Islamic Art

Reduction of Energy Consumption Through Optimal Shutters in High-Rise Residential Buildings in Accordance with the Skylights of Traditional Buildings in Shiraz

Abstract

From time immemorial, the issue of energy management has been a human concern in architecture. The concern of the outer layers of a structure is of particular importance since it is regarded as the first external element of the building in energy management issues. The study of historical monuments in Iran demonstrates that this dispute has been considered by architects in the past. Shiraz, one of the ancient cities of Iran, behods many historical and traditional buildings. The issue that can be raised here is the application of new methods in energy consumption with skylights of traditional buildings in Shiraz. This research seeks to answer this question in a descriptive and analytical manner with a quantitative and qualitative approach. Due to this standing, in the present study, the optimal percentage of openings, prime angle of louvers and ideal glass in a high-rise residential building has been simulated using Design Builder software. For this purpose, initially, for the optimal percentage of openings, the percentage of exterior windows from ۰٪ to ۱۰۰٪ each with a step of ۱۰٪ was examined, then to determine the best Louvre angle in the building on three fronts: south, east and west, ۱۷ different modes; the Louvre angle was considered and in order to determine the optimal glass in the outer wall of the building for their effect on the cooling load of the building, three types of glass were selected. Due to the fact that skylights have had the necessary efficiency in traditional architecture and have been used for years and the results of their use are known, and most traditional methods of lighting and light control can be replaced with new procedures. The outer layer is designed with the same function and quality, consequently the methods that were used in the past in the design of skylights in buildings can be re-modeled for new buildings.

Research aims:

١- Recognizing the best position of the window in order to reduce energy consumption and comfort of building occupants.

٢. Using the patterns used in traditional skylights in modern buildings to reduce energy.

Research questions:

١- How much energy can be saved by optimizing skylights in a high-rise residential building?

٢- Can traditional skylights be adapted and modeled for today's buildings?

Keywords: energy consumption, optimal openings, traditional skylights, Shiraz traditional buildings, high-rise residential houses

Introduction

In the present era, the energy crisis and environmental problems have overshadowed many human activities and have caused architectural design to face a severe challenge as one of the factors affecting high energy consumption. In order to solve this problem, Iranian indigenous architecture, especially in hot and dry climates, due to its valuable experiences and patterns, offers wise solutions in the field of sustainable architecture. From the study and analysis of elements and patterns of Iranian architectural history, it is concluded that these elements and patterns, although each was created in a certain period of architectural history, bestow a continuous presence in later periods and have evolved and refined and behold an identity independent of time and present the general concept of a pattern or an architectural element. Moreover, this phenomenon has an abstract dignity and a mental image and by so carries a heavy burden. Following the increasing growth of the urban population due to the increase in inhabitants and rural immigrants in recent decades in Iran, the face of Iranian-Islamic housing and architecture changed. In conditions of limited land resources and the impossibility of occupying the surface and the horizontal growth of cities, housing was built at a height instead of dispersion on the surface, which is called "high-rise. The outer layer of the building as the main mediator between indoor and outdoor space has a

significant role in modifying the weather conditions and providing comfort to residents and thus reducing cooling and heating loads, and design and implementation of building shells that can provide the highest amount of thermal comfort indoors without the help of mechanical equipment with appropriate thermal behavior can aid in energy preservation.

Regarding the background of the present study, it should be said that no independent work with this title has been written so far. Many researchers have studied the thermal behavior of outer layers and facades through simulations. The research has been composed in different climates and the simulation processes have been mainly influenced by factors such as facade configuration, glass material, use of natural ventilation, type and depth of canopies, dimensions of openings and applied materials of the outer layers. One of such researches has been done by Ghobadian and Sharifi (۲۰۱۷). In this work, the effect of physical properties of building outer layers on latency and heat transfer reduction coefficient in high-rise buildings in Hamadan have been investigated. The results show that double-glazed glass has ۵۰٪ better performance than the single-layer glass, as well as thicker glass with a longer intermediate distance between double glazing in double-glazed glass, compared to other types of glass and has a performance of ۱۶٪ better in relation to the heat latency factor. Barzegar and Heydari study the relationship between solar radiation and building energy consumption in the home sector and show that houses with a climate orientation have less energy consumption. Nora Qabra (۲۰۱۷) in her doctoral dissertation entitled “The effect of building shell on energy efficiency in high-rise buildings in Saudi Arabia (warm climate)” investigates to reduce the cooling loads of the building in regard to the architectural design parameters; furthermore, she simulates the best examples of windows, glass and walls with simulation software. Rachel Gunderson (۲۰۱۵), in her dissertation entitled “Responsive Building Shells” designed a special building shell that absorbs the movement of air, light and water to use energy; she has used flexible, dynamic and interactive elements in architecture to achieve a smart shell. In another study, Granadiro, Correa, Lille, and Duartaz (۲۰۱۳) used a new energy consumption simulation tool to determine building consumption and, by simulating building models, analyzed the physical properties affecting energy consumption. The results of this study showed that materials, window area and building form are the most important factors affecting energy consumption.

The present research is applied in terms of a simulation research method. In this study, by selecting two high-rise residential buildings as a case study, environmental factors and the current situation are considered to identify the function of the building walls. In order to determine the optimal percentage of window in the exterior walls, the optimal angle of the louvers and the effect of the type of glass on the exterior walls on energy consumption in a residential building, first a building with dimensions of ١٦ * ٨ m with a height of ٣،٢ m was selected. This building has an east-west extension as shown in Figure ١. The simulated model unit is located on the middle floor of a ١٦-storey residential building and is adjacent to other units on its upper and lower floors. In the simulated building, the amount of light according to the Ashri standard is ٤٠٠ Lux.

Conclusion

This study, considering the importance of building outer layers in the amount of energy consumption in buildings, has tried to explain the method of selecting the main elements of the outer shell in terms of energy saving performance and also providing internal thermal comfort of a high-rise residential building. How to use the modeling of shutters, glass and canopies as one of the most effective factors in the design of the exterior of the building is the main aim of this study and also to achieve this important and while confirming the performance in this building to determine its optimal type. The results indicate that variables such as the percentage of windows and the angle of the louvers have a significant effect on energy consumption and comfort of residents in high-rise residential buildings. The results of the research are as follows: In conditions where the area of the window is larger, the amount of heat gain and loss through the window increases. In a situation where the ratio of window area to wall area on the north and south fronts is ١٠ to ٣٠ percent and on the west and west fronts is ١٠ and ٢٠ percent, they have the lowest cooling load. Also, they have the minimum heating load on all fronts with ١٠٠٪ windows. Then, ١٧ different Louvre angles were examined on three fronts: south, east and west. The results showed that the lowest cooling load is on the three fronts of the Louvre with an angle of +٧٠ ° and the lowest heating load is on the southern front with an angle of -٣٠ °. Finally, by examining three types of plain glass, double glazing, it was found that the cooling load in all months of the year with low glazing is less than the other two models of glass. Also, double glazing has better performance than plain glass, but it emits more cooling load than low glass. Therefore, by recognizing and obtaining the best size of windows, the optimal angle of the louvers and also the

most suitable type of glass, energy consumption can be saved to a great extent. Also, the results obtained from this study can be used for high-rise residential buildings in the hot and dry climate of Shiraz to save energy consumption of these buildings and provide thermal comfort to the building's occupants. Valuable solutions of traditional architecture in old houses can be repeated in modern buildings in order to prevent energy loss, reduce energy use, decrease the use of fossil energy, use renewable energy in energy supply; also, it will reduce economic costs and increase the durability and longevity of the building in the upcoming years.

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