indicate that traditional architecture consistent with Damghan climate, is totally in accordance with sustainable architecture principles and besides saving energy consumption, has a complete compatibility with the environment.

Keywords: Damghan, Energy Consumption, Environment, Iran, Sustainable Architecture

ORIGINAL ARTICLE

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INTRODUCTION

Most of the energy used by humans is non-renewable. In developed countries such as Europe, every people consumes about hundred "GB Jones", equal to 3.5 tons of coal energy annually. In the U.S. and Canada this amount is ten tons per person in year. Meanwhile, in other developing and non-industrialized countries each person consumes 0.1 tons, which is 0.01 of the highest consumption of energy (Behling, 1996).In the past, the traditional architecture made humans to think that was an example of people trying to take advantage of maximum climate potentials for welfare (Kasmaee,1999). Most practitioners have imitated the physical forms of the traditional architecture on which they called it traditional architecture (Climate Ghomes, 2008). Today, not only in Iran but also in some urban areas no serious activity has been taken, but in some cities houses which coordinate with the climate are destroyed and the reason is nothing but destructive imitation of the West architecture style and the advantage of some people involved and irresponsibility of official that have caused two errors in this way as: First, following a wrong architecture style, second, incomplete implementation of this type of architecture (Memarian, 1996).Though the physical form of the old architecture shapes as a result of using the local building materials, efficiency of materials from resistance power against winds and pressures on the building, , resistance against heat and cold, and precipitation (Watson, 1993.). One way to deal with these problems, saving in consuming fossil fuels through the architecture is consistent with climate because by this method in addition to saving in consumption of limited energy resources, environmental pollution will be considerably reduced and a comfortable degree and urban areas by developing appropriate and sustainable architecture will be achieved.

Statement of the Problem

The Great Architecture to create more interesting lives makes climate variability on Earth; therefore man should have a basic role to play in improving the climate out (Kaviani, 1993). Accordingly, in the traditional architecture of Iran, based on the geographical location of the building through roofs, reducing external surfaces in direct sunlight, basements and choosing appropriate materials, provide appropriate shelter with local , wind towers and etc., deals with the outside environment. In a way that it allows the best interior space without the use of sophisticated and polluting energy equipment. It is from here various ways in different countries of the world, in keeping with the local architecture and cultural climate of the region are represented.

Technology a need for clean energy

One of the important aspects in order to increase energy efficiency is trust in using the appropriate energy for a specific purpose. For example, the cost of power losses in transmission lines is much greater than the cost of consumed energy. The energy wasted in this process is able to heat all American houses (Behling, 1996).

In a decade from 1986 to 1995, the chief energy consumption of the world was Q-BTU 361 equal KWh or 8/105 * 10 ^ 2. Much of the consumed energy has been from coal, petroleum products, nuclear power and

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renewable energy sources. The rate of use of renewable energy sources is 12.6 percent that of this value 10.3 percent owned by energy is generated by traditional biomass. In the building, industry and transport sectors this consumption is 50 and 25 and 25 percen respectively t. Energy consumption in building sector is as follows (Mofidi, 1998):

A. Light 25
B. Heating and cooling 45
C. Equipment 15
D. Wasting energy 15

Considerable amount of energy consumption in buildings is wasted about 15 percent on one side and 70 percent on the other side for lighting, heating and cooling is important. How much to save huge amounts of energy will have a significant effect.

The Study Region

City Damghan in Semnan Province, with 12,110 square kilometers area is limited from north to the Alborz Mountains, from east to the city Shahroud, from south to the central desert of Iran and Isfahan province, from west to city Semnan and its distance to the center of the province (Semnan) is 114 km. Damghan is located between 53 degrees and 42 minutes to 45 degrees and 49 minutes east longitude and 36 degrees 34 minutes of north latitude. The city Damghan is placed in the southern slopes of the Alborz and in 120 km East of Semnan and 70 km of west Shahroud. Much of the city area is covered by plains and other parts are formed by mountains.

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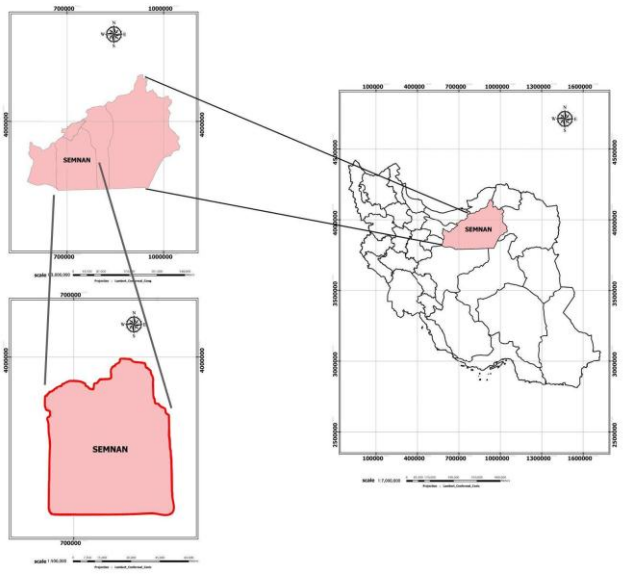

Figure 1. Situation in the country and the city of Damghan, Semnan Province (Management Planning province in 2011).

MATERIALS AND METHODS

Architectural properties of the hot and dry region of Damghan

Building in areas where the climate is hot and dry thatch used for walls, of materials used to can mention to brick, stone, etc. This material has a high thermal resistance and heat capacity of the solar radiation absorbed by the surfaces. Low steam pressure in this kind of weather makes with little conditioning temperature raises only 28-27 ° C. Only the minimum ventilation during the hot hours of the day, indoor temperature can be kept lower than the temperature of outer space. In some of these courses for a variety of climates windows and skylights are used. Thatch in these areas is better thermal insulation compared to brick or concrete, but with a little resistance. The bricks used to build walls and baked brick walls and the use of other materials which are used in grounds and walls. In areas near the mountains, stone and plaster interior walls and ceilings are working. Olegi method is related to determining safety procedures and criteria associated with it. December to March environment is heated through energy consumer devices and should only be in closed and controlled environment. During December and January, about 65 calories per hour heat acclimatization day will feel comfortable (Alihani, 2004).

A) Walls:

The walls are very bulky thickness. Concrete bricks are not good thermal insulation save energy transfer, but do it slowly. The wall using suitable materials can absorb and store heat during the day and at night the temperature drops to transfer it into the environment. Another advantage is that the walls in places where the temperature stays low during the day and at night the heat transfer by radiation is lost.

B) Windows:

In dry and heat weather windows are small and their number is low .these windows are created in the upper portions near the ceiling and walls . Generally only one side of the central courtyard houses, narrow alleys is the other side of the wall of the neighbouring house. One reason may be the type of Islamic culture design.

C) Introversion and central courtyard:

The location (central courtyard) is the centre of the home and social environment. Until it forms a thin and provides the needed shade in summer and in winter is receiving enough light. Usually in central garden there is a pond and trees to create a green space and helps to increase the relative humidity of the environment. Garden that includes trees, pond and plants are one of the factors affecting humidity (Talebi,2011).

D) Roofs:

The roof form of introverts have generally flat with a central courtyard and a small turret. The turret in addition to security and privacy, maintain some bodies of building from direct sunlight in some cases domes are used for roof water storage and mosques, in addition to structural reasons for physical reasons and degree of light angle of reflection is equal.

Building direction:

The most appropriate direction for placement of building is south-southeast since these directions are among the best directions for minimizing thermal

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influence caused by sun light in the afternoon (Ghobadian, 2008).

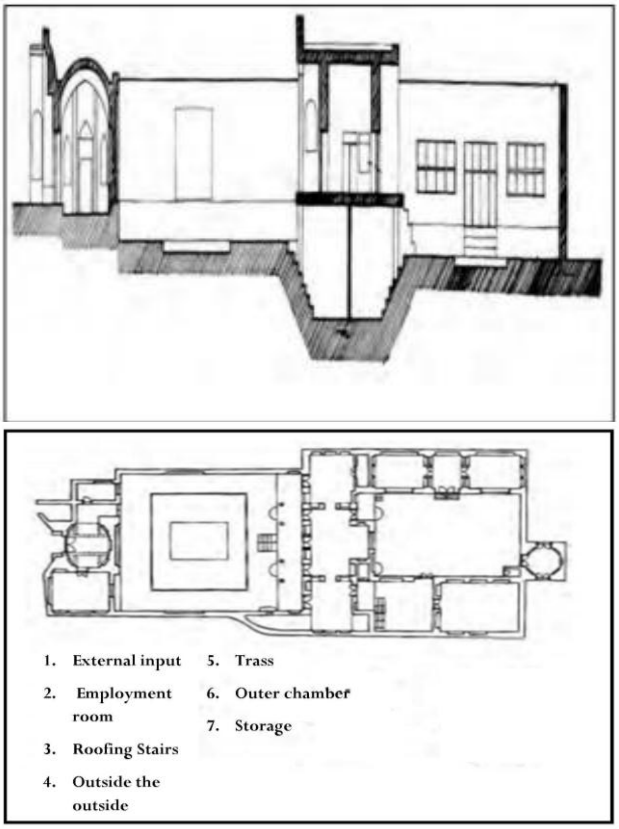

Figure 2. How to measure the texture of traditional housing cover,(Province Cultural Heritage, 2005).

Diagram analysis of Damghan climate(Olegi method)

A range identified in this chart, which shows the temperature and humidity of the climate. With the implementation of Damghan thermal conditions in the table to determine the climatology of monthly temperature and humidity of air in a year, it is possible to obtain critical durable cold and warm weather annually in Damqan (Kasmaee, 1999,145). July and August are above the zone of thermal comfort and the comfort of the air by evaporation of water particles in the air to be done. Meanwhile, you can prevent it from sunshine. The mean temperature for the months of May, June and September is located in the comfort zone. These hot months are like July and August. October is also about the limits of thermal comfort. Months of October, November, December, January, February and March, a person must be exposed to the sun's heat in addition to the heat source as well as the need for environmental design this is so important in architecture and building design.

Heating and humans (comfort and indoor air)

The overall thermal comfort in the body is when the skin temperature is 34 ° C .Most individuals (passive mode and normal wear indoors) when the ambient temperature is 22 ° C, was read in comfort.

There is a 12 degree difference between the two temperatures is due to 60 watts of heat through metabolism of the food that is produced in the body and through the skin would be repelled. If 60 Watt extra energy from reach from outside the body where the body could reasonably be expected ambient temperature is 24 ° C lower than the temperature of the skin it will be in comfort.

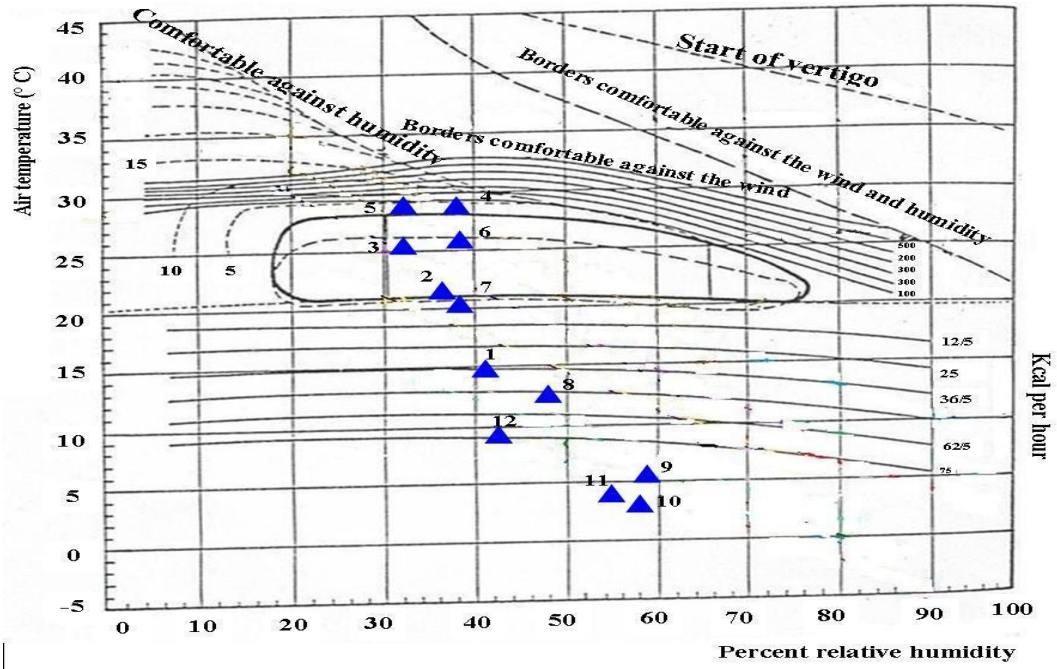

Figure 3. Chart eco building (Oleg) Damghan city in statistical terms, the author

Heat exchange between the human body and the environment will be in four methods:

-Conductivity (In Direct Contact)
-Conduction - Convection (Air Movement)
- Evaporation - Moisture Displacement
- Radiation (solar and thermal)

In the building design and its technical issues, human thermal comfort is defined as a state of mental and intellectual human thermal comfort is in good condition. Several experiments were conducted to test the consensus of the easiest subjects to be identified.

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Kansas State University researchers have come to the conclusion, people who wear the dress in the style offices are satisfied normally with dry environment with temperature 79 and relative humidity 50 and air velocity less than 35 feet per minute .In the building design and its technical issues, human thermal comfort is defined as a state of mental and intellectual human thermal comfort is in good condition. Several experiments were conducted to test the consensus of the easiest subjects to be identified. Kansas State University researchers have come to the conclusion, people who wear the dress in the style offices are satisfied normally with dry environment with temperature 79 and relative humidity 50 and air velocity less than 35 feet per minute .

Climatic factors affecting the choice of materials:

Weathering factors affecting the materials include loading, architecture, installations and performances like: radiation, temperature, wind speed and direction, snow, rain, freezing temperatures, humidity, evaporation and air pollution. Importance of climatic factors in relation to each of the load cases, architecture and is different. Generally, an architect before any action must be aware of atmospheric factors, and analyse the interrelationships among variables.

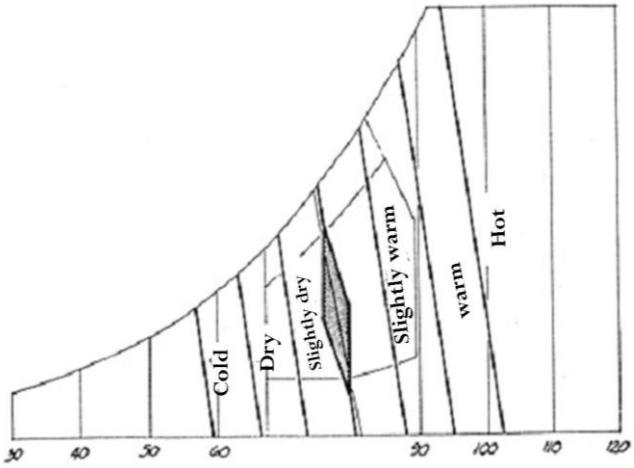

Figure 4. Feeling the heat based on research commissioned by the "Ashry " at Kansas State University has been done (Behyar, 2011).

RESULTS AND DISCUSSION

Data for the study of the climate elements were received from the synoptic station of the region and were classified during the period 2000- 2011(12 years old). Then the existing data were reviewed and analyzed. One of the main elements of weather and climate parameters is temperature. On sunny days in winter, a south wall absorbs about 75 percent of total energy, but the amount of solar heat on cloudy days is 7% and in semi-cloudy days is 18%. On days when the weather is clear the most amount of heat energy reaches the earth. In summer this heat on horizontal surfaces is 2 times higher than vertical level. Horizontal surfaces of a building may have reflected a great deal of it (Behling, 1996). Considering the conditions in Damghan shows that in 2011 rate of temperature compared to the previous period (years 2010) was more and much warmer year was passed.

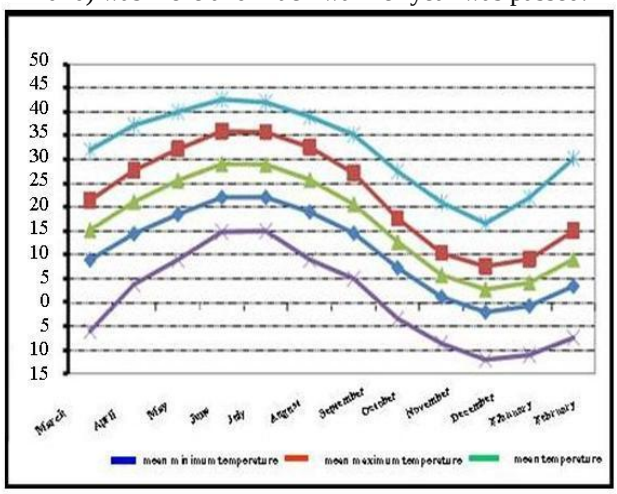

Figure 5. temperature regimes station cover the period (2000-2011)

The role of architecture as a strategy to reduce energy consumption

Building is considered one of the largest energy consuming sectors in most countries. Existing dissatisfaction is returned to the lack of comfort in relation to mechanical heating and cooling equipment. The building that has an air conditioning system includes higher energy consumption and much higher dissatisfaction compared to buildings that do not have air conditioning. So, the question is what are the factors affecting the efficiency and optimizing energy consumption? The main factors in this regard are divided into three categories:

A. Architectural design of building
B. Designing electrical and mechanical installations
C. Behaviour of residents

Studies by Baker (Baker, 1996) shows that mentioned factors increase normal intake of energy up to a ten times. The share of the architectural design in rate of energy consumption can increase normal intake up to 2.5 times. If electrical and mechanical installations are also add to, energy consumption will increase twice, that is up to two times, which is 5 times the amount of energy consumption. The proportion of the residents is the rest of ten times that is 2. At first look the issue that the role of the architect is tied with the role of facilities engineers and residents can cause for concern. There are two justified and acceptable reasons for importance of strategic decisions of an architect in designing a building.

Firstly, the structure factors are factors their probability of change is wrong. Only in reproduction or fundamental changes, when the structure of the facilities will be replaced, this event may occur. Secondly, these three factors do not act separately from each other, and certainly strategy of optimal energy consumption in building design is dependent either on either used installation system or all residents of the building. Apart from architectural design decisions in order to save energy is used, the use of renewable energy and save renewable energy more actually is obtained from fossil

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fuels, use of passive systems by architectural predictions and environmental compliance are of optimize energy consumption goals. Traditional architecture of Iran is the overt and obvious example of such a combination of using the non-passive method.

Resuscitation and storage culture has been given us from the past can easily help us in this direction .This is the evidence that the use of simple equipment and facilities in a building designed at the beginning of the building of more importance to technical studies (Arbabian, 2008).

Architecture and optimization of energy consumption in buildings

According to the role of architecture as the building designer in optimal use of energy and reduction of energy waste, it is necessary to consider balance between thermal exchanges in different sections of the building. The rate of heat loss through the building such as walls, roofs, floors and openings depend to such factors as the degree of thermal insulation, the temperature difference between the interior and exterior coatings. Studies (Najafi,1987) show that in a typical house with four open sides, the rate of energy dissipation in the walls is 29%, in roofs 26%, floor with open air 20%, openings 14%, and vents 11 %.

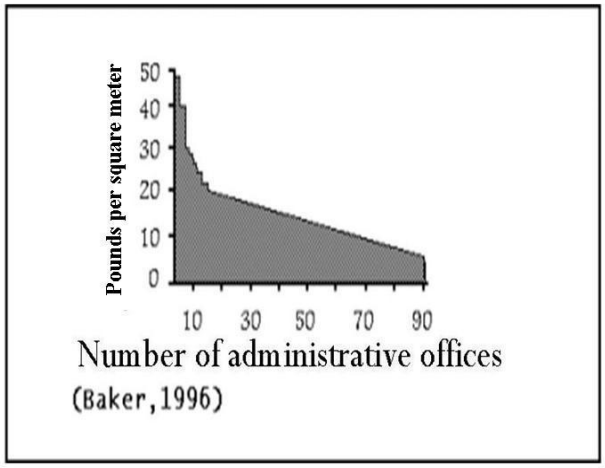

Figure 6. Energy costs in office buildings, Climate Ghomes, 2008, Journal of Semnan Province Meteorological, Climatological Statistics Division, No. 42, Page 5

Placement and form of the building can reduce energy loss in two ways. First, the sun direction and second is the wind direction. Navigation of the building compared to sun radiation and wind direction depends upon the type of climate and form of building can be designed in a way that has the highest conformity with sun radiation and wind. In this regard these two factors make opening and closing spaces. Existence of Greenbelt and open space trees can also act as a deterrent to heat and cold. In one hand trees absorb high temperature and on the other hand they can work as an obstacle against cold season. In conditions that for cooling the space air stream are needed, trees in open space should be predicted in a way that in this conditions air flow and wind see no limitation. Where the need for cooling air is wind, the trees should be in such a space can be predicted that these conditions may not prevent the movement of air and wind. Recessed rear projection and form of the building is effective in wasting. Compressed plans have less loss .Reduction of main spaces with outdoor wall construction reduces heat loss to a great extent. Interpolation of a space such as the vestibule can be used as entrance that is effective. In relation to form of building the important factor is largeness of building. Moderate and office buildings and residential apartment buildings have less heat loss. Figure 3 shows the construction of a number of administrative offices that some are added to the building, the energy costs are reduced.

Ombrotermic diagram

In the Ombrotermic diagram the average monthly temperature and rainfall are drawn in a vertical axis . So that the horizontal axis shows months of the year, the monthly temperature in degrees Celsius on the left vertical axis and the right vertical axis is allocated monthly precipitation in millimetres. Grading the vertical axis is so that the number of divisions for rainfall is twice the number of temperature, because experience has shown that if rainfall is less than or equal to twice the temperature, the region is facing with drought in the season .the point in the Ombrotermic diagram of Damghan is location of the rainfall curve above temperature diagram in September that shows an anomaly of rainfall in the station. In September, the station has faced with a sudden increase in rainfall. However, rainfall was shower and short-term, but it is very noticeable in this month.

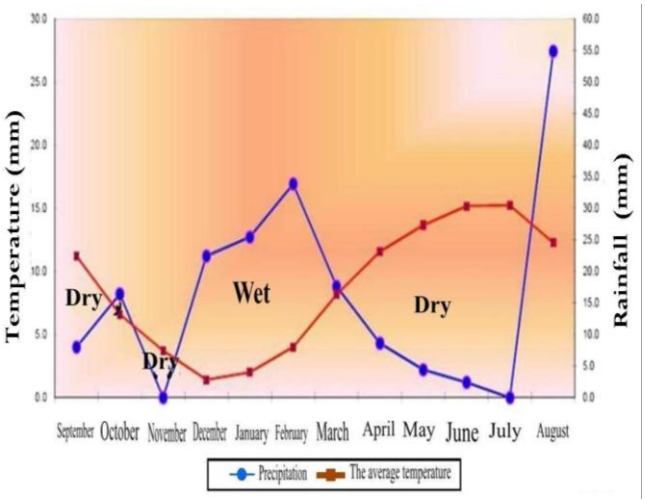

Figure7. Ombrotermic diagram Damghan city in the crop year (90-89), the author

It's the month of September to be considered as a wet month. The comprehensive planning in different fields, ranging from agriculture, livestock, water supply, architecture, materials and energy consumption and is necessary. In Stations of each region diagram approximately 5 months face with wet and and 7 months with wet conditions.

CONCLUSION

Iranian traditional architecture in different weather ensures comfort, logical design and optimization manifestation of this climate. The central courtyard of houses with features such as thick walls, porch and basement, wind, and arch demonstrate architects' clear understanding of the environmental conditions. Due to weather conditions, the use of appropriate benchmark for optimal utilization of energy and minimizing disruption of essential comfort nasty and heavy construction materials and thermal capacity, trees in the green space, prevention from severe gust of wind and trees to reduce evaporation rate, and the reduction of the number of small windows, creating a canopy of interior spaces with high ceilings such as architecture practices in this area seem required. Traditional architecture in warm and dry regions is designed based on non-fossil fuels and renewable energies such as solar energy for heating and cooling season as well as wind energy, wind for ventilation in the hot season spaces that is on the basis of sustainable architecture. in Damghan It is better that buildings are in rectangular form and its longer axis is in east and west and the view is to the south in order to avoid severe exposure to sunlight. For exterior walls Materials with high thermal capacity would be convenient. Also, the external color of the traditional architecture of the radiation is not absorbed. According to the traditional architecture of region natural and climatic conditions as well as the criteria for selection of materials, building orientation, type of facility it can be said that local architectural environment is consistent with the architecture of the main goals of human welfare, respect for environmentally sound and energy efficiency in buildings .

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