Islamic Art

The Performance of Atriums in Optimizing Energy Consumption in Commercial Complexes in Central Tehran

Abstract

Today, one of the most important concerns in the issue of design is how to manage energy. Atriums are one of the most influential components in energy consumption. According to its nature, the research method in this research is simulation and with the approach of case study and analysis and in terms of applied approach. In this research, first, the basic model is validated according to the consumer bills of the commercial center in question. Then it is analyzed by comparing eleven various phases in the software. After applying energy consumption optimization solutions and building smartness, it is found that the central atrium has a better efficiency than the basic model in low-rise (٣ floors), mid-rise (٥ floors) and finally high-rise (١٣ floors) commercial centers; this had a better efficiency than the basic model (without implementing solutions) and removing the side walls in these atriums improves natural ventilation in the building. From these studies, which are carried out with high computational accuracy and by dynamic modeling with Design Builder software, it shows that the potential of increasing productivity and saving energy in these buildings is also very high. Likewise, this research demonstrates that the total reduction in annual energy consumption after applying energy consumption optimization strategies compared to not implementing these strategies, in a comparison of two ١٣-story atrium buildings (١١ percent) and two ٥-story buildings (without atrium and with atrium with the application of solutions) is ١١,٧٪ and in the comparison of two ٥-story atrium buildings is ١٦٪ and in the comparison of two ٣-story atrium buildings is ١٩٪ and in the comparison of two ٣-story and ٥-story atrium buildings is ٥٠,٨٪. Finally, the use of atriums will significantly reduce carbon dioxide gas and improve the thermal comfort factor in commercial buildings.

Research objectives:

١. Reducing energy consumption by emphasizing the thermal role of atriums in commercial centers in central Tehran.

٢. Providing thermal comfort and reducing the emission of carbon dioxide gases in the commercial complexes of Tehran.

Research questions:

١. What is the most optimal type of side wall of atriums to provide thermal comfort in commercial complexes in central Tehran?

٢. What is the most optimal height of atriums to increase energy efficiency in the mentioned commercial centers?

Keywords: optimization, energy, Atrium, commercial centers, Tehran.

Introduction

Optimizing energy consumption in recent years has become one of the chief priorities for building designers, especially for public and commercial buildings, the demand for the use of mechanical systems such as heating, cooling and air conditioning (HVAC) are a fundamental problem that can affect thermal loads. Buildings are affected and ultimately cause excessive energy consumption. One of the common solutions to reduce the energy required by citizens in dry areas is the use of passive systems (Rostami et al.: ٢٢٨). Atriums in the building as a passive solar system can, in addition to providing sunlight and heat, reduce the consumption of artificial lighting and ventilation systems in large spaces, especially in commercial centers, and while creating a suitable microclimate in the building, it can improve air quality, reduce maintenance costs and increase energy saving in buildings; Therefore, it is necessary that by optimizing the consumption of fossil fuels and using passive solar methods in the building, the amount of carbon dioxide emission is reduced as much as possible and prevent global warming and climate change.

In a report published by the International Energy Agency in ٢٠١٤, about ٤٠٪ of the energy produced is used in the building sector (Cuce and Riffat, ٢٠١٤), of which ٨٠٪ is related to services such as air conditioning, lighting and equipment. (Ihm et al., ٢٠٠٩). It is obvious that energy sustainability in huge commercial centers that are visited by thousands of visitors every day is much more effective than energy control in a residential house. Therefore, the architecture of commercial spaces is heavily involved with the principles of sustainable architecture and technical points. Natural ventilation in such buildings plays a key role in providing optimal indoor air circulation quality and maintaining an acceptable level of thermal comfort without the need for mechanical devices such as heating, ventilation and cooling (HVAC). Therefore, natural ventilation is able to reduce the energy consumption of building air conditioning systems, which has a significant contribution to saving energy consumption in buildings (Thirugnanasambandam et al., ٢٠١٠) and includes more than ٦٠٪ of the total energy consumption of the building (Chan et al. ٢٠١٠). The main advantage of using natural ventilation in the design of the atrium in the building is not only saving energy and costs, but also aids in providing acceptable comfortable, healthy and productive conditions for the residents. Bringing warm air indoors during cold winters and leaving hot air out during summer time are important goals in desert architecture (Rostami et al.: ٢٣٠). Due to the complexity of the variables and parameters in energy consumption in the building, it is not conceivable to make a correct decision regarding the optimization of energy consumption without considering simulation tools; therefore, in this research, the variables and parameters that affect the thermal performance of atriums are simulated in DesignBuilder software, and by comparing the thermal performance of atriums in the climate of the central regions of Tehran, the required calculations of energy intake, loss, and consumption are performed exactly based on the climatic conditions. The results of the simulations for the entire building will be analyzed and will ultimately lead to providing architectural and sustainable solutions to optimize energy consumption in commercial complexes in central Tehran. According to its nature, the research method in this research is simulation and follows a case study with an analytical approach implemented within an applied study.

Extensive studies and researches have been conducted in the field of atrium performance and optimization of energy consumption in buildings with different topics. In the research of Navvab and Selkowitz (١٩٨٤), one of the most comprehensive studies on atrium roof structures has been conducted with fourteen types of glass settings in different sky conditions. Wall (١٩٩٦), investigated a multi-story apartment with a cold atrium design and glass-roofed passageway in Sweden. According to Wall's research, if the atrium is heated to thermal comfort conditions in the Nordic climate, the overall final building energy demand for the atrium and adjacent buildings will increase. Bansal and Mathur (١٩٩٣) used a solar chimney to enhance stack ventilation and achieved a flow rate of hundreds of cubic meters of air per hour. Hagen et al. (٢٠٠١) investigated the atrium ventilation design in a case study with numerical simulation for thermal comfort evaluation and optimization. Yang and Li (۲۰۰۵), studied the effect of thermal mass on energy consumption in office buildings with air conditioning during the day and cooling at night to quantify the hourly changes and air conditioning cooling load. Hussain and Oosthuizen (۲۰۱۲) also used experimental and CFD methods to evaluate the efficiency increase of different atrium dimensions and geometries. Berardi and Wang (۲۰۱٤) investigated the absorption of solar radiation through the atrium and concluded that using natural light can greatly reduce the lighting energy consumption of the building. Jia and Lee (۲۰۱۸) studied the design of an optimal pattern for the orientation of buildings in residential complexes by analyzing the level of energy consumption in Mehr housing in Tehran. In Iran, a number of researchers have studied and researched in the field of energy and climate design. In an article, Nasrullahi (۲۰۱۰) discussed the effect of architectural design on the amount of energy consumption in a cold climate (Tabriz) using Design Builder software. Fatahalian et al. (۲۰۱٦) presented an article titled energy simulation of office building with Design Builder software and its validation with energy bills. Sepehri and Masnavi (۲۰۱٦) in an article entitled “Optimization of Energy Consumption with the Solution of Building Form Selection by Design Builder software in Tehran region (with a case study design)” researched this issue. In ۲۰۱٦, Modirrousta and Boostani (۲۰۱٦) investigated the design of atriums and the amount of energy absorption and their impact on building energy consumption. In this article, which is derived from a doctoral thesis, the thermal performance of atriums in the commercial centers of the central part of Tehran is investigated with nine variables at the same time and in eleven different phases and scenarios by Design Builder software; it concluded that the most optimal type of atrium in this climate is the type without lateral walls and with a short height, which has not been done so far or this variable extent.

Conclusion

In this research, after simulating and analyzing the thermal performance of atriums and applying strategies to optimize energy consumption, including compliance with topic ۱۹ of the National Building Regulations, removing the side walls of the atrium, increasing the dimensions of the air outlet valves, increasing the dimensions of the atrium roof, making the building smarter through smart ventilation with Controlling the internal temperature of ۲۲ degrees, installing a light sensor and movable canopy, and installing glass with new technology, it was finally determined that the central atrium is located in low-rise (۳ floors), mid-rise (٥ floors) and then high-rise (۱۳ floors) shopping centers, respectively. This model has better efficiency than the basic model (without applying solutions) and removing the side walls in these atriums improves natural ventilation in the building. Likewise, this research demonstrates that the total reduction in annual energy consumption after applying energy consumption optimization strategies compared to not implementing these strategies, in a comparison of two ۱۳-story atrium buildings (۱۱ percent) and two ۵-story buildings (without atrium and with atrium with the application of solutions) is ۱۱,۷٪ and in the comparison of two ۵-story atrium buildings is ۱٦٪ and in the comparison of two ۳-story atrium buildings is ۱۹٪ and in the comparison of two ۳-story and ۵-story atrium buildings is ۵۰,۸٪. Finally, the use of atriums will significantly reduce carbon dioxide gas and improve the thermal comfort factor in commercial buildings. For future studies, it is recommended that in order to further verify the studies in the field of atriums, especially in commercial uses, the simulation results of the preheating and precooling temperature of the internal environment of the building, in addition to the change in the area of the facade openings can be analyzed as new variables.

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