

# Experimental Evaluation of a Louver-Integrated Layered Window for Heat Gain Control and Daylight Diffusion

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## Abstract

The implementation of various strategies in building design that take into account climate change is crucial for enhancing energy efficiency and improving the indoor environmental quality. The purpose of this study is to evaluate a window system designed by a student that incorporates louver elements, aiming to optimize internal space lighting while minimizing heat gain. An experimental study was conducted using a comparative analysis of two window models: a conventional window and a modified one with layered glazing and triangular louvers. Both models were exposed to artificial lighting simulating solar radiation, and internal surface temperatures were measured at regular intervals using an infrared thermometer.

The experimental results showed that the student's designed window system maintained comparable or even lower maximum surface temperatures than the conventional window under similar conditions. The use of louvers also enhanced internal space lighting by reducing glare and improving lighting diffusion. Although both window models exhibited increased surface temperatures over time, the designed window offered superior visual comfort without compromising thermal performance.

The findings indicate that well-designed shading devices, combined with layered windows, can effectively balance the control of heat gain and the optimization of daylight availability. This study is expected to contribute to the development of sustainable design practices in architecture by demonstrating an effective and cost-efficient method of experimentation.

**Keywords:** climate-responsive design, heat gain, daylight optimization, thermal performance, window design, louvers, shading devices, energy efficiency, sustainable architecture, heat transfer, glare control, infrared thermography, experimental analysis.

## 1. Introduction

In light of the increasing focus on the energy efficiency and climate responsiveness of buildings, it has become increasingly important to consider and analyze the issues of heat gain and daylight performance. In particular, an increase in solar heat gain can lead to higher indoor temperatures, which in turn may

result in increased energy consumption. On the other hand, effective management of daylight performance is essential for ensuring visual comfort and the well-being of building occupants.

The experiment was conducted by students and aims to assess and analyze the performance of specially designed windows, which are expected to aid in minimizing heat penetration while allowing proper natural light penetration into the building.

The experiment is based on the scientific theory of heat transfer, including conduction, convection, and radiation, as well as ray convergence or interior daylight optimization. Specifically, the experiment aims to evaluate and analyze how solar rays converge and interact with windows and buildings. It is based on observations and aims to propose ways of enhancing building performance through effective window design.

### 1.1. Definition

Daylight through ray convergence is the strategic use of natural light to illuminate spaces while minimizing the need for artificial lighting. It is focused on maximizing the comfort of the visual environment.

Interior glow through ray convergence: It concerns ensuring that a space is sufficiently lit with natural light, allowing people inside to work comfortably without the risk of glare.

Techniques used: The techniques that can be used in this aspect include window positioning, shading, and multiple glazing.

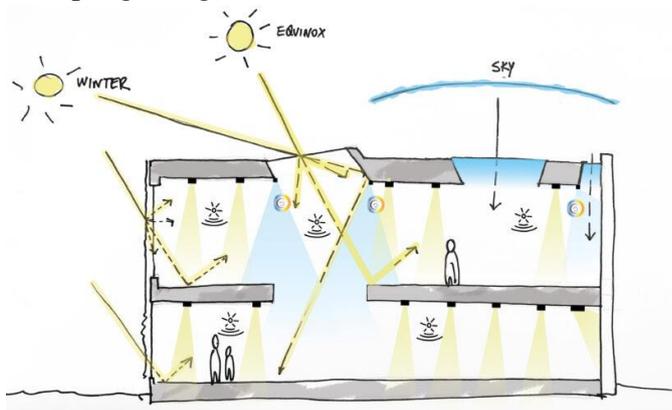


Fig.1.1

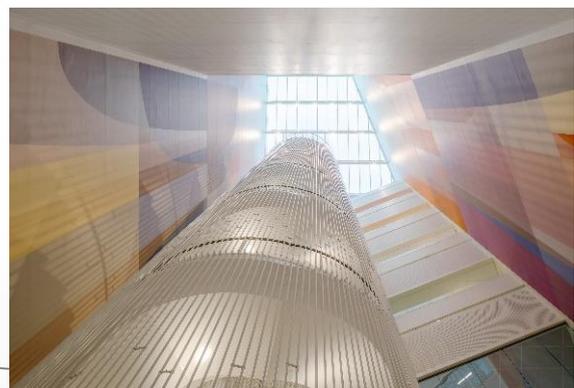


Fig.1.2

Figures 1.1 and 1.2 explain the interior daylight distribution in a building

### 1.2. Innovative Aspect of the Study

The innovative aspect of this study was the manner in which the student-designed window, with the addition of louvers, was able to provide improved daylight quality and convergence of natural rays by reducing glare and optimizing the distribution of natural light.

All of this was achieved with the same or even lower level of heat gain compared to the conventional window system. This was accomplished through a simple, practical, and hands-on experimental approach.

## 2. Objective of the Experiment

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## 3. Theory and Concept

Buildings receive heat mainly through solar radiation entering via openings such as windows. Poorly designed windows can increase indoor temperatures, leading to higher energy consumption for cooling. The concept of interior glow optimization through **ray convergence** focuses on optimizing daylight penetration while minimizing heat gain. By designing shading elements, louvers, and layered window components, it is possible to control both light and heat effectively.

- **Heat Transfer:** Conduction, convection, and radiation contribute to heat entering the building.
- **Daylight Optimization:** Properly designed windows can diffuse light to illuminate interiors without causing glare or overheating.

## 4. Experimental Setup

An artificial light source was used to stand in for the sun in both models. The experiment took place indoors to keep the conditions the same. The light was set at a particular angle to mimic how the sun hits windows. This helped avoid changes in weather or temperature that might affect the results.

Surface temperatures on the inside of both window models were checked using a calibrated infrared thermometer.

This helped measure how much heat was getting through. Measurements were taken at regular times to track how heat moved over time. All the tests were done indoors to keep the setup consistent. This made the results more reliable and accurate.



Fig.4.1

Fig:4.2

Fig.4.3

Figures 4.1, 4.2, and 4.3 explain the experimental setup conducted by the students

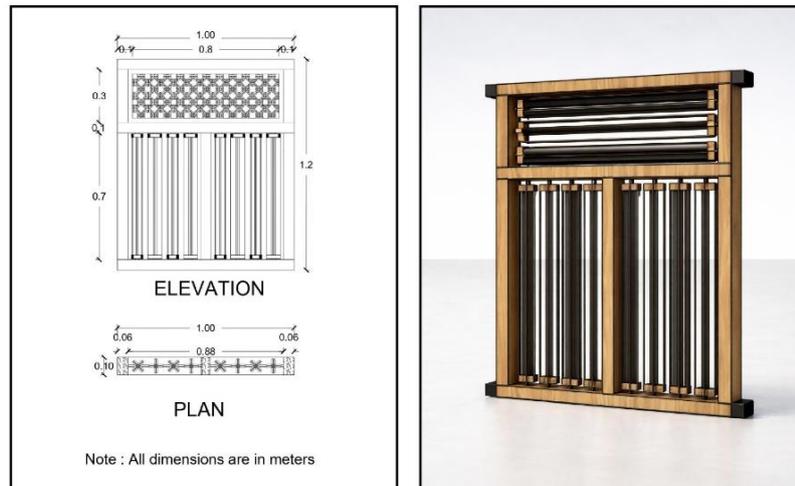


Fig.4.4. student-designed window (drawing and view)

## 5. Methodology

The study used a scientific process to examine how heat moves through the window models. Both the regular windows and the student-designed ones were placed so they faced the controlled light source. This light was used to simulate sunlight. The light was turned on for a set time to study how sunlight affects buildings.

To measure the inside temperatures of both models, an infrared thermometer was used. This tool allowed precise readings without touching the surfaces. Temperatures were recorded at regular intervals to get reliable data. The results were kept track of so they could be used to compare how much heat each window type lets in.

## 6. Experimental Investigation

The experiment was split into two parts. These parts were set up to test the thermal and daylight performance of the new window design. This setup allowed for a clear comparison.

### 6.1. Stage One

In the first part, the standard transparent window model and the basic glazed model were placed so they faced the artificial light source, which stood in for the sun. The light was set at a certain distance and angle to hit the window surfaces consistently. To make sure both models got the same amount of light, the light was left on for a specific time.

During this time, the inside temperatures of the window models were measured using a calibrated infrared thermometer. This device helped find temperature changes without affecting the test. Temperatures were taken at regular intervals to see how heat moved through the windows and how much heat built up. All the data collected was written down for comparison. This data helped understand how much heat went through the regular window system and how daylight behaved. This part of the experiment served as a base to compare with the improved window design.

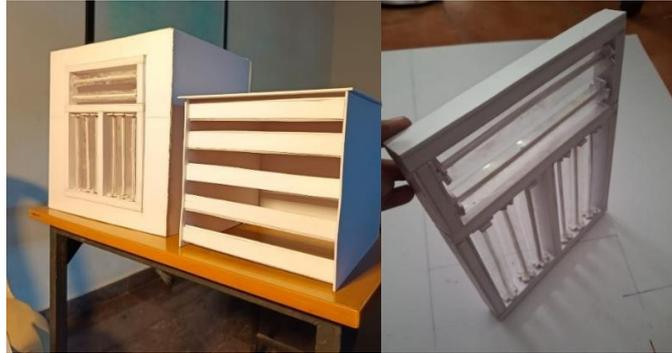


Fig.6.1

Fig.6.2

Figure 6.1 and 6.2 showing the experiment setup of designed louvers (transparent material) and conventional louvers (opaque material)

## 6.2. Stage Two

The second stage of the experiment introduced a change in the initial window configuration to evaluate the performance of the shading and material modifications in controlling heat gain and daylight performance. In this stage, the transparent material used in the first stage was replaced with an opaque one.

Additionally, triangular louvers were incorporated in the second stage. These triangular louvers were positioned in a way that they could block direct sunlight while allowing the controlled convergence of the sun's rays within the interior space. Moreover, the triangular louvers were designed to diffuse the natural daylight entering the interior space.

The newly designed window model was positioned to face the same artificial light source. The same duration of time was used in the experiment to ensure consistency.

In addition, the inner surface temperature of the modified window model was measured using the same calibrated thermometer. The temperature values were recorded at regular intervals throughout the process. This helped in monitoring heat accumulation over time. The reliability of the data could thus be guaranteed. The recorded temperature values were then documented and compared with the data from the first stage of the experiment. This helped assess the efficiency of the opaque material and triangular louvers in reducing heat gain, glare, and improving daylight distribution within the space.

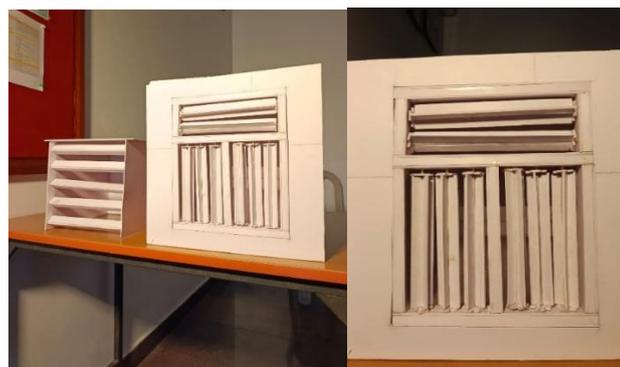


Fig.6.3

Fig.6.4

Figure 6.3 and 6.4 showing the experiment setup of Designed louvers (opaque material) and conventional louvers (opaque material)

### 6.3. Observations

The designed window model achieved much lower surface temperatures compared to the conventional window. This indicates that the window performed better under similar test conditions. The reduction in surface temperature shows that the elements used in the window design effectively controlled the amount of solar radiation entering the space.

By incorporating horizontal louvers and layers, the window was able to interrupt the light rays before they reached the interior surface, thus reducing heat accumulation and the rate of heat transfer. The shading elements acted as barriers, preventing heat from the sun from penetrating while allowing natural light to enter in a controlled manner. improved indoor environmental quality. The conventional window lacked such mechanisms, allowing natural light to penetrate more intensely.

Additionally, the developed model ensured a consistent amount of daylight within the space. This is because, unlike relying on direct sunlight that may cause hotspots, the use of louvers ensured the convergence and diffusion of such sunlight. This, in turn, helped reduce visual discomfort and hotspots while ensuring appropriate levels of brightness.

Thus, it can be seen that, in addition to efficiency in terms of temperature, the application of shading and layering strategies was also effective in ensuring visual comfort, highlighting the role windows play in creating sustainable environments.



Fig.6.5. Internal surface temperature (Conventional window)



Fig.6.6. Internal surface temperature (Designed window)

## 7. Results and Analysis

### 7.1. Stage One

Table 7.1. Experimental Observations (Stage one)

Time	Window Type	Max Surface Temperature (°C)	Observations on light
1:35pm	Conventional Window	28.1°C	Direct light, glare present

	Designed Window	28.7°C	Diffused light, uniform distribution
2:15pm	Conventional Window	28.1°C	Direct light, glare present
	Designed Window	27.9°C	Diffused light, uniform distribution

### 7.2. Stage Two

Table 7.2. Experimental Observations (Stage Two)

Time	Window Type	Max Surface Temperature (°C)	Observations on light
2:20pm	Conventional Window	30.5°C	Direct light, glare present
	Designed Window	30.3°C	Diffused light, uniform distribution
3:00pm	Conventional Window	30.4°C	Direct light, glare present
	Designed Window	30.1°C	Diffused light, uniform distribution
3:40pm	Conventional Window	30.2°C	Direct light, glare present
	Designed Window	29.9°C	Diffused light, uniform distribution

### 7.3. Analysis

The results from the two stages of the experiment provide a comprehensive comparison of the performance of the conventional window and the designed window in terms of temperature and daylighting.

In the first stage of the experiment, conducted during the early afternoon at 1:35 pm and 2:15 pm, both windows exhibited similar performance in temperature control.

The conventional window had a maximum surface temperature of 28.1°C at 1:35 pm, while the designed window reached 28.7°C, slightly higher. This difference may be due to the materials' ability to absorb heat at the beginning of the experiment. However, at 2:15 pm, the designed window recorded a temperature of 27.9°C, slightly lower than the conventional window's 28.1°C.

Although both windows remained within the same temperature range, their qualitative performances varied. The conventional window allowed direct light penetration, resulting in glare, while the designed window provided diffused light with uniform distribution, indicating its ability to converge light rays.

In Stage Two, this distinction became more pronounced as temperatures rose in both models. At 2:20 pm, the conventional window reached 30.5°C, whereas the designed window had a lower temperature of 30.3°C. The same pattern was observed at 3:00 pm and 3:40 pm, with the designed window maintaining temperatures 0.2°C to 0.3°C lower than the conventional window. While this difference is minimal, it

clearly shows that the designed window is more effective in resisting heat penetration with prolonged exposure.

Notably, in Stage Two, as temperatures increased, the quality of daylight remained distinct. The conventional window continued to allow direct sunlight, causing glare and uneven daylight distribution, while the designed window maintained diffused and evenly distributed daylight throughout the period. This difference may be attributed to the layered structure of the designed window, which obstructed direct sunlight.

In summary, the analysis indicates that the proposed window achieves a balance in optimization, ensuring that surface temperatures within the room are either equal to or lower than those of the conventional window, especially with extended exposure.

Furthermore, it enhances visual comfort by reducing glare and providing uniform natural lighting. This demonstrates that incorporating shading devices, such as louvers, in windows can improve indoor environmental quality without compromising comfort.

## 8. Learning Outcomes

This experiment provided a thorough understanding of the relationship between window design, thermal comfort, and daylight penetration within the indoor environment. By comparing the conventional window with the modified design featuring shading elements, the experiment illustrated the impact of window design on heat transfer and daylight entry within indoor spaces. The practical aspect of the experiment allowed for a deeper visualization of the relationship between solar radiation and architectural components.

The use of an infrared thermometer to measure surface temperatures within the indoor environment provided accurate data on temperature changes. By measuring surface temperatures at regular intervals, students were able to observe the accumulation of heat within the indoor environment and the effect of shading devices on this accumulation. This enhanced understanding of heat transfer through radiation.

Additionally, the study raised greater awareness regarding the concept of sustainable architecture, particularly in terms of energy efficiency. It emphasized the importance of passive architectural elements, such as shading devices and multi-layered window structures, in reducing heat gain without the need for artificial air conditioning. The inclusion of louvers in the design helped illustrate the filtering of direct sunlight.

Most importantly, the experiment highlighted the adaptive potential of adjustable louvers. These systems can adjust according to seasonal variations in the sun's angle, intensity, and temperature. In the summer, louvers can block direct sunlight, while in the winter, they can allow solar rays to provide passive heating. Thus, the experiment underscored the significance of responsive facade systems in climate-responsive architecture, reinforcing the role of window design in creating sustainable, energy-efficient, and occupant-focused spaces.

## 9. Conclusion

The experiment showed that the design of a window is very important in balancing how well it handles heat and how comfortable the indoor space is with daylight.

The window designed by the student worked better than the usual design in improving the quality of daylight by spreading the light more evenly, which made the indoor space more comfortable. Both window designs got hotter as they were exposed to sunlight for longer periods, but the student's design stayed at similar or even lower temperatures than the traditional one, especially during the hottest times.

The design of the window, which included a louver, layered structure, and the right materials, was effective at controlling how much heat came in while still letting light come in the right way. This helped improve the overall effect of the light inside the space.

## 10. Acknowledgment

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## References

1. Givoni, B. (1998). *Climate considerations in building and urban design*. John Wiley & Sons.
2. Szokolay, S. V. (2014). *Introduction to architectural science: The basis of sustainable design* (3rd ed.). Routledge.
3. Oke, T. R. (1987). *Boundary layer climates* (2nd ed.). Routledge.
4. Tzempelikos, A., & Athienitis, A. K. (2007). The impact of shading design and control on building cooling and lighting demand. *Solar Energy*, 81(3), 369–382.  
<https://doi.org/10.1016/j.solener.2006.06.015>
5. Wong, N. H., Istiadji, A. D., Tan, C. L., & Wong, J. (2008). Impact of external shading devices on daylighting performance in tropical buildings. *Energy and Buildings*, 40(6), 1185–1194.
6. ASHRAE. (2021). *ASHRAE Handbook—Fundamentals*. American Society of Heating, Refrigerating and Air-Conditioning Engineers.
7. Alwetaishi, M. (2019). Impact of glazing to wall ratio in various climatic regions: A case study. *Journal of King Saud University – Engineering Sciences*, 31(1), 6–18.

8. Bellia, L., De Falco, F., & Minichiello, F. (2013). Effects of solar shading devices on energy requirements of standalone office buildings for Italian climates. *Applied Thermal Engineering*, 54(1), 190–201.  
<https://doi.org/10.1016/j.applthermaleng.2013.01.039>
9. Heschong, L. (2002). Daylighting and human performance. *ASHRAE Journal*, 44(6), 65–67.