



Evaluating the Efficiency of Double-glazed Windows and Awnings in Improving the Performance of Educational Land uses (Case Study: Mehrayin and Afarinesh Elementary Schools in Rasht)

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Abstract

The rise in energy consumption in the building sector, particularly in educational spaces that are continuously used and highly occupied, has become a major concern in sustainable design. In this context, employing passive strategies such as double-glazed windows and shading systems (both fixed and movable) can play an effective role in reducing cooling and heating loads, enhancing thermal comfort, and lowering operational costs. This study aims to assess the effectiveness of these two architectural elements in improving the thermal performance of primary schools, examining two case studies: Mehrayin Boys' Elementary School and Afarinesh Boys' Elementary School in the city of Rasht. The research utilizes energy simulation through DesignBuilder software to analyze different design scenarios. In these scenarios, the existing conditions of the schools were compared with proposed conditions including the use of double-glazed windows, fixed shades, and movable shades. The results indicate that the simultaneous use of double-glazed windows and movable shades provides the most optimal performance in reducing energy consumption and improving thermal comfort indicators compared to other configurations. These strategies are especially more effective in humid climates. In conclusion, suggestions are provided for optimizing the architectural design of schools with an emphasis on using passive elements and improving energy efficiency.

Keywords: Shading, Double-Glazed Windows, Energy Optimization, Climatic Design

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Extended Abstract

Introduction

Windows and shading systems are among the most significant components of buildings, particularly in regions with diverse climatic conditions, as they directly influence indoor energy performance. Double-glazed windows and shading systems are key technologies for optimizing energy consumption and enhancing indoor environmental quality. By minimizing energy losses, these systems help regulate temperature and daylight levels, thereby reducing overall energy demand and creating more comfortable indoor environments. Since climatic variations have a major impact on building performance, evaluating the efficiency of different systems under varying conditions can provide valuable insights for design improvement. This study focuses specifically on fixed and movable shading systems combined with double-glazed windows. With growing design challenges related to energy efficiency and the demand for sustainable and high-performance buildings, enhancing the thermal and visual comfort of educational buildings has become increasingly important. In this context, technologies such as double-glazed windows and fixed or movable shading devices are considered innovative strategies. However, assessing their effectiveness particularly in educational buildings—requires detailed, data-driven analysis. Accordingly, this research investigates Mehr Ain and Afarinesh elementary schools in Rasht as case studies to evaluate the impact of these systems on the energy performance of buildings. Fixed and movable shading systems can enhance indoor conditions and reduce energy costs by controlling sunlight penetration and limiting heat gain and direct radiation. This study seeks to answer the following questions: What role do fixed and movable shading systems play in improving the energy performance of educational buildings? Can combining double-glazed windows with these systems optimize indoor environmental quality and lower energy costs? The findings aim to identify the most effective configuration of these systems for application in educational buildings located in similar climatic regions.

Data and Method

This study employs energy simulation techniques to analyze the effects of different window and shading system configurations. In addition to simulation, a field investigation and analysis of real-world data from selected school buildings in Rasht form the second phase of the research. Energy modeling and simulations are conducted using specialized software tools EnergyPlus and DesignBuilder to evaluate the thermal performance and energy consumption of the buildings across different seasons. In the field phase, data related to temperature, humidity, solar radiation, energy consumption, and thermal comfort are collected from two elementary schools in Rasht: Mehrayin and Afarinesh. These schools were selected as case studies due to their differing façade systems—Mehrayin features double-glazed windows with fixed shading devices, while Afarinesh incorporates double-glazed windows with movable shading systems. Field data are gathered using environmental measurement instruments such as thermometers, hygrometers, digital thermometers and solar radiation sensors to ensure precise and reliable analysis.

Results and Discussion

The simulation results revealed that the use of movable shadings in Afarinesh School effectively reduced temperature fluctuations in educational spaces compared to the fixed shadings used in Mehraïn School. During the summer, the average indoor temperature in Afarinesh classrooms was approximately 2–3°C lower than in Mehraïn. In the winter, although double-glazed windows in both schools contributed to minimizing heat loss, the inability to adjust the fixed shadings in Mehraïn limited solar radiation gain, resulting in lower indoor temperatures. Subsequently, the annual



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energy consumption for cooling and heating systems was analyzed. A combination of field data and standard references was applied to estimate the annual energy demand for both heating and cooling in the selected schools. In the initial stage, average monthly consumption was obtained through interviews with school facility managers and by reviewing electricity and gas bills over the course of a school year (2022–2023). These data were then extrapolated to determine the annual consumption levels. The collected information was compared and validated against standard benchmarks reported in reliable national and international sources to ensure the accuracy of the findings. In Afarinesh School, the use of movable shadings provided greater flexibility in controlling the intensity and duration of natural daylight, leading to a noticeable reduction in the need for artificial lighting. Conversely, in Mehraim School, where fixed shadings were installed, periods of excessive or insufficient daylight were observed during certain hours of the day.

Conclusion

The findings of this study which examined the combined effect of double-glazed windows with fixed and movable shading systems on the energy performance of educational buildings in the temperate and humid climate of Rasht demonstrate that these passive architectural elements play a crucial role in regulating environmental conditions and optimizing energy use. The analysis of simulation data obtained through DesignBuilder software revealed that movable shading systems, owing to their capacity to adjust according to the sun's position throughout the day and across different seasons were more effective than fixed systems in reducing cooling loads. This effect was particularly evident during the warmer months especially in the summer where the use of movable shading devices resulted in approximately a 25% reduction in cooling energy consumption compared to the baseline scenario. Moreover, integrating these shading systems with double-glazed windows significantly decreased heat transfer thereby enhancing thermal comfort for occupants during school hours.

References

1. Ahmed, R., & Johnson, M. (2021). The impact of shading devices on energy consumption in educational buildings. *Energy and Buildings*, 13(2), 112–123.
2. Alwetaishi, M. (2021). Impact of Window to Wall Ratio on Energy Loads in Hot Regions: A Study of Building Energy Performance. *Energies*, 14(4), 1080
3. Ardouzadeh, N., Borna, R., Jebraeil, Gh., & Morshadi, J. (2024). Determining the most suitable school days for students in Ahvaz based on the results of the Climate Consultant Index. *Journal of New Ideas in the Geographical Sciences*, 6(2), 29–48 (In Persian)
4. Asadi, E., da Silva, M. G., Antunes, C. H., & Dias, L. (2012). Multi-objective optimization for building retrofit strategies: A model and an application. *Energy and Buildings*, 44, 81–87.
5. ASHRAE. (2023). *ASHRAE handbook—Fundamentals*. American Society of Heating, Refrigerating and Air-Conditioning Engineers.
6. Bakó-Biró, Z., Clements-Croome, D. J., Kochhar, N., Awbi, H. B., & Williams, M. (2012). Ventilation rates in schools and pupils' performance. *Building and Environment*, 48, 215–223.
7. Barrett, P., Zhang, Y., Moffat, J., & Kobbacy, K. (2015). A holistic, multi-level analysis identifying the impact of classroom design on pupils' learning. *Building and Environment*, 89, 118–133.
8. Ghaffarianhoseini, A., Berardi, U., & Ghaffarianhoseini, A. (2013). A review on environmental sustainability and energy efficiency in buildings. *Building and Environment*, 68, 1–13.
9. Givoni, B. (1994). *Passive and low energy cooling of buildings*. Wiley.
10. Gratia, E., & De Herde, A. (2007). Green roofs and solar shading: Impact on cooling energy need. *Energy and Buildings*, 39(5), 505–513.



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11. Heschong, L. (2002). Daylighting and human performance. *ASHRAE Journal*, 44(6), 65–67.
12. Iranian Institute of Architecture and Urban Planning & University of Guilan. (2018). *Comparative study of the performance of awnings and windows in schools in the north of the country*.
13. JISC. (2006). *Designing spaces for effective learning: A guide to 21st-century learning space design*.
14. Karami, A., Hashemi, S. A., & Nabati, M. (2017). Energy performance of buildings in northern Iran: A case study of the city of Rasht. *Renewable and Sustainable Energy Reviews*, 67, 578–589.
15. Karava, P., Stathopoulos, T., & Athienitis, A. K. (2012). Evaluation of wind-driven rain on building facades using CFD: The case of low-rise buildings. *Building and Environment*, 57, 35–48.
16. Mohammadi, F., Bayat, M., & Jafari, R. (2019). Energy performance analysis of primary schools in hot and dry climates. *Iranian Climate Architecture Journal*.
17. Mozaffari, M., Deylami, M., & Soleimani, B. (2018). Climatic classification of the city of Rasht for architectural design. *Journal of Environmental Engineering*, 144(3), 04018017.
18. Norouzi, S., Asadian, F., Daryabari, S.J., & Borna, R. (2024). Climate and architecture with an emphasis on two factors: building orientation and sunlight (Case study: Ahvaz metropolis). *Journal of New Ideas in Geographical Sciences*, 5(2), 23–42 (In Persian)
19. Olgyay, V. (2015). *Design with climate: Bioclimatic approach to architectural regionalism*. Princeton University Press.
20. Olgyay, V., & Seruto, C. (2010). Whole-building retrofits: A gateway to climate stabilization. *Environmental Building News*, 19(7), 1–10.
21. Sharifi, A., Naghibi, S. A., Kabiri, K., & Murayama, A. (2022). A review of climate-sensitive urban design strategies for mitigating urban heat island effects. *Sustainable Cities and Society*, 76, 103498.
22. Smith, J., Brown, T., & Lee, K. (2020). Energy efficiency in modern buildings: The role of double-glazed windows and shading systems. *Journal of Sustainable Architecture*, 12(3), 45–58.
23. Taleghani, M., Smith, J., & Johnson, A. (2023). Evaluation of passive cooling strategies for sustainable architecture in arid climates. *Journal of Building Engineering*, 68, 102982.
24. U.S. Department of Energy. (2017). *Energy efficiency trends in residential and commercial buildings*.
25. Wargocki, P., & Wyon, D. P. (2013). Providing better thermal and air quality conditions in school classrooms would be cost-effective. *Building and Environment*, 59, 581–589.
26. Wong, N. H., & Huang, B. (2004). Comparative study of the indoor thermal environment of naturally ventilated classrooms. *Building and Environment*, 39(1), 43–50.
27. Zolfaghari, A., Farhadi, H., & Ghasemi, F. (2019). Evaluating the energy performance of adjustable shading devices in educational buildings in humid climates of northern Iran. *Journal of Building Performance*, 10(1), 45–58.