An Analysis of Energy Consumption Performance of Almas Shargh Commercial Complex based on the Most Suitable Type of Atrium Glass and Azure Blue Color with the Symbol of Islamic Architecture

Abstract

The choice of glass has continuously played an important role in the physical structure of Islamic architecture and this selection has a direct impact on energy consumption. Meanwhile, azure blue as one of the most common colors in Islamic architecture, has received special attention. The present study seeks to study the type of indoor skylights in commercial complexes of Mashhad due to its importance in the amount of cooling load; heating; lighting, ventilation and indoor temperature. Due to this prominence, in the present study, by using a comparative research method; the most suitable type of glass in commercial complexes with indoor skylights is simulated using Builder Design software. For this purpose, primarily, the Almas Sharq Complex of Mashhad was simulated in software and then in order to determine the most appropriate type of interior skylight in commercial complexes, in terms of the effect on heating load, cooling, lighting, ventilation and temperature in the commercial complex; five types of glass were selected in two Hvac states, on and off. It was found that in the Almas Sharq complex of Mashhad in regard to the type of glass applied, the Thermochromics glass is the most suitable type of glass in order to reduce the temperature by ١٠٪, and increase the entry of natural light in the cold and dry climate commercial complexes of Mashhad in both modes of ventilation system on and off.

Research aims:

١. Simulating the most suitable type of glass in Mashhad commercial complexes.

٢. Investigating the effect of glass type on energy management in Mashhad commercial complexes.

Research questions:

١. What is the effect of the type of indoor skylight on energy flow management in Mashhad commercial complexes?

٢. Considering the climate of Mashhad, what kind of glass is more suitable for use in commercial complexes?

Keywords: Indoor skylight, Glass, Thermal comfort, Climatic performance, Energy consumption simulation.

Introduction

In the last decades of the twentieth century, following the energy and environmental crises, the need to reduce energy consumption and environmental pollutants was agreed upon by most countries in the world. About ٥٠٪ of the world's energy consumption is accounted for by buildings, and ٢٠٪ of this amount is used in commercial buildings today. In the past, the atrium was called the central courtyard, which was surrounded by adjoining rooms. In modern architecture, the atrium refers to a large, open space that is often several stories high and is covered by a glass roof or large windows, or both. In the late ١٩th century, natural lighting was consciously introduced to increase light, in which atriums played a valuable role. Atrium allows natural light to penetrate into the center of the dark areas of adjacent rooms, reducing the need for artificial light energy and maximizing the benefits of receiving direct solar energy. In addition, the atrium forms a suitable middle space between the interior and exterior to create a connection between the floors of the building. Skylights actually act as a filter against the effects of adverse environmental factors such as rain, snow, wind and other similar elements. At the same time, they permit the use of favorable environmental factors such as sunlight, fresh air and scenery and reduce heat loss from adjacent spaces.

These spaces have been observed in all the great civilizations of the world with a physical transformation from the central Iranian courtyards and porches and rooms without Roman roofs to stores and green spaces inside the towers. After determining the greenhouse effect in glass spaces and the accumulation of heat in the confined space below, methods for using it for heating in winter and cool ventilation for summer in buildings without the use of mechanical installations and with the subject of systems with solar statics have been developed. The amount of energy received depends on the climatic conditions of the environment, the orientation of the building and the physical characteristics of the structure, but the land that increases the area of the skylight due to the variety of uses and functional needs, and its volume is increased in the same proportion and large areas coating glass has potentially adverse effects due to overheating, heat loss from its surfaces, lack of airtightness, thermal lamination, chimney effect and glare. In addition, the interaction of physical and environmental conditions on skylights on the one hand and the internal conditions of spaces adjacent to skylights, safety and installation issues on the other hand, has faced designers with complex factors. Since reducing energy consumption and using environmental forces in an integrated design requires comprehensive decisions, atriums have been studied from different perspectives and in different climatic conditions.

The purpose of this study is to analyze the performance of indoor skylights in cold and dry climate commercial buildings in order to optimize energy consumption. Therefore, the hypothesis proposed to achieve this goal is that by identifying the most appropriate type of indoor skylight in commercial buildings in cold and dry climates can reduce energy consumption by up to ٢٠٪.

In the fifties, John Portman, who invented the use of interior skylights in hotels and commercial spaces; examined the atriums in commercial spaces and compared the fun and open atriums, which provide a suitable view of the floors and surfaces of the building. Atrium features in commercial complexes include: space for green spaces and fountains, games, conferences, chats and coffee shops. In this regard; Maria Wall uses the term glass-covered spaces for all spaces with skylights and greenhouses with balconies, porches and central courtyards. She attributed the different perceptions of the thermal performance of indoor skylights to the strong dependence of these spaces on the outside climatic conditions and the incompatibility of the physical properties of the skylight with the ambient conditions. Also, in a study conducted in ٢٠١٣ by Gilani et al., who analyzed the thermal layering of buildings using CFDs, it was found that by reducing air conditioning systems, it is possible to identify and control the layer. Thermal insulation in the interior of the building achieved more efficient efficiency and air conditioning control. Leila Mousavi and her colleagues in ٢٠١٤ studied the thermal layering of the atrium as a natural ventilation and using its solutions in the design and found that the provision of fresh air using natural ventilation with inactive systems it can improve the thermal layering and ventilation of the atrium [١٤]. Carlsen also found in (٢٠١٦) that: The potential advantage of some interior skylights is that: they can reduce the overall surface area of the building. Since heat transfer is usually directly proportional to the building surface, this reduction can provide a path to energy savings [١٥]. In ٢٠١٦, Suzanne Bajrakaria simulated thermal stratification in atriums by confirming the appearance of early models and found that a relatively stable ESP-r model could accurately thermal stratify in atriums. It simulates a lot and for this purpose, in addition to the initial heat transfer, it uses computer simulation software: a) the capacity to perform simulations with time steps of up to ١٠ minutes; b) the ability to model mass flow; c) solar radiation transmission capacity from the first point of impact. The validation process of the model showed the value of thermal data for days with different weather conditions. A simulation model that provides good results for one-day weather data is not necessarily good results for other days' weather data. Therefore, validation studies for atrium modeling should be based on experimental data for at least two days with different climatic conditions. In ٢٠١٦, Farhoudi also looked at how sunlight enters the rectangular atriums directly and found that if the walls of an adjoining room and the windows were well designed, there would be a difference in the penetration of natural light between the upper floors and the middle area can be minimized. This means that there is an exchange between cheaper construction and uniform natural light for areas near the atrium floor.

The present research is applied in terms of simulation research method and based on an experimental process, field measurement and comparative analysis. First, a general study of the climatic conditions of the central region, cold and dry climate and how to install indoor skylights in commercial complexes and the amount of cooling, heating, lighting, ventilation and temperature in Mashhad and then Almas Shargh commercial complex with internal skylight in the center of the building (covered with green polycarbonate glass in the body of the skylight and truss-shaped structure); was selected as a case study. In the next stage, by Design Builder simulator software, which has an energy-analyzer plus engine and is able to analyze and calculate the cooling, heating, lighting, comfort and ventilation loads in buildings; On and off with HVAC for one year was measured. (To determine the amount of energy consumption in the building and thermal comfort in both off and on of HVAC systems.) The time of measurements is from April to March ٢٠١٧ and the amount of brightness is considered according to the Ashri ٤٠٠ luxury standard.

Conclusion

In this study, the importance of energy consumption to reduce the energy consumption transferred from windows into the atrium in the Almas Sharq Commercial Complex in Mashhad was discussed and in this regard to achieve an optimal type of window that has the lowest energy consumption and Provide maximum thermal comfort for visitors to the commercial complex in cold-weather climate; annual solar gain, cooling, heating, lighting and ventilation were examined. In this way; due to the importance of optimizing energy consumption in commercial complexes, five types of glass (clear glass, green glass with a thickness of ۳ to ۱۳ mm filled with air gas in the middle layer, polycarbonate glass, thermochromics glass, green single layer glass with a thickness ۳ mm and ٤-layer Leo film glass) were selected and simulated in Design Builder software to replace the interior skylight of the Almas Sharq Commercial Complex. It should be noted that all simulations were performed in both HVAC on and off modes and it was found that in HVAC mode off (despite the inability of the building to provide thermal comfort), the building has a better performance than on HVAC. In HVAC mode, all of the glass had a natural ventilation size and the brightness of the polycarbonate glass currently used in the Almas Sharq Commercial Complex; Has the least amount of natural light. While calculating the heating load and cooling consumption of the glass building; Thermochromic glass has the lowest cooling load in the building and polycarbonate glass has the lowest heating load in the Almas Sharq commercial building. In this regard; In HVAC mode, thermochromic glass has the lowest heat and Leo glass has the lowest relative humidity. For this reason, the most suitable glass in commercial complexes of Mashhad; Thermochromic glass with more ventilation and lighting, lower temperature and cooling energy consumption and slightly higher heating energy consumption; Compared to other alternative glass and glass, it is a case sample (polycarbonate). In addition to the functional aspect, this type of glass is also used aesthetically.

All cases performed in the present study seek to achieve the following:

- Creating a relationship between the type of interior skylight and the amount of energy consumption (heating, cooling, lighting and ventilation)

- Selecting the most suitable type of glass in order to achieve thermal comfort and optimize energy consumption in cold and dry climates in commercial complexes with indoor skylights.

- Guiding the relevant designers, engineers and architects to improve the thermal performance of indoor skylights in commercial complexes of cold and dry climate, as well as energy efficiency and comfort of clients.

- Developing simple and low cost solutions to reduce building energy consumption and overall operating costs.

- Providing experimental measurements for the development of future algorithms and confirm existing simulation models.

The present study shows the best type of glass in order to achieve optimization of energy consumption and thermal comfort in indoor skylights of commercial complexes in Mashhad with cold and dry climate and the conditions obtained from this study can be used for other commercial complexes with skylights. In addition, in order to measure the reduction of energy consumption, architectural capabilities such as appropriate materials and forms, as well as the dimensions of the interior skylight should be considered.

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