Thermal analysis of insulations used in the building shell with the optimization approach and reduction of energy consumption

Vahid Ebadati[1], **Naser Ebadati**[2], **and Mohammad Ebadati**[3,*]

[1] *Department of Management, Islamic Azad University, West Tehran Branch, Tehran, Iran*
[2] *Department of Geology, Islamic Azad University, Islamshahr Branch, Tehran, Iran*
[3] *Department of Civil Engineering, Islamic Azad University, Roudehen Branch, Tehran, Iran*
[*] *Corresponding author: ebadati.dr@gmail.com*

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Energy is one of the most important and basic needs in human life. Due to the high share of energy consumption in residential buildings, an important need to optimize energy consumption in this field is felt. In between, the role of building shell is very important, because it can play a pivotal role in this field and reduce energy consumption. In this research, initially different types of insulations used in various buildings were examined and classified. Determination of the physical and thermal characteristics of each material lead to the selection of the appropriate options. Finally, a simulation is performed using the EnergyPlus software to measure the efficiency of said materials in different roles. The work method is that first a building with all the standard specifications is designed in the software environment. The simulation is then done using the EnergyPlus software for different time periods and climate conditions in Tehran and the results are obtained. Moreover, by adding effective insulations to reduce energy consumption and re-simulation, the effect of each of them is analyzed. The results of this research show the reduction of energy consumption by up to 30%.

keywords: *Thermal insulation, energyplus, energy saving*

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1. INTRODUCTION

The geographical extension of Iran, climate diversity and the magnitude of the temperature spectrum in most parts of the country during the year have caused excessive consumption of electricity for cooling applications as well increasing as natural gas consumption for heating during winter and other cold months. Increasing energy consumption demand for cooling and heating has caused irreparable environmental damage to our country's natural resources, including the dramatic increase in air pollution, Increasing greenhouse gas emissions, as well as urban heat island effect phenomenon [1]. To take a step in sustainable development, the attention of the construction industry experts should be attracted to the adverse energy consumption situation. Green construction industry strategies have been created and adapted by increasing concerns on carbon dioxide emissions and dependence on the energy associated with fossil fuels [2, 3], In Iran country, building and housing sector with more than 40% of the energy is the largest consumer of energy. The building and housing sector is one of the main sources of pollution production. The housing sector accounts for up to 26.4% of the carbon dioxide emissions in Iran. Buildings in Tehran province produce more than 40% of the carbon dioxide. Green buildings are the flag of sustainable development and balance between environmental, economic and social issues. The reduction in energy consumption in the building and housing sector will have a significant impact on the energy consumption of the whole country. The potential for energy savings in this sector is greater than other sectors. The reduction in energy consumption in this sector is easier and by less investment available [1, 4]. The building facade and energy consumption of the building have a direct relationship with each other and today the impact of the building facade on energy loss is considered, because it is the highest consumption from the total consumption of energy in the building. The type of implementation, the type of insulation and the canopy system are very effective on the optimization of energy consumption and its cost. As it is important to choose and design the building facade for the beauty of the facade, the energy debate and energy loss are also important in the building facade. In fact, if a façade usage is chosen correctly, it does not meet its energy consumption in terms of the region and other cases it still has problems and does not account for a desirable façade.

Oree & Anatah in a study in 2016, initially introduced the feasibility of positive energy residential buildings in the tropical island of Mauritius. Results reveal that the application of passive strategies such as shading, insulation and natural ventilation have precluded the need for artificial cooling and ventilation in the positive energy (PE) house. The resulting electricity consumption of the house decreases from 24.14 to 14.30 kwh/m^2/year [5, 6]. In between, the role of insulation used in the outside facade of the building is very important and practical [7]. Oree & Anatah, their study results showed The energy performances of diverse types and thicknesses of insulation materials applied internally or externally on the façades of the baseline house were compared. When placed on the exterior of façade walls, increasing the thickness of the insulation material definitely yields a decrease in electricity consumption. Simulations reveal that on a typical summer day, the heat gain from the façades increases only by 0.28 kw when an insulation layer of 0.15 m is applied to the external walls as compared to the baseline case. A similar change on a typical winter day causes a heat loss of 1.18 kw. Accordingly, on a yearly basis, less heat is trapped inside the house and less cooling energy is required. Conversely, increasing the thickness of the internal insulation layer increases the electricity consumption. On a typical summer day, the solar heat gain increases by 1.82kWwhen an insulation layer of 0.15m is applied internally whereas the corresponding heat loss in winter is 1.12 kw. Therefore, the solar gain over a year is positive, suggesting a rise in the cooling requirements. The most efficient internal and external layers of insulation for the façades were 0.05-m expanded polyurethane and 0.15m unfaced polyurethane, respectively [6]. The results of the Ghafari Jabari and Saleh study indicate that the impact of insulating in façade on energy consumption is very high and the greatest energy loss occurs through elements of the facade. By insulating facade and isolating the roof, you can reduce the total energy demand. Double-wall insulated, double-walled window and insulated roof have reduced the total energy consumption by 41%, and it is the most optimal method in the selection of materials [8]. The purpose of this research is to optimize and reduce energy consumption due to insulations used in the building shell and to investigate the effects of the canopy system in reducing the thermal loads of a residential building in the arid and warm climate (Tehran). In this paper, it is tried to design different models and obtain the best results using the role of thermal insulations in the prevention of energy loss and by assisting the canopy system for windows used in facade.

2. THEORETICAL FOUNDATIONS

A. Insulations recognition

The insulations practical features are a set of science and empirical data that make a significant impact on the final result. Different types of building shell insulation materials were compared and classified considering thermal conductivity by utilizing previous studies Table 1. With regard to their application as well as the thermal resistivity coefficient as well as the ease of performance, glass wool insulations, rock wool, glass foam and polyurethane foam were used to simulate as insulation used in the model building. Polystyrene insulation has also been used as part of the EIFS system to determine the impact of applying the EIFS system to warm and arid climates such as Tehran. One of the other influencing parameters in the building facade is the amount of light and solar energy that these entrances can be controlled by the canopy system. The efficiency of the canopy role was investigated by using the canopy system in the model building.

A.1. Recognition and comparison of insulations used in this research

- Glass wool thermal insulation: fiberglass thermal insulation or glass wool thermal insulation is a composite of glass fiber and polymeric materials which results in a significant reduction of heat transfer. Installation and carrying of glass wool thermal insulation without safety devices, because of the silicone, glass powder and glass fragments can be harmful to the eyes, skin and lungs. Due to its non-flammability and low cost, fiberglass thermal insulation is one of the most commonly insulation used in the world. The thermal resistivity of fiber glass insulation is between 2.9 and 3.8 [m^2K/W] depending on the installation and quality of the material [9].
- Rock wool thermal insulation: Rock or mineral wool thermal insulation is made from volcanic rocks or slag wool manufactured by steel plants. The thermal resistivity coefficient for the mineral wool insulation is between 2.8 and 3.5 [m^2K/W]. The most important characteristic of rock wool is its high resistivity to fire and is used as a protective material against fire and melts at a very high temperature. Rock wool insulation for growth of pest, fungi, bacteria and vermin is the improper environment and is as safe as a non-organic material against these parasites [9].
- Cellulose Glass insulation: cellulosic glass insulation, which in semi-solid mode is one of the different types of environmental-friendly building insulation, such as paper and cardboard. Due to the high compression of cellulose glass insulation and the lack of oxygen penetration into the layers of building insulation, this is the best type of thermal insulation to reduce damage and destruction after the occurrence of fire. The disadvantages of the cellulose glass insulation can be attributed to the creation of sensitivity for a small percentage of sensitive people to paper tower and also the shortage of specialists to install cellulose glass insulation. The thermal resistivity of cellulosic insulation is between 3.1 and 3.7 [m^2K/W] [9].
- Polyurethane thermal insulation: While polyurethane thermal insulation is not common like rock wool insulation, it has a very good efficiency. Non-chlorofluorocarbon gases are used to produce foam state with new technology. Polyurethane thermal insulation has a very low weight and high resistivity to fire and is easily sprayed on a surface that has not insulation. The resistivity amount of thermal exchange of polyurethane thermal insulation is 3.6 m^2K/W] and has good efficiency against non-heat exchange [9, 10].
- Polystyrene thermal insulation: Polystyrene thermal insulation is the water proof thermal foam that is highly resistant to heat and sound exchange. Unlike other types of building insulations, polystyrene thermal insulation has a unique, very smooth, flat final surface. Polystyrene thermal insulation as thermal insulation of the wall is very appropriate, but due to the flammable polystyrene thermal insulation, fire-resistant coatings must be applied on the finished surface of polystyrene insulation. It is available in two types with varying efficiency and thermal resistivity coefficients of 4 and 5.5 [m^2K/W] [9].

B. Introducing a shading Role in the Design of the Building Shell

The shading is used to control the amount of sunlight to the light levels of the building. Not necessarily the shading will be

Table 1. Comparison of the types of insulations used in the building facade

Types Insulation	Advantages	Disadvantages
Glass wool thermal insulation	1. Significant reduction of heat transfer 2. Low cost 3. Non-flammable	1. Installing unprotected equipment is harmful to the eye, skin and lungs
Rock wool thermal insulation	1. High resistance to fire 2. Sound insulation	1. Facing the creation of skin sensitivity
Cellulose thermal insulation	1. Consistent with the environment 2. High resistivity against erosion 3. Proper thermal insulation 4. High compressive strength	1. Creating sensitivity for people sensitive to paper tower 2. Shortage specialist for installation
Polyurethane thermal insulation	1. Very low weight 2. High resistivity against fire 3. High resistivity against erosion 4. Proper thermal insulation	1. Gases emitted during work are harmful to the performers. 2. The 400 - year - old recycling cycle
Polystyrene thermal insulation	1. Proper thermal insulation 2. Use in different colors 3. Proper humidity insulation	1. Flammable 2. Low resistivity against erosion

required in all climatic regions. In order to determine the needs of the canopy, the area's climate needs to be studied closely to determine the hot times of the year in the area. If hot times exist in different building fronts, due to the hot times of the year and the angles of the Sun at the time, the canopy angle may be either horizontal or vertical. This is where all the window surfaces are in shadow, preventing the sun from entering and increasing the temperature and causing adverse thermal conditions [11]. The creation of shadows on the windows or glass walls prevents direct sunlight from falling to the surface of the glass, thus reducing the heat generated by the sun in the back of the glass. This amount of reduction depends on the location of the created shadow. When shaded by the outer surface of the shadow, a very small amount of solar thermal energy is transferred to the back of the glass. Because heat transfer is in this mode (conduction) and heat transfer is seldom performed in conduction, and transparent bodies do not pass rays of long wavelength. But when it was used to prevent direct sunlight from the inner shutters, the direct beam of the window would pass through the window and reflected the shutters. The heat insulation by waves of long wavelength and heat the heat as it cannot pass through the glass, which makes it warm to the inner space, causing the atmosphere to warm up [12, 13].

3. RESEARCH METHOD

In this research, first the types of insulations used in different buildings were examined and classified and by determining the physical and thermal characteristics of each of them to select the appropriate options. Then the simulation is performed using software method (EnergyPlus, SketchUp, Ecotect) and the role of each of these insulations is measured. The work method is that first a building with all the standard specifications is designed in the software environment. Then simulation is then done using the energy plus software for different time periods and climate conditions in Tehran and the results are obtained. Moreover, by adding effective insulations to reduce energy consumption and re-simulation, the effect of each of them is analyzed.

A. Energy Simulation

The simulation of building energy enables the building energy consumption to be determined before the construction and operation of the building. In addition to determining the building energy performance in different climate conditions, the building problems can be determined and taken for the necessary measures. In order to determine the effect of different factors on improving the energy performance of the building, the energy consumption of the building can be determined and the energy level of the building can be determined. Also by examining the thermal behavior of the building at different times, it is possible to identify weaknesses of the building in terms of energy consumption and thermal comfort and take the necessary strategies to improve it. This method is no longer sufficient to ensure the suitability of the capacity and power of heating and cooling systems and ensuring proper functioning of them based on the smallest possible capacity of equipment, and there is no need to take into account the unrealistic assurance factors that are due to lack of understanding of future construction conditions. The designer and the building maker will be sure to build the desired building with the lowest cost and best conditions of thermal and visual comfort.

EnergyPlus software is created to calculate the energy required to heat and cool a building that works in a variety of ways. Energy systems and resources do this by simulating buildings and related energy systems when exposed to various environmental and operating conditions [14]. he energy function principles Plus are the volume of control and the remains of mass and energy conservation (first law of thermodynamics) and heat transfer mechanisms: displacement, radiation, and guidance. The time dependent conduction and conductivity of the building surfaces is calculated by the conduction transfer function (CTF) mechanism. The energy Plus software lacks a graphical environment so it is necessary to coupling a suitable software with it [15]. The software used in this research is sketchup.

4. MODELING

A. Reference building

A form of the proposed building with all the specifications required by the standard. Usually the reference building and the test structure, the source of energy, number of residents and design conditions have the same design and only parameters in the simulation are variable so that each simulation operation is carried out and measured relative to the reference building. The building reference building is designed under the foundation of

150 square meters and is designed in five stories, and its location has been considered to be three - fold so that the north, south and east side of no building is considered, and only the west side is adjacent to a building with the height of the reference building. The ratio of the window area to the wall on the north side of the building is 31.2% and the south side of the building is 23.3% of the total area. The materials specifications used in the reference building as well as the specifications and systems used in Tables 2 and 3. The plan perspective plan is also available in Figs. 1 and 2.

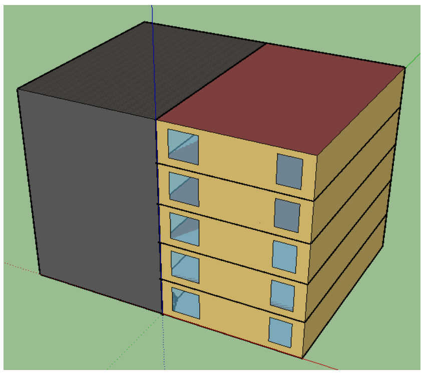

Fig. 1. Perspective view - south of model building.

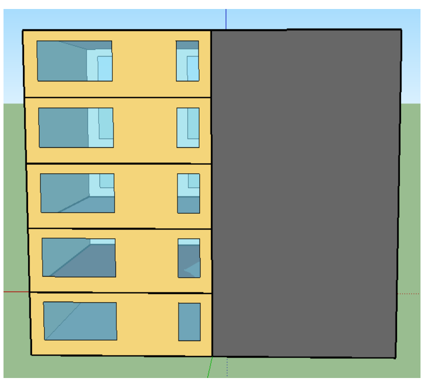

Fig. 2. Perspective view - north of model building.

B. Shading device Features

The shading system is used in simulation of the Zebra curtains and is horizontal. The width of the blades are 0.025 meters, And the distance of the blades from each other is 0.018 meters. The thickness of each blade is 0.001 m, which closes the blade at a 45 degree angle and prevents direct sunlight from direct sunlight. The heat transfer coefficient of the screen is 0.9 W/m-k and its reflection power 0.5. Note that the Auto-activation System is considered inactive in autumn and winter due to the lack of need to reduce the reflection of the sunlight.

5. RESEARCH FINDINGS

The simulation results of the reference building for the city of Tehran are shown in Fig. 3. This provides an average of monthly energy consumption for the cooling and cooling of the building. The simulation results for the reference building indicate the consumption of 23116 kW/h to cool the building (cooling system) and consume 5909 kW/h to heat the building (heating system). The largest energy consumption to heat the building was in the months of Jan, Feb and Dec. The months of Jun, Jul, and Aug had the greatest need for energy to cool the building.

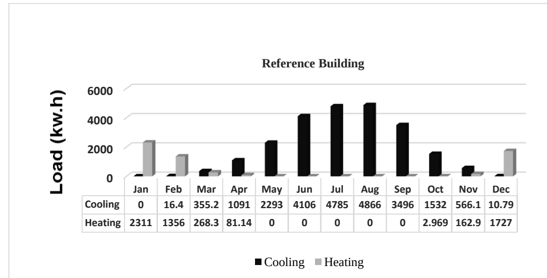

Fig. 3. Heating and cooling energy consumption of the reference building.

The use of the shading system in building windows with respect to Fig. 4 could have a relatively substantial reduction in the facility's cooling energy consumption due to the prevention of direct sunlight penetration into the building and consequently heat. But the use of the shading system in the cold months of the year, which requires maximum solar energy intake to heat the building's inner space, will backfire and increase energy consumption. Considering that the use of the shading system is considered inactive for two autumn and winter seasons, the shade of the shading has raised a slight increase in heating energy consumption so that energy consumption from 5909 Kw/h has reached 6032 kW/h. But this increase is negligible for reducing the energy consumption from the 23116 to 21602 kW/h and justifies the use of shade.

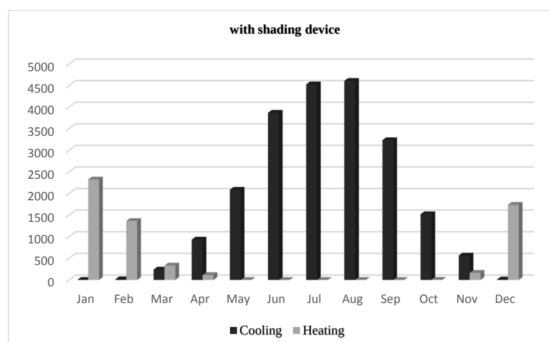

Fig. 4. Heating and cooling energy consumption of the reference building with shading device.

According to Fig. 5, effects of polystyrene insulation usage in building facade represent the consumption of 20153.91 kW/h for cooling systems and consumes 2479 kW/h for the building heating system, indicating a decrease of 12.81% and 58% respectively, compared to the reference building.

The simulation results for polyurethane insulation indicate the consumption of 20119 kWh for the building cooling system and the use of 1826 Kw/h for the heating system, which witnessed a reduction of 13% and 70% compared to the reference building, respectively. As it is clear from the results of Fig. 6 and comparison with the reference building, the amount of energy consumption in the months of Jan, Feb, Dec has been reduced, indicating the high performance of polyurethane as thermal insulation.

Table 2. Specifications of materials used in building

Building structure	Materials used								
	First layer				Second layer	Third layer			
Ceiling	Final cover				Insulation	Concrete			
	Thickness (Meter)	Heat conduction (W/mK)	Density (kg/m^3)	Specific heat (J/kg-K)	2 cm	10 cm			
	0.02	0.06	368	590					
External wall	Cement				Brick	Plaster			
	4 cm				20 cm	3 cm			
Interior wall	Plaster				Brick	Plaster			
	2 cm				10 cm	2 cm			
Floor	Insulation				Concrete	Final cover			
	2 cm				10 cm	Thickness (Meter)	Heat conduction (W/mK)	Density (kg/m^3)	Specific heat (J/kg-K)
						0.02	0.06	368	590
Window	Glass				Air	Glass			
	3 mm				3 mm	3 mm			

Table 3. Characteristics of the insulation used in the building [16]

Roughness	Thickness (Meter)	Heat conduction coefficient (W/mK)	Density (kg/m^3)	Specific heat coefficient (J/kg-K)
Characteristics of the insulation layer used in the reference building				
Normal	0.2	0.049	265	836
Characteristics of polyurethane insulation layer used in model building				
Rough	0.025	0.0245	24	1590
Characteristics of polystyrene insulation layer used in model building				
Very Rough	0.025	0.035	24	1210
Characteristics of Glass wool insulation layer used in model building				
Normal	0.025	0.042	50	840
Characteristics of Rock wool insulation layer used in model building				
Normal	0.025	0.04	80	840
Characteristics of Cellular Glass insulation layer used in model building				
Normal	0.075	0.05	136	750

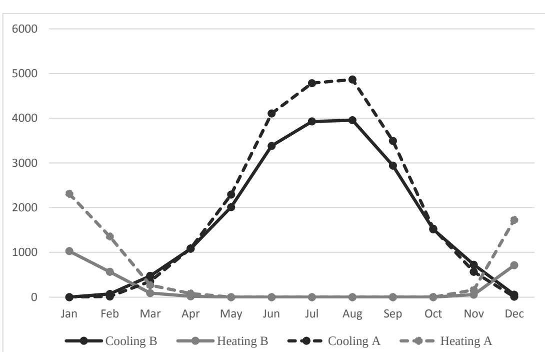

Fig. 5. Heating and cooling energy consumption of the reference building with shading device.

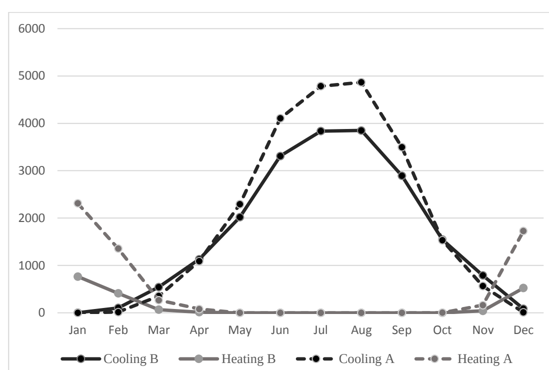

Fig. 6. Comparison of heating and cooling energy consumption of reference building (A) and Building with polyurethane insulation (B).

The simulation results for Rock wool insulation indicate the consumption of 20527.58 Kw/h for the building cooling system and the use of 2618.54 Kw/h for the heating system, which witnessed a reduction of 11% and 55% compared to the reference building, respectively. As it is clear from the results of Fig. 7 and comparison with the reference building, indicating the high performance of rock wool as thermal insulation.

The simulation results for Glass wool insulation indicate the consumption of 20567.36 Kw/h for the building cooling system and the use of 2706.36 Kw/h for the heating system, which witnessed a reduction of 11% and 54% compared to the reference building, respectively. Fig. 8 shows the Comparison of heating

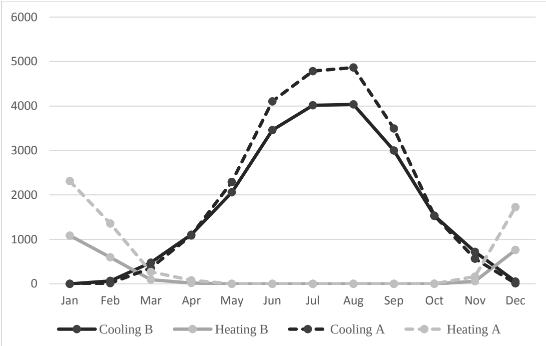

Fig. 7. Comparison of heating and cooling energy consumption of reference building (A) and Building with rock wool insulation (B).

and cooling energy consumption of reference building with Building with glass wool insulation.

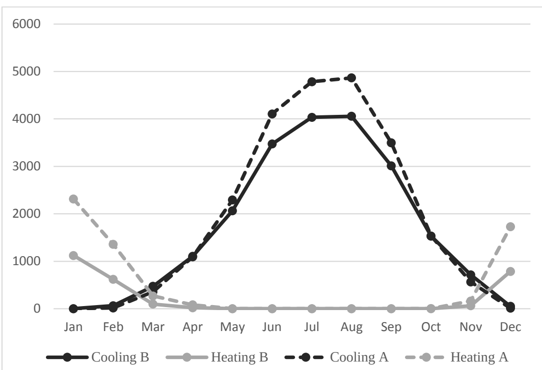

Fig. 8. Comparison of heating and cooling energy consumption of reference building (A) and Building with glass wool insulation (B).

The simulation results for Cellular Glass insulation indicate the consumption of 20005.45 kW/h for the building cooling system and the consumption of 1344.17 kWh / for the heating system, which witnessed a decline of 13% and 77% compared to the reference building, respectively As it is clear from the results of Fig. 9 and comparison with the reference building, the amount of energy consumption in the months of Jan, Feb, Dec has been reduced, indicating the high performance of Cellular Glass as thermal insulation.

Considering that the use of the shading system in hot months of the year causes a relatively substantial reduction in energy consumption. But in the cold months of the year, the combination of insulation like polystyrene and Cellular Glass, which have excellent performance as thermal insulation in the cold month of the year, can be used to improve the optimization of energy consumption. In Fig. 11, the simulation results have been used for the combination of the canopy and insulation polystyrene system, which represents an increase of 15.3% compared to the shading system and dropped by 9% compared to insulation polystyrene. It also has a 21% decline in reference to the reference building. The results for heating energy have shown a 69% reduction compared to the canopy system, but an increase of 2% compared to insulation polyurethane and has experienced a 69% decline in the reference building. In Fig. 10

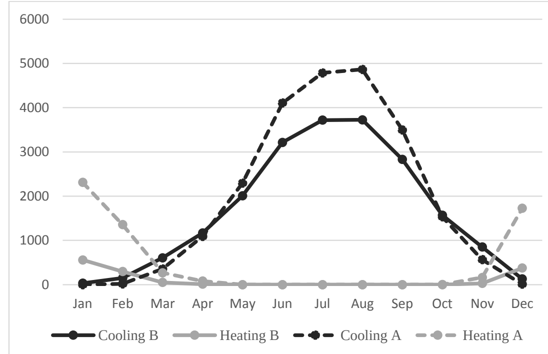

Fig. 9. Comparison of heating and cooling energy consumption of reference building (A) and Building with cellular glass insulation (B).

comparison of the reference building (A) of the shading system (B), polyurethane foam (C), and the canopy and insulation (D)system combined. To better understand, the synthetic simulation results of the canopy and polyurethane resin systems are shown in Table 4.

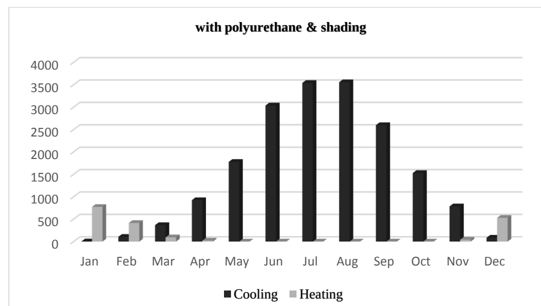

Fig. 10. Heating and cooling energy consumption of the reference building with polyurethane and shading device.

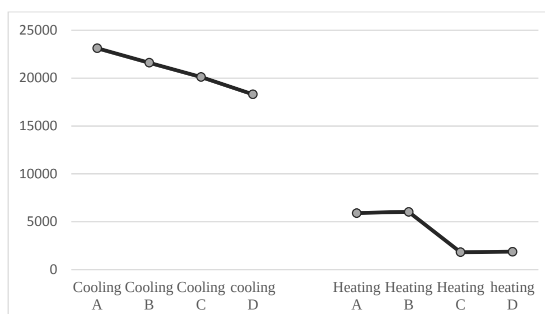

Fig. 11. Comparison of Reference Building Performance (A), shading (B), polyurethane (C), the combination of shading and insulation(D).

Fig. 12 is the simulation results for the combination of the canopy and Cellular Glass systems, indicating a 15.3% decrease in the storage energy consumption compared to the canopy system and dropped by 9% compared to Cellular Glass insulation. And also has a 21% decline in reference to the reference building. The results for heating energy showed a 69% reduction compared to the canopy system, an increase of 2% compared to

Table 4. Comparison of heating and cooling energy consumption of building with shading and polyurethane insulation with each factor

	with polyurethane & shading	shading device	Polyurethane insulation	reference building
Cooling energy	18305.88	21602.46	20119.54	23116.37
Heating energy	1874.546	6032.512	1826.04	5909.456

Table 5. Comparison of heating and cooling energy consumption of building with shading and cellular glass insulation with each factor

	With Cellular Glass & shading	shading device	Insulation Cellular Glass	reference building
Cooling energy	18125.98	21602.46	20005.45	23116.37
Heating energy	1360.29	6032.512	1322.171	909.456

Cellular Glass insulation, and has experienced a 69% reduction compared to the reference building In Fig. 13, the comparison of the reference building (A) of the canopy system (B)and Cellular Glass (C)and the combination of the shaded and insulation system (D)system are presented. To better understand the combination of the combination of the shading and glass foam, the glass foam is produced in Table 5.

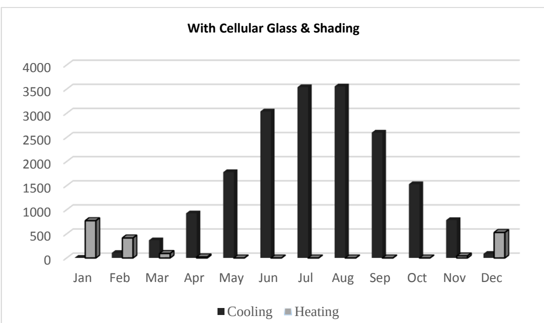

Fig. 12. Heating and cooling energy consumption of the reference building with cellular glass and shading device.

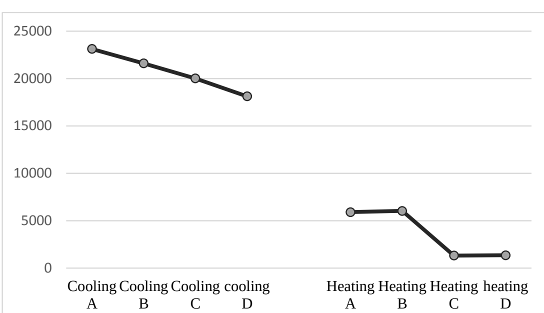

Fig. 13. Comparison of Reference Building Performance (A), shading (B), cellular glass (C), the combination of shading and insulation (D).

A. Thickness Sensitivity of Glass Wool and Rock Wool Insulators

The sensitivity test for the effect of the thickness of the matrix of rock and glass wool is done to reduce the energy consumption of the model building. in this way, the thickness in the first mode is 0.025 m and is second in the second mode. Fig. 14 shows the sensitivity done for the insulation of rock wool. Table 6 shows the exact amount of decrease in energy consumption by increasing the thickness of the insulation.

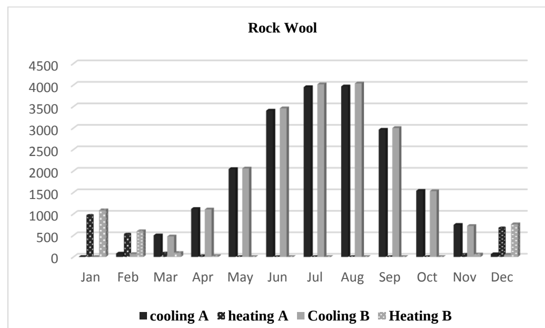

Fig. 14. Impact of rock wool insulation performance in two modes: A:(thickness 0.03m) and B:(thickness 0.025m).

Table 6. Energy consumption of building with rock wool insulation in two basic and secondary modes

Rock Wool Insulation	Cooling energy	Heating energy	Total
Thickness 0.025 meters	20527.58	2618.54	23146.12
Thickness 0.03 meters	20383.08	2301.59	22684.67

The sensitivity for the fibers fiber in Fig. 15 is shown. Table 7 shows the exact amount of energy consumption reduction by increasing the thickness of the insulation.

B. Results and discussions

The simulation result for the reference building indicates the consumption of 23116 kWh per hour to cool the building (cooling system) and consumes 5909 kW/h to heat the building (heating system). The use of the polystyrene insulation in the building facade reflects the consumption of 20153.91 kW/h for cooling systems and consumes 2479.51 kW/h for the building heating system, indicating a decrease of 12.81% and 58% respectively,

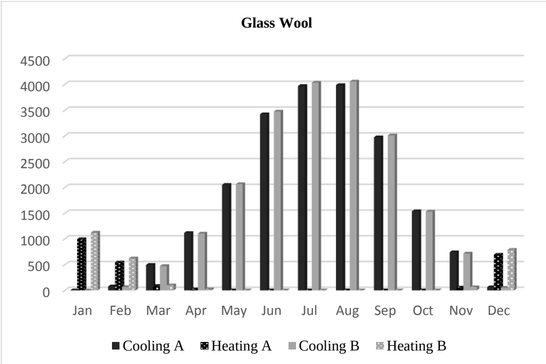

Fig. 15. Impact of glass wool insulation performance in two modes: A:(thickness 0.03m) and B:(thickness 0.025m).

Table 7. Energy consumption of building with glass wool insulation in two basic and secondary modes

Glass Wool Insulation	Cooling energy	Heating energy	Total
Thickness 0.025 meters	20567.39	2706.36	23273.72
thickness 0.03 meters	20420.39	2387.10	22807.49

compared to the reference building. Also Use of shading system has a 6.5% reduction in cooling energy consumption and an increase of 2% in heating energy consumption. The use of polyurethane insulation has reduced 13% for cooling and 70% for heating energy. Rock Wool insulation decreased by 11 and 55% and glass wool insulation decreased by 11 and 54%. The use of cellular glass also has resulted in a reduction of 13 and 77%, respectively, for the building cooling and heating system. These figures also went down to 21 and 69% for the combined canopy and polyurethane combined system, respectively, and 21 and 68% for the canopy combined system and cellular glass respectively. The final consumption rate of each in Fig. 16 and comparing all parameters are given in Table 8.

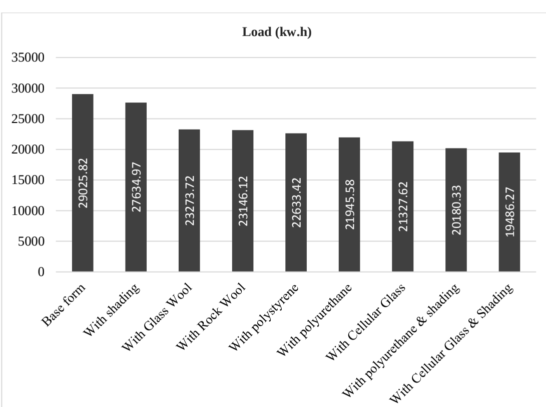

Fig. 16. Compare the energy consumption of the reference building with the role of each insulator.

Table 8. Comparison of reference building energy consumption with the role of each parameter

Load (KW.h)	TEHRAN (COOLING)	TEHRAN (HEATING)	TOTAL	Energy saving rate (%)
Base form	23116.37	5909.45	29025.82	_
With polystyrene insulation	20153.91	2479.51	22633.42	22
With polyurethane insulation	20119.54	1826.04	21945.58	24.4
With Cellular Glass insulation	20005.45	1322.17	21327.62	26.5
With Glass Wool Insulation	20567.36	2706.36	23273.72	20.2
With Rock Wool Insulation	20527.58	2618.54	23146.12	20.2
With Shading system	21602.54	6032.51	27634.97	4.8
With polyurethane & shading	18305.88	1874.54	20180.33	30.5
With Cellular Glass & shading	18125.98	1360.29	19486.27	32.8

6. CONCLUSIONS

In this research, the best performance is achieved to reduce energy consumption by applying different insulation in the building shell. The results showed a reduction in the 21% cooling energy consumption in the building cooling energy consumption as well as 77% for the building's heating energy, (It is reminded that the 77% reduction in energy is for the three cold months of the year). Also considering data analysis and return and the use of the shading system in hot months of the year causes showed a significant reduction in energy consumption. But in the cold months of the year, it has also been used to improve the efficiency of insulations such as cellular glass and polyurethane, which have excellent performance as thermal consumption in the cold month of the year, with the results of a 30% reduction in energy consumption compared to the reference building.

REFERENCES

1. F. Nasrollahi, "Climate and Energy Responsive Housing in Continental Climates: the Suitability of Passive Houses for Iran's Dry and Cold Climate," Doctoral Thesis, University of Berlin. P:1, 2009. http://dx.doi.org/10.14279/depositonce-2306

2. R. Chang, V. Soebarto, Z. Zhao, G. Zillante, "Facilitating the transition to sustainable construction: China's policies," Journal of Cleaner Production, vol.131, pp. 534–544, 2016. https://doi.org/10.1016/j.jclepro.2016.04.147
3. Y. Lu, V. Le, X. Song, "Beyond boundaries: a global use of life cycle inventories for construction materials, " Journal of Cleaner Production, vol.156, pp. 876-887, 2017. https://doi.org/10.1016/j.jclepro.2017.04.010
4. A. Raesinezhad, "The Effect of Architectural Design on Energy Consumption of Buildings, " Second International Conference on Architecture, Tehran, 2016. https://www.civilica.com/Paper-IACUT02-IACUT02_531.html
5. Y. Ye. P. Xu, H. Sha, P. Yue, & H. Zhang, "ShadingPlus - a fast simulation tool for building shading analysis, " Journal of Energy Efficiency, vol.9, pp. 239–248, 2016. https://doi.org/10.1007/s12053-015-9360-4
6. V. Oree, H. Anatah, "Investigating the feasibility of positive energy residential buildings in tropical climates, " Journal of Energy Efficiency, vol.10, pp. 383-404, 2017. https://doi.org/10.1007/s12053-016-9462-7
7. R. Kunič, "Carbon footprint of thermal insulation materials in building envelopes, " Journal of Energy Efficiency, vol.10, pp. 1511-1528, 2017. https://doi.org/10.1007/s12053-017-9536-1
8. S. Ghafari Jabari, E. Saleh, "Review Strategies for Improving the Design and Construction of Settlements in Tehran, " Quarterly Journal of Energy Policy and Planning Research, vol.1, pp. 115-132, 2013. URL: http://epprjournal.ir/article-1-26-fa.html
9. Encyclopedia of Iran Insulation. http://www.irima.ir/home/en/thermal-insulation/thermal-insulation-classify
10. Zh. Cao, Zhi, W. Liao, Sh. Wang, H. Zhao, Hai. Yu.Wang, "Polyurethane foams with functionalized graphene towards high fire-resistance, low smoke release, superior thermal insulation, " Journal of Chemical Engineering. Vol.361, pp. 1245-1254, 2019. https://doi.org/10.1016/j.cej.2018.12.176
11. Topic 19 of the National Building Regulations of Iran, p. 36, 2011.
12. H. Shen, A. Tzempelikos, "Daylighting and energy analysis of private offices with automated interior roller shades, " Solar Energy, vol.86(2), pp.681–704, 2012. http://linkinghub.elsevier.com/retrieve/pii/S003
13. M. Kasmai, "Climate and Architecture Book, " Publication of Iran Housing Investment Company, P. 48, 2013.
14. Engineering Reference, "The Reference to EnergyPlus Calculations, " P28-32. https://energyplus.net/
15. Y. Pan, R. yin, Z. Huang, " "Energy modeling of two office building with data center for green building design, " Energy and Buildings, Vol. 40, p.1145-1152, 2008. https://doi.org/10.1016/j.enbuild.2007.10.008
16. ANSI/ASHRAE Standard, " American Society of Heating, Refrigerating and Air Conditioning Engineers, " 2005.