PASSIVE SOLAR SYSTEM POTENTIAL ANALYSES FOR ADAPTATION IN COLD-DRY CLIMATE ARCHITECTURE AT ISLAMIC AZAD UNIVERSITY OF BONAB, IRAN

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ABSTRACT

Today, energy efficiency and renewable energy sources' utilization are the most important issues in the contemporary world. Solar energy can be used efficiently in building design with the aid of construction elements like: windows, materials and insulation materials. But applying proper strategies of passive solar design to meet the thermal comfort conditions and energy efficiency as well in educational buildings must be taken into account. In this paper, the building of Institute of Graduation Studies at Islamic Azad University of Bonab in the cold-dry climate of Iran has been investigated in terms of architectural elements, and the amount of heat loss and received energy (heating and cooling loads) were calculated and analyzed using Cooper Software. Then, based on passive solar architectural principles such as building orientation, the number of openings, skylight space, solar gain on envelope surfaces and thermal insulation, the amount of heat loss has been compared before and after implementing the values and solutions for energy consumption optimization based on passive approach are provided..

Keywords:
Educational buildings; climatic design; passive solar energy; energy efficiency

1. INTRODUCTION

Limited resources of fossil fuels and increased rates of environmental pollution are issues that necessitate the reduction of fossil fuel consumption more than ever. It is obvious that achieving this objective is not possible except major strategies be implemented to optimize fuel consumption and renewable energy sources be used. The intensity of fuel consumption in Iran is 9 times higher than Japan and Norway, 7 times higher than developed European countries, 3 times higher than Saudi Arabia, and 4 times higher than Turkey and the world average as well. The case that Iran ranks first with regard to fossil fuel resources but is ranked 11th regarding the energy consumption in the world is because of high rate of domestic consumption [1]. The highest percentage of energy consumption in buildings is related to heating systems and the provision of hot water. In Iran, the per capita annual energy consumption is equal to 36000 kilowatt hours for every citizen. The mentioned number and its increasing trend have necessitated the need to make changes in consumption approaches and the enhancement of energy consumption culture in the country [2]. One of the ways of optimizing fuel consumption is the use of passive solar systems. These systems are placed in the exterior sections of a building and have been designed in a way that collect and store solar energy in a passive way and transfer it to the internal space of the building in due time. In these passive systems, buildings are designed in a way that cooling, heating, and lighting requirements be fulfilled in a natural manner and compatible with the specific climate. Since the need to the implementation of cooling and heating equipment is minimized in these systems, they are called passive systems. Passive systems have been used in Iran for a long time and the traditional architecture of the ancient Iranians show signs of their particular attention to the accurate and efficient use of solar energy. This attention could be observed in the architecture of old and historical Iranian buildings. Hence, it could be argued that the recognition and use of solar energy of diverse purposes dates back to the pre-historic era [3]. Perhaps in the Pottery Period, priests in the temples would light the fire pots by the help of sun's rays. One of the Egyptian pharaohs had built a temple whose door would open by the sunrise and close by the sunset. However, the most important story about the use of solar energy is the one related to Archimedes, the great scientist and investor in ancient Greece who put the Roman ships on fire through the use of thermal energy coming from the Sun. Since a gap has appeared between modern and traditional architecture and modern buildings lack principled architecture in harmony with the climatic conditions and the use of passive systems in buildings has gradually been forgotten, combining the traditional and modern forms of passive systems would lead to the increased optimization of energy consumption in buildings. Phase-change materials (PCMs) such as smart glasses, thermal insulators, etc. are the modern forms of passive systems (or could be regarded as the complements to the traditional systems) and encourage architects to observe the principles of architecture and permanent development [4]. Based on what was discussed before, the following applied goals could be mentioned for the current study:

1. Presenting solutions for the design and construct educational buildings from the beginning of the project
2. Presenting solutions for the use and adjustment of passive solar systems in the current buildings in order to obtain a principled model that is in harmony with cold climates.

2. LITERATURE REVIEW

Gilani et. al. (2010) found that the use of greenhouse systems in comparison to the traditional forms of heating systems reduces the heating load of the building in a significant way. However, this results in the reduction of direct radiation. The optimal orientation of a building on order to receive the highest amount of solar radiation is the south-western and western side and the optimal orientation for the least amount of heating load during a year is the south-western side. The highest rate of heat waste and the lowest rate of solar radiation is in the northern side of the building. As a result, in the climate being studied, the optimal condition for the implementation of this system is in the south-western side and the most inappropriate orientation is in the northern side [5]. Nowrouziyan et al. (2010) argued that the construction should be conducted in an area with the minimum of severe climatic conditions and the increase of sea levels. They have also suggested that the insulation of a building has to be enhanced in order to reduce heating and cooling costs [6]. Azamati et. al. (2012) stated that for cold, cold-mountainous, hot-humid, and mild-humid climates, the south orientation is the most appropriate one, while for the hot-dry and foothill climates, the north orientation is preferable. In addition to reducing the cooling and heating loads into their minimum, winds are important with regard to the natural conditioning and ventilation. So, the two sets of parameters have to be taken into account simultaneously [7]. According to the research by Kasmayi (2013), the exothermic areas be located at the canter of buildings and less important areas such as storerooms be located in the cold northern or western sides of the building as a thermal insulator. In addition, it should be taken into consideration that the major areas in a building have to be designed at the southern side [8]. With regard to the studies mentioned above and other studies, we concluded that educational buildings have been studied concerning their optimization of fuel consumption. However, the congruency of such buildings with the particular climatic conditions has not been studied before. In other words, no educational building has been investigated with regard to the use of passive solar systems.

3. THEORETICAL FRAMEWORK

3.1. Climatic factors

3.1.1. Climatic factors' effects on energy consumption

The amount of solar energy received by each point on the surface of the Earth depends on the intensity and duration of solar radiation on that region. The amount of heat and coldness on the Earth's surface determines the temperature in the upper layers. The average temperature above the lands in the summer and winter is higher and lower, respectively, than the average temperature above the sea. Another important factor is altitude; in the same latitude, the areas with higher altitudes are colder than the lower regions.

3.1.2. Air humidity

The amount of water that exists in the form of vapour in the air is called air humidity. The hotter the air, the more water vapour will exist in it. Maximum amounts of air humidity can be recorded near the equator and as we move towards the north or the south, the amount of humidity will decrease. Always, the pressure of vapour in the layers of are closest to the ground is higher than other layers. Because of that, any form of mixture of air in the vertical dimension will result in the reduction of the pressure of vapour in the layers closest to the ground.

3.1.3. Wind

The main reason for the existence of pressure belts in the Earth is the unbalanced distribution of the Sun's rays on various parts of the Earth, resulting in the creation of wind. Large masses of air always move from the high-pressure regions towards the low-pressure regions. Of course, such movement is not conducted in a direct line and is influenced by the Coriolis Effect (caused by the movement of the Earth around its own axis). Thus, the masses of air are deviate from their courses. In the northern hemisphere, this movement is conducted clock-wise, while in the southern hemisphere, the movement is in the counter-clockwise mode. This effect loses its force in the equator and increases in intensity as we move towards the poles.

3.1.4. Solar Radiation

The solar radiation is in the form of electromagnetic rays that originate from the Sun. These rays have diverse wavelengths ranging from 0.28 to 3 micron. The spectrum of the Sun's light can be divided into three parts: ultraviolet, the visible part, and infrared. The wavelengths for the ultraviolet, the visible, and the infrared parts are 0.28-0.4 micron, 0.4-0.7 micron, and >0.76, respectively. Particles in the air cause the Suns' rays to be reflected. However, since this re-election does not change in the quality of the rays, we still see the light in a white colour. When the Sun's rays are radiated on molecules and particles whose size are the same or lower than the wavelength of the ray, they are reflected and scattered in the environment. These scattered rays cause the areas away from direct radiation to be bright. When particles and molecules in the air scatter the Sun's rays having smaller wavelengths (related to the blue and purple colours), the sky seems to be blue. On the other hand, when there are large amounts of dust in the air, rays with higher wavelengths (related to the red and yellow colours) are scattered and the sky seems to be white.

3.2. Passive solar systems

Passive systems collect and transfer heat through the use of non-mechanical measures. The most general definition of a passive cooling and heating systems is that the flow of thermal energy in such systems is designed in a natural way (e.g., radiation, conduction, and movement). In principle, the structure itself or parts of the structure of a building constitute the system. In these systems, there are no separate collectors, the storage sections, or mechanical components. In other words, the passive systems work according to the accessible energy and the environmental factors. In general, energy is received through three main ways in such systems: direct, indirect, and isolated. Each one of these three methods has a different manner of receiving solar energy.

3.3. Environment requirements and features in educational buildings

The range of thermal comfort: Proper environmental conditions, or conditions where the thermal conditions in the environmental are within the physical comfort of human beings are among the factors that provide a ground for the higher efficiency of various activities. Range of comfort defined for the east Azerbaijan province is 18-25.7˚C in the winter and 21.5-29˚C in the summer [9].

Since students usually wear formal clothes in the educational buildings and their presence in the class increase the temperature by 2-3˚C, the range of thermal comfort defined for these classes has to be a little below the ones defined for ordinary buildings. With regard to the fact that students usually prefer the class temperature to be around 20˚C and considering the fact that the humidity in the environment is usually high during an academic year, the range of thermal comfort for educational buildings can be defined as 18-20˚C [3].

3.3.1. Air flow

In the region investigated in the current study, there are usually 30-37 students in each class. Lack of air flow and the concentration of the air resulting from the exhalation lead to the relative pollution of air in the classrooms. In order to prevent this situation, the subsidence of polluted air during class hours has to be stopped. In so doing, the classroom air needs to be ventilated. During cold seasons, this can be achieved by opening the door or the class once or twice for limited durations. It is obvious that opening the windows can facilitate the rush of cold air into the classroom and result in increased rates of energy consumption. The speed of air flow within the internal areas of a building is important, as well. In case that the air speed is lower than 0.1 m/s, the students would feel uneasy. Speeds higher than 1.5 m/s would interfere in the process of education, too. For this purpose, it suggested that the speed of air flow in educational buildings be around 0.1 to 1.5 m/s.

3.3.2. Heating load

Human body is continuously producing heat. This heat results from the metabolism within the body occurring in various organisms of the body. In the natural mode, the normal temperatures of human body in the inside and on its skin are 37˚ and 32˚C, respectively. In cold and hot environments, human body undergoes thermal exchanges. These exchanges in the form of radiation, evaporation, conduction, and convection. The amounts of exchange in the convection, evaporation, radiation, and conduction are 40 percent, 20 percent, 40 percent, and a negligible amount, respectively. Of the overall energy produced in the human body, just 20 percent is used and 80 percent is left unused. The extra thermal energy in the body is transferred to the environment where the human being is located. This extra heat varies depending on the rate of metabolism in the body and depends on the amounts of activity that one performs. With regard to the above discussion, it could be argued that the heating load in the educational buildings will be different from the residential buildings. What can be inferred from this difference is that educational buildings in comparison to similar residential buildings require lower amounts of thermal energy [3].

Table 1: Thermal Comfort Zone in Building in Summer and Winter

Building Type	Winter					Summer				
	With humidity			Without humidity		Luxury		Ordinary		
	Flux in temperature	Relative humidity	Dry temperature	Relative humidity	Dry temperature	Dry temperature	Relative humidity	Dry temperature	Relative humidity	Flux in temperature
Apartment residential House hotel Hospital office School, etc.	74 - 76	50 - 45	77 - 79	50 - 45	2 - 4	74 - 76	35 - 30	-3 to - 4	75 - 77	-4
Places with A limited activity duration Such as banks beauty salons supermarkets etc.	76 - 78	50 - 45	78 - 80	50 - 45	2 - 4	72 - 74	35 - 30	-3 to - 4	73 -75	-4
Place with A high rate Of latent Heat such as conference halls mosques churches restaurants theaters cinemas etc.	76 - 78	55 - 50	78 - 80	60 - 65	3 - 2	72 - 74	40 - 35	-2 to - 3	74 -45	-4
Industrial buildings and factories conference rooms machinery buildings	77 - 80	55 - 45	80 - 85	60 - 50	3 - 6	68 - 72	36 - 30	-4 to -6	70 -74	-5

3.3.3. Brightness

Most of the activities conducted in educational buildings are related to the sight. Conducting these activities require an environment where brightness is sufficient for human eyes. As much as possible, brightness in educational buildings has to provide through natural sources and environmental facilities [9]. For this purpose, the roof louvers could be placed in classrooms where the major education activity is going on. With regard to the time range for the use of educational buildings (i.e., 7.30 A.M. to 6 P.M.), Daily brightness can have a major role in the provision of lighting for classrooms. For this purpose, the duration for the use of classrooms can be adjusted according to the length of the day. On the other hand, since the use of integrated lighting control systems in educational buildings results in the waste of energy, it is suggested that smart lighting systems be used in such buildings [2]. In addition, renewable sources of energy (in the form of passive or active systems) can be used in educational buildings in order to save and optimize the energy consumption in educational buildings. Hence, we can get the maximum use of the solar energy in the production of heat and electricity.

4. MATERIALS AND PROCEDURES

The type of research method in the current study is a descriptive-analytical one. First, the climatic characteristics of Bonab City (East Azerbaijan) have been analysed through the investigation of 10-year climatic statistics related to this city. In doing so, such climatic parameters as radiation, temperature, rainfall, relative humidity, pressure of water vapour, average monthly maximum temperature, average daily maximum temperature, etc. were used. Through the analysis of the data and climatic factors, major climatic characteristics of Bonab were obtained. Next, through the use of climatic features and elements and obtaining the range of thermal comfort for Bonab during different seasons of the year, the educational building selected for the purpose of the current study was investigated and analysed with regard to being in harmony with the climate (i.e., the cold climate). In addition, the building was investigated with regard to the direction of the structure, elements of the buildings and the manner of their line-up and their definition in the whole building, the type of materials used, the plan design, etc. Then, the amount of thermal waste in the building was obtained for different seasons of the year. Based on these data, the principles of designing an educational building in Bonab which is in harmony with the cold climate were concluded.

The current study was conducted according to field and library studies in the area of construction and energy consumption in this particular climate and the manner of using passive solar systems in the cold climate. In addition, the “career” software was implemented in order to conduct the thermal analysis of the building. In the process of conducting the current study, qualitative and quantitative methods have been used in order to collect, analyse, and combine the data.

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5. ENERGETIC ANALYSES

The energy-architecture analysis on the Institute of Graduation Studies building at Islamic Azad University of Bonab, according to the principles of climatic design are as following:

5.1. Building form

The form of the building was investigated according to the standard form of buildings in the cold climate. In cold regions, the form of buildings should be a square since in this mode, the ratio of surface area to volume is 6 to 1; this small ratio of the surface area to the volume minimizes the thermal exchange between the building and the environment and the thermal waste. According to the calculations conducted in the current study, the ratio of surface area to volume in the building Institute of Graduation Studies is 3 to 1. Thus, this building is not suitable for a cold climate and does not have enough capability in order to minimize thermal exchanges with the environment.

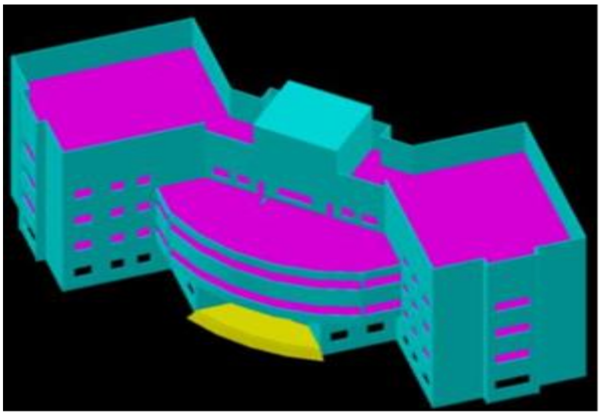

Fig. 1. Building Form of the Institute of Graduation Studies

5.2. Building compactness

The compactness of any building is calculated according to the ratio of the exterior surfaces to the total interior floor surfaces. According to the calculations performed in the current study, the compaction ratio in the Postgraduate Building is 1 to 2.12 (the exterior surfaces area = 4922 square meters, total interior floor surfaces = 10469).

5.3. Building stretch and orientation

The building investigated in this study has a northwest-southeast stretch because of a 10-degree turn in the building from the south towards the east, at 12 P.M. (the most significant time of the day for the reception of solar energy), the eastern side of the building was deprived from the solar energy, while the western and southern sides were able to receive the energy. The 10-degree turn in the building (according to the principles of design in cold climates) resulted in the enhancement of lighting in the afternoons. This 10-degree turn has resulted in a situation where the building benefits more from the heat received before the noon rather than the afternoon light. In such case, the absorption of heat starts earlier and results in the reduction of heating loads in the building.

5.4. The plan and the design of internal spaces

With regard to studies done on the plan of buildings in cold climates, it was concluded that the best plan for constructing a building in a cold climate is in the form of a compact one and constructing multi-storey buildings with a limited plan is more efficient than one-storey and vast buildings. Studies on the plan of the Postgraduate School Building showed that it has two cubic wings that are more compact in comparison to the other sections of the building and busy areas such as classrooms have been designed at these two wings. In addition, the thermal waste is reduced in this building because of the fact that the floors are located on each other.

5.5. Solar radiation intensity on different surfaces of the building during daytime

The intensity of solar radiation on the building was investigated and the energy received by different surfaces of the building was obtained in terms of w/m^2 through the use of the Carrier software. The results are provided in the following tables

Table 2. The intensity of solar radiation on different surfaces of the building in a day

Layers	Thickness mm	Density kg/m^3	Specific Ht KJ/ (kg- ^{0}k)	R – Value (m^3 – ^{0}k) /w	Weight kg/m3
Inside surface resistance	0.000	0.0	0.00	0.12064	0.0
25mm stucco	25.400	1858.1	0.84	0.03519	47.2
203 mm common brick	203.000	1922.2	0.84	0.27954	390.6
25 mm stucco	25.400	1885.1	0.84	0.03519	47.2
Outside surface resistance	0.000	0.0	0.00	0.05864	0.0
Totals	254.000			0.52920	485.0

5.6. Walls of the building

The walls in a building could be in two forms: rigid walls and transparent walls. Transparent walls could be subdivided into horizontal and vertical ones.

Table 3. area of crusts

	N	NNE	NE	E	SE	S	SW	W	NW	NNW	H	TOTAL
wall	122	65	576	43	568	230	557	41	598	54	0	2854
window	36	21	66	0	80	202	78	0	61	24	0	568
door	0	0	4	0	0	10	0	0	4	0	0	18
roof	0	0	0	0	0	0	0	0	0	0	1482	1482
floor	0	0	0	0	0	0	0	0	0	0	734	734

As it is illustrated in the above table, the total area of the vertical walls equals 3440m, the area of the rigid walls equals 2854 m, and the area of transparent walls equals 568m. In other words, 82.9 percent of the walls in the building are in the form of rigid vertical walls, 16.51 percent in the form of transparent walls, and 0.52 constitute other forms. Considering the fact that transparent surfaces should constitute 15 to 25 percent of the total vertical surfaces, the building studied in the current study has 16.51 percent transparent surfaces and has been designed according to the principles of design for the cold climate.

The ratio of the openings to the rigid surfaces in different sides of the building: The percentage of transparent surfaces in different sides of the building is portrayed in table 4.

As is illustrated in table 4, the southern side of the building has the highest surface are and number of openings (i.e., 40.19 percent).

Table 4. The ratio of the transparent surfaces to rigid surfaces

Orientation	Opening	Percentage
N	36	21.47
NNE	21	3.69
NE	66	11.61
E	0	7.57
SE	80	14.08
S	202	40.49
SW	78	13.73
W	0	7.21
NW	61	10.73
NNW	24	4.22
H	0	0
Total	568	100

5.7. Materials used in the walls

The materials used in different walls (vertical and horizontal sides and openings) are described below.

Walls (internal and external walls) in their basic form: In basic form, the heat transfer coefficient for a wall is 1.9 W/m2K˚. Layers of the wall are described in the following section.

Table 5. Layers of the wall in its basic form
(Source: Calculations made by the researchers, 2016)

Wall Details

Outside Surface Color…………………..…Light

Absorptivity……………………………..0.675

Overall U-Value………………1.890w/(m^2 °k)

Layers	Thickness mm	Density kg/m^3	Specific Ht. KJ/ (kg- ^{0}k)	R – Value (m^3 – ^{0}k) /w	Weight kg/m3
Inside surface resistanc e	0.000	0.0	0.00	0.12064	0.0
25mm stucco	25.400	1858.1	0.84	0.03519	47.2
203 mm common brick	203.000	1922.2	0.84	0.27954	390.6
25 mm stucco	25.400	1885.1	0.84	0.03519	47.2

Outside surface resistanc e	0.000	0.0	0.00	0.05864	0.0
Totals	254.000			0.52920	485.0

Wall Details

Outside Surface Color.................Medium

Absorptivity................................0.675

Overall U-Value.................1.904w/$(m^2\,°k)$

Layers	**Thickness mm**	**Density kg/m^3**	**Specific Ht. KJ/ (kg- ^{0}k)**	**R – Value (m^3 – ^{0}k) /w**	**Weight kg/m3**
Inside surface resistance	0.000	0.0	0.00	0.12064	0.0
25mm stucco	25.400	1858.1	0.84	0.03519	47.2
203 mm common brick	203.000	1922.2	0.84	0.27954	390.6
30 mm HW concrete	30.000	2242.6	0.84	0.01733	67.3
Slate	20.000	4325.0	1.26	0.01387	86.5
Outside surface resistance	0.000	0.0	0.00	0.05884	0.0
Totals	278.600			0.52521	591.6

Ceiling in its basic form: In its basic form, the heat transfer coefficient for the ceiling was 0.95 W/m2K$^\circ$ and different layers of the wall in its basic form are in the following form.

Table 6. The layers of ceiling in its basic form (Source: calculations performed by the researchers, 2016)

Roof Details

Outside Surface Color.................. Medium

Absorptivity................................0.675

Overall U-Vale..................0.954w/$(m^2\,°k)$

Layers	**Thickness mm**	**Density kg/m^3**	**Specific Ht. KJ/ (kg- ^{0}k)**	**R – Value (m^3 – ^{0}k) /w**	**Weight kg/m3**
Inside surface resistance	0.000	0.0	0.00	0.12064	0.0
25mm stucco	25.400	1858.1	0.84	0.03519	47.2
200 mm HW concrete block	200.000	977.1	0.84	0.019280	185.4
50 mm LW concrete	50.000	640.7	0.84	0.28889	32.0
10 mm HW concrete block	10.000	977.1	0.84	0.01229	9.8
Asphalt roll	20.000	1121.3	1.51	0.33988	22.4
Outside surface resistance	0.000	0.0	0.00	0.05884	0.0
Totals	305.400			1.04813	306.8

Roof Details

Outside Surface Color.................. Medium

Absorptivity.................................0.675

Overall U-Vale................1.231w/$(m^2\,°k)$

Layers	**Thickness mm**	**Density kg/m^3**	**Specific Ht. KJ/ (kg- ^{0}k)**	**R – Value (m^3 – ^{0}k) /w**	**Weight kg/m3**
Inside surface resistance	0.000	0.0	0.00	0.12064	0.0
25mm stucco	25.000	1858.1	0.84	0.03484	48.5
200 mm HW concrete	200.000	2242.6	0.84	0.11558	448.5
50 mm LW concrete	50.000	640.7	0.84	0.28889	32.0
10 mm HW concrete	10.000	2242.8	0.84	0.00578	22.4
Asphalt roll	10.000	1121.3	1.51	0.16994	11.2
20 mm HW concrete	20.000	2242.0	0.84	0.01156	44.9
Slate	10.000	4325.0	1.28	0.00894	43.3
Outside surface resistance	0.000	0.0	0.00	0.05884	0.0
Totals	325.000			0.81259	648.7

Openings in the basic form: In the basic form, the heat transfer coefficient for a double-glazed window is 4.25 W/m2K$^\circ$ and different layers of the window are in the following form.

Table 7. The layers of openings in basic form (Source: Calculations conducted by the researchers, 2016)

W.D 2

Door Details:

Gross Area.................................2.2m^2

Door U-Value...................4.259w/m^2 °k

Glass Details:

Glass Area................................0.0m^2

Glass U-Value...................3.293w/m^2 °k

Glass Shade Coefficient..................0.880

Glass Shaded AI Day?.............................No

5.8. Using various strategies to reduce heat loads in the building

5.8.1. Use of triple-glazed windows with UPVC frame and casement

Replacing the double-glazed windows with triple-glazed ones having a UPVC frame. In addition, all the interior and exterior door have been replaced with UPVC doors.

Calculated Values	
Total solar transmission (SHGC)	0.527
Direct solar transmission	0.392
Light transmission	0.54
U-value (ISO 10292/ EN 673) (W/m2-K)	2.032
U-Value (ISO 15099 / NFRC) (W/m2-K)	**1.901**

Fig. 2. Thermal features of triple-glazed windows

5.8.2. Use of thermal insulations in the walls and the ceiling

Using insulators in order to reduce the heating and cooling loads in a building (in other words, the load of the whole building) is one of the factors of reducing the load of the building. Different types of thermal insulators having their specific heat transfer coefficients have been presented in table 8.

Table 8. types of thermal insulations

Type of insulator	Heat transfer coefficient (W/mk)	Description	Color
Polyurethane	0.025W/mk	A yellow – colored insulator being used in the walls of storage facilities	Yellow
Polystyrene	0.036W/mk	Rigid placers formed out of tiny polystyrene grains	White
Fiberglass (Glass wool)	0.03 W / mk	It is produced through melting glass and changing it into tiny fibered. These fibers are formed in to panels or rolls and are resistive against fire. It can be easily cut and installed.	Yellow
Mineral wood	0.039 W / mk	Raw material for the production of mineral wood is diabase or basalt. It is denser than glass wood and has a higher rate of resistance against fire. It is a fine material for soundproofing	Creamy - yellow

Regarding the high levels of fuel consumption in cold climates and the shortage of fossil fuels in addition to the air pollution resulting from the use of these fuels, the use of passive solar systems and the construction of buildings according to the principles of design in the cold climate have been taken into consideration in constructing the Institute of Graduation Building at Islamic Azad University of Bonab.

6. RESULTS

Without doubt, design and construction of buildings according to the principles of design in the cold climate and the use of passive systems in addition to the application of ways in order to optimize fuel consumption and reduce the use of energy in a building, the tendency is towards constructing a building with the minimum energy requirements. In this regard, the heat transfer coefficients measured for the walls, ceilings, and windows in the building studied in the current study were .19W/m2K, 0.95W/m2K, and

4.25W/m2K, respectively. The first step in the reduction of heat waste in the building was the reduction of heat transfer coefficients related to the walls and ceiling. In this regard, the major task was the use of thermal insulators in the exterior walls. Through the reduction of heat transfer coefficient of the wall to 0.554W/m2K, the heat waste through the walls was reduced by 63 percent. In addition, by the use of thermal insulators for the ceiling, the heat transfer coefficient was reduced to 0.43W/m2K. Consequently, the amount of waste from the ceiling was reduced by 83 percent. In addition, through the use of triple-glazed windows, the heat transfer coefficient was reduced to 1.9W/m2K and the waste was reduced by 79 percent. As a result, the heating load in the whole building (calculated by the use of Carrier) was reduced by 87.5 percent. Hence, observing the principles of design in the cold climate such as using materials consistent with the climate and with high rates of heat capacity, using dark-coloured materials, and using forms that are square-like, with compactness, and proper orientation will have a major role in the reduction of the heat load in a building.

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