International Journal of Architecture and Urbanism Vol. 08, No. 01 (2024) 116 – 124

International Journal of Architecture and Urbanism

Journal homepage: https://talenta.usu.ac.id/ijau

Enhancing Lighting Efficiency In Kost's Rooms By Utilizing Bamboo Panels

Rania Ababssi*[1], Yulianto P. Prihatmaji*[1]

[1]*Department of Architecture, Faculty of Civil Engineering And Planning,Universitas Islam Indonesia, Yogyakarta, 55584, Indonesia*

*Corresponding Author: prihatmaji@uii.ac.id

ARTICLE INFO

Article history:
Received 19-01-2024
Revised 16 Maret 2024
Accepted 23-03-2024
Available online 31-03-2024

E-ISSN: 2622-1640
P-ISSN: 2622-0008

How to cite:
Rania, A. and Prihatmaji, Y. P. Enhancing Lighting Efficiency In Kost's Rooms By Utilizing Bamboo Panels. International Journal of Architecture and Urbanism. 2024. 8(1):116-124.

http://doi.org 10.32734/ijau.v8i1.14254

ABSTRACT

This research paper examines the sustainability aspects of bamboo as a versatile building material, with a particular emphasis on its potential to enhance lighting efficiency in construction. Sustainability in building construction necessitates eco-friendliness, affordability, versatility, and durability, all of which bamboo embodies. Beyond its well-documented thermal benefits, bamboo's rapid growth rate, adaptability to diverse climates, and inherent qualities position it as an eco-conscious choice for building materials. Notably, bamboo offers advantages such as high yield, environmental friendliness, lightweight properties, and rapid maturation for harvesting, making it a cost-effective option. This research delves into the key attributes and noteworthy applications of bamboo, including its innovative use in student boarding houses around Universitas Islam Indonesia. Through rigorous research, Bamboyasa workshop and experiments, we identified one of the 3 bamboo panels we made then selected the most promising panel for practical experimentation, focusing on bamboo panel technologies then modify the design to enhance the daylighting and thermal target. Our aim is to harness bamboo's unique characteristics to enhance human comfort and create sustainable building components tailored to lighting efficiency.

Keywords: bamboo panel, house, natural lighting

1. Introduction

Bamboo, known for its rapid growth and abundance, is a valuable resource in architecture due to its aesthetic appeal and environmental benefits. Acting as a natural air purifier, bamboo efficiently regulates air temperature and humidity, contributing to environmental balance. Its life cycle embodies sustainability, making it an environmentally friendly and cost-effective choice in construction. In Indonesia, especially on the island of Java, bamboo is widely present, with over 5 million clumps, and has a historical significance in Archipelago Architecture spanning millennia.

Its unique combination of hardness and flexibility makes it a prevalent choice in traditional construction. It serves as a foundational and versatile building material, commonly used in load-bearing elements like walls and flooring. The structural framework methodology in bamboo construction mirrors that of timber, emphasizing the interconnected walls for stability [1]. notes this similarity. Bamboo's primary application is in building walls and partitions, where its strength is crucial for the structural framework in (Figure 1). According to Irnawan's research, bamboo supports the building's weight, functional loads, and withstands environmental factors with the help of stainless steel bolts that enhance structural integrity.

Figure 1 Bamboo as wall and flooring

Achieving comfort in a building hinges on two key design factors: lighting and ventilation. These can be natural or artificial, with natural lighting deriving directly from nature and natural ventilation influenced by temperature conditions, materials, and environment [2]. Proper examination and application of these elements aim to deliver optimal comfort for activities within the building. Rooms with ideal natural ventilation and illumination also foster good air humidity, impacting the overall environmental health. Enhancing natural lighting and ventilation not only promotes comfort but also saves electrical energy by reducing the reliance on artificial sources. Optimizing lighting and ventilation involves considerations such as material selection, door/window arrangement, and ventilation system optimization. Lighting plays a crucial role in creating a comfortable and safe space, supporting various activities and forming visual aesthetics. It can be artificial from lamps or natural from sunlight, with openings facilitating maximum natural lighting. The strategic use of sunlight, especially during (08:00 am-16:00 pm). To regulate sunlight distribution, adding a secondary skin to the building's facade is proposed [3]. This secondary skin, available in diverse shapes and sizes, not only reduces sunlight intensity but also enhances the building's aesthetic value. It serves multiple purposes, including mitigating solar radiation exposure, reducing wind and noise, and ensuring indirect light for occupants [4]. Choosing environmentally friendly secondary skin materials is crucial for minimizing negative impacts on the surrounding environment. The advantages of using a secondary skin include protection from excessive sunlight, heat reduction, facilitation of air circulation, increased privacy, and improved aesthetic appeal. The study aims to assess the performance of bamboo panels as a secondary skin in a building, exploring how they enhance illumination quality in alignment with the building's function.

1.1. Purpose of The Research

This research endeavors to explore the nexus between the craftsmanship and physical properties of bamboo wall panels and their impact on the daylighting efficiency of buildings, with a specific focus on daylighting strategies. Ultimately, the goal is to identify optimal conditions for the production of high-quality, energy-efficient bamboo wall panels. Insights derived from this research will not only shed light on the potential of bamboo wall panels as a sustainable and energy-efficient substitute for traditional wood-based wall panels in the building construction industry but also contribute to the broader goals of sustainable bamboo resource utilization and reduced environmental impact associated with conventional wall panel materials.

1.2. Review

Energy Efficiency and Daylighting Synergy: The quest to evaluate the energy efficiency of buildings constructed with bamboo wall panels has been a subject of rigorous examination. Previous research has drawn comparisons between the energy consumption of structures featuring bamboo wall panels and those constructed with traditional building materials. For instance, [5] discovered that buildings employing bamboo wall panels exhibited reduced energy consumption for air conditioning when contrasted with buildings sporting conventional brick walls. This correlation can be linked to the Theory of Bioclimatic Design, advanced by Givoni. Bioclimatic Design theory posits that incorporating design strategies that adapt to local climatic conditions can substantially bolster energy efficiency according to [6]. In the context of this research, the Theory of Bioclimatic Design underscores the potential of bamboo wall panels not only to optimize thermal conditions but also to harmonize with natural daylight, leading to reduced energy consumption in buildings.

2. Method

Figure 2 Diagram methodology

This study utilizes a hybrid approach, combining quantitative research with hands-on experimentation, specifically focusing on the Bamboo Panel Construction Method. Implemented at Bambooland Indonesia in Ngepring Village, the construction process follows a systematic procedure involving site visits, material selection and dimension measurements for a 2x2 meter bamboo panel structure (Figure 2). The design considerations address distinct functions of panels. For WALL design, the focus is on enhancing natural ventilation and daylighting by incorporating a bamboo bone main opening, strategically blocking strong winds with variations in tight bamboo weaving and crashed bamboo. FLOOR design modifications prioritize structural integrity, utilizing tight bamboo intertwining and crashed bamboo for aesthetic appeal. Black bamboo or wulung is employed. Throughout construction, detailed measuments, sketches, and photos are collected for simulation studies. VELUX simulation tools, including the Daylight Visualizer software, optimize natural daylighting. Physical data are obtained from site visits to Kost Putra Arjuna 1 in Yogyakarta. A 3D model is created and assessed to understand how daylighting illuminates a 3x5 meter fully furnished room with private amenities. This integrated approach contributes to a comprehensive understanding of the Bamboo Panel Construction Method and its impact on optimizing natural daylighting in architectural spaces.

Following my visit to the boarding house (Figure 3), I conducted thorough examination and analysis of the room. I discovered that the room measures 3 meters by 5 meters, is fully furnished, includes a private toilet, and features a single door, double windows, and four registers for ventilation on the east side of the room.

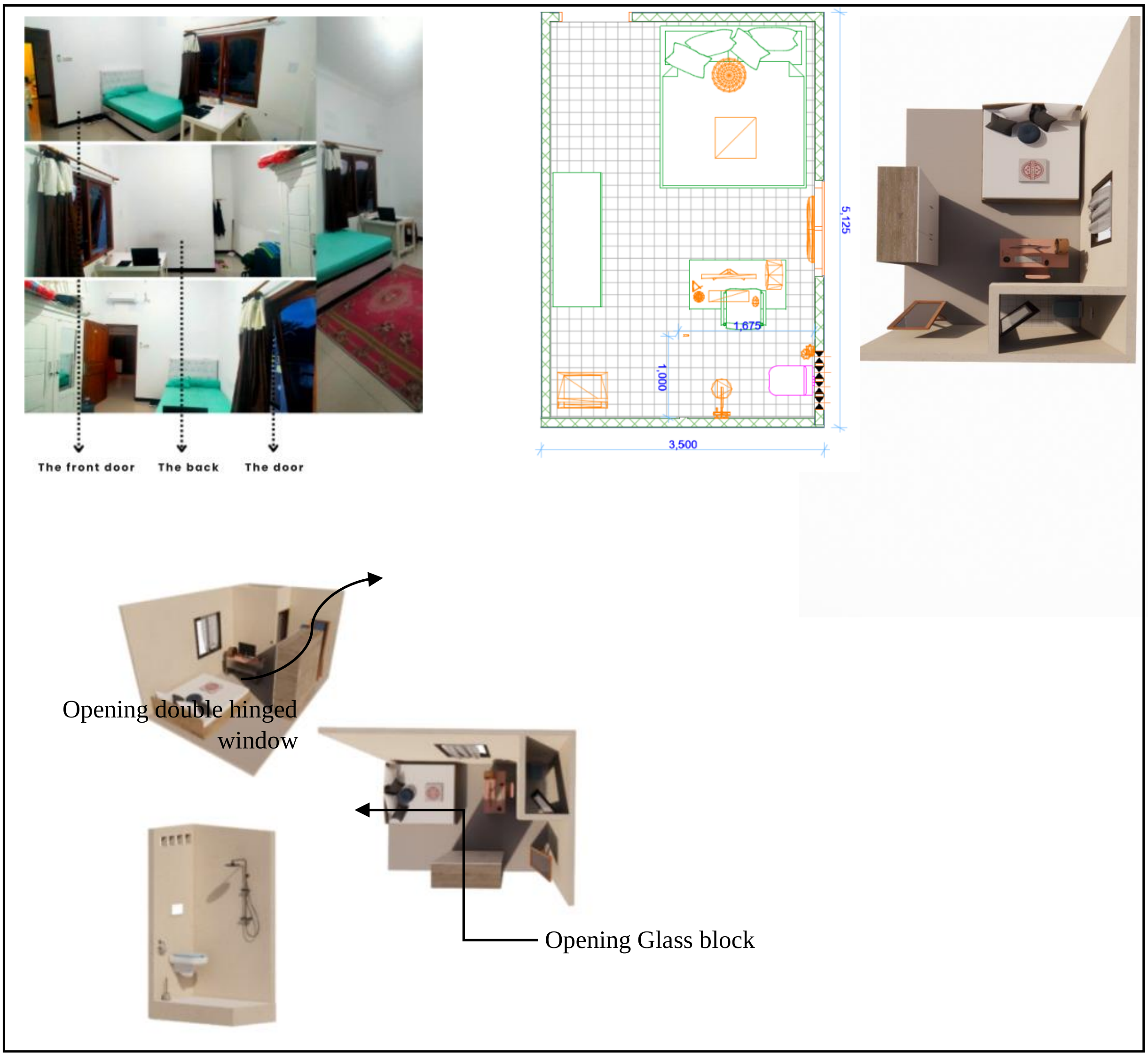

Figure 3 The Room's Interior, Floor Plan And Analysis

3. Result and discussion

Although bamboo's characteristic round and hollow structure presents certain challenges during construction, especially for connections, its structural qualities and environmental advantages make it a top contender for sustainable construction. Bamboo can be utilized as whole culms, split longitudinally, pressed flat, or woven into mats for use in conventional building [7]. For this reason I needed to introduce some change on the panels and make one for wall to be stimulated and that consider some elements: frame and solid bracing system, openings to be adjust and the user can decide how much lighting to enter the room.

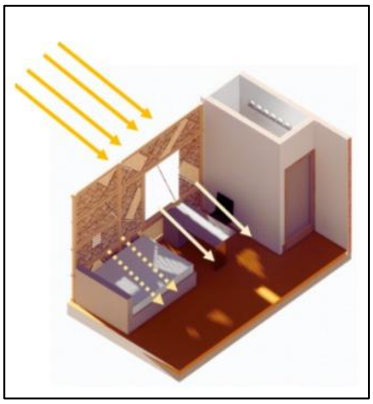

Figure 4 The Room's lighting

Light Impact : The direct sunlight coming from the east will be blocked by the weaving panels and the shades will only allow the only the daylight to pass into the room so it will increase the quality of light and decrease the temperature (Figure 4).

The chosen design : there are many types of bamboo, each has different specifications and impact on thermal energy, depends on the area and the famous types of bamboo that can be found near from the location, I have chosen three main types of bamboo according to figure 5 and figure 6.

Figure 5 Bamboo types

For the material chosen in this bamboo panel design according to the information I got from [8] , [14], [15] and the material available on site during workshop; Bamboo Petung that is renowned for its strength and reliability with an average heights between 15 -30 meters and average diameters between 8 to 20 cm. Also Bamboo Tali hitam that is prized for its flexibility and robustness with average heights between 8-22 meters and average diameters between 4-13 cm

Also acknowledging that the usage of each type depends on the function itself according to [9], [11], [13] and the workshop material; for structural components both bamboo petun and bamboo tali hitam, for weaving components both bamboo petung and bamboo tali hitam and finally for ventilation using bamboo petung

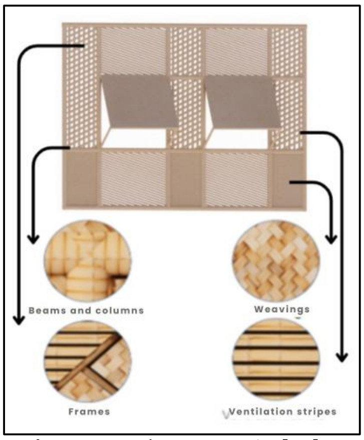

Figure 6 The Room's lighting

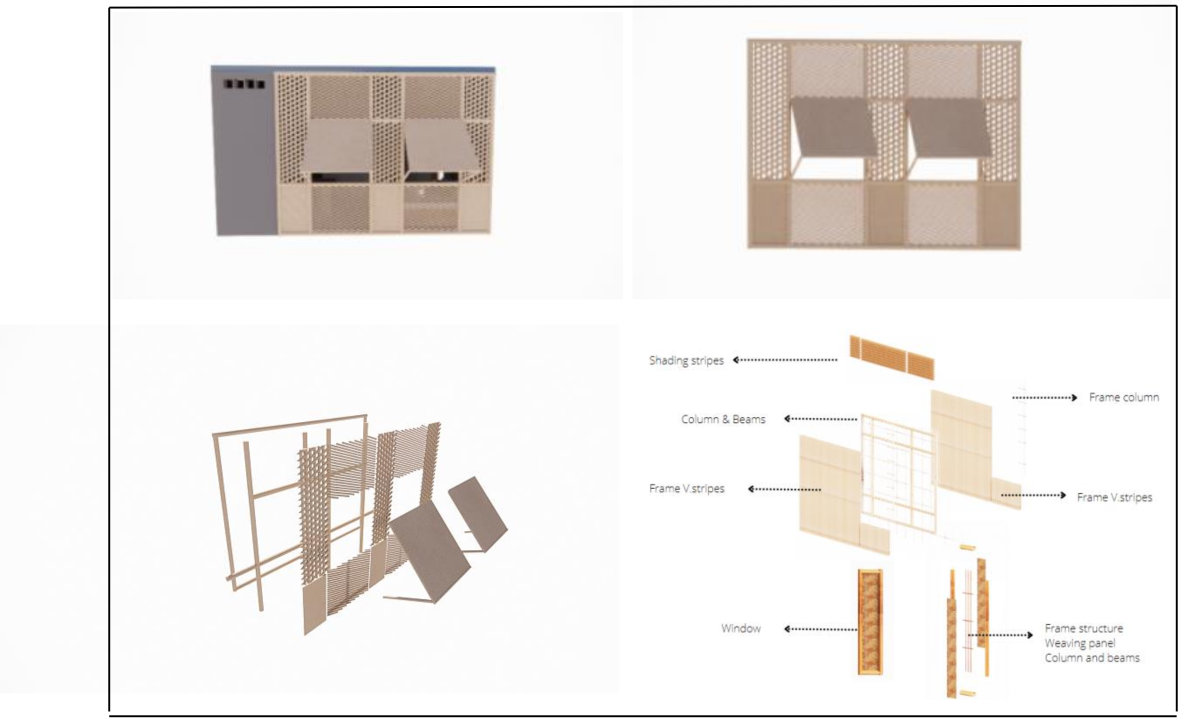

Figure 7 New altered wall panel, After Adding The Panel To The Desired Facade

The bamboo's panel framework for the wall considering the load distribution according to [10]. Wall panels were constructed using freshly cut Apus bamboo, utilizing its high moisture content and flexible fibers for easy shaping. The process involved creating an inner frame with wormwood bamboo sticks, bamboo bones, and vertical splits. Bamboo sticks and crashed bamboo were prepared for weaving. Construction materials included axles, nuts, bolts, washers, wire, and bamboo pegs. Petung bamboo frames were tied with wire to maintain shape, and the inner frame was assembled with woven bamboo using various patterns. The final step involved securing the Petung bamboo frames with bolts and nuts (Figure 7).

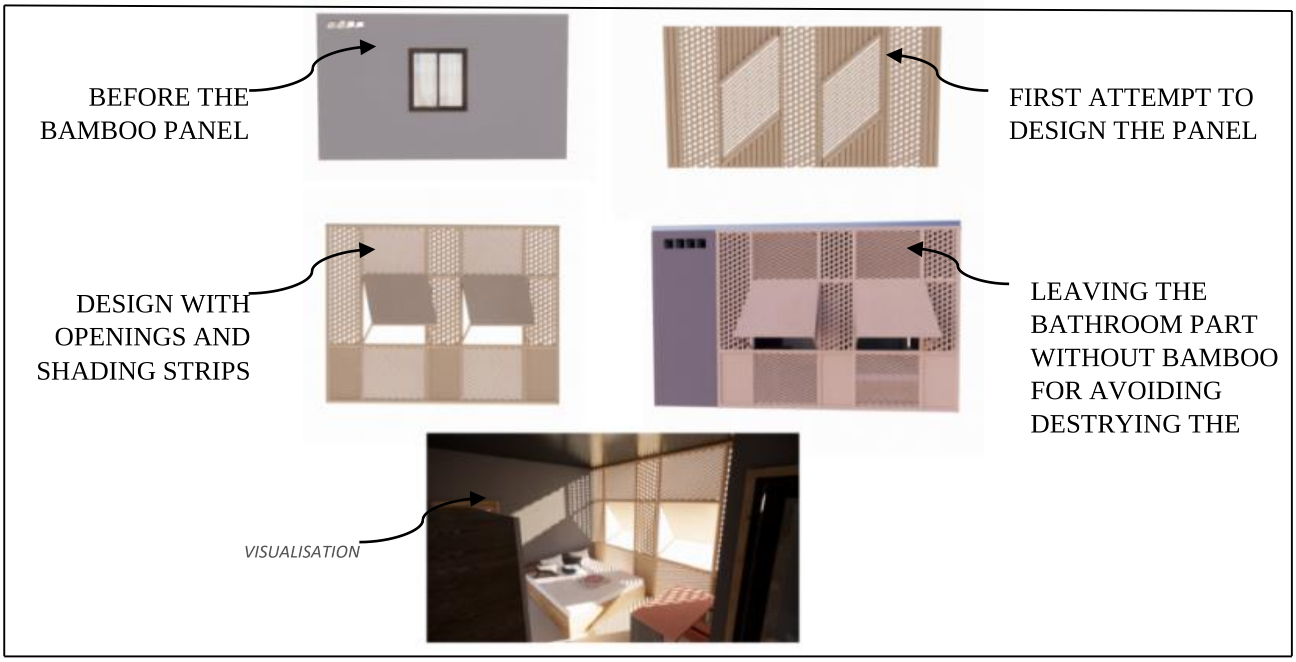

Figure 8 New the development of bamboo panel transformation

After redesigning from the previous suggested and made in Bambooland wall‘s panel *(figure 8)*, this bamboo panel consists of columns, beams and frames as structure to hold the other elements together, horizontal bamboo stripes for ventilation at many placements of the panel, window and the rest of the panel are made by a traditional weaving method, is also according developed with this structure to fit the norms (small ventilation openings and 2 windows to equilibrate the light entered) according to the note made from [12].

Figure 9 Location of Kost Putra Arjuna 1
Source: Google Earth, 2023

This kost Kost Putra Arjuna 1 (Figure 9), is located in the Special Region of Yogyakarta, road Mbahdrono No.2, Candirejo, Sardonoharjo, District Ngaglik, Sleman regency, Daerah Istimewa Yogyakarta 55581. The broader side of this kost is facing South due to its orientation, which ensures that the amount of light coming in will be at its maximum while excluding heat from the sun itself when openings are placed on this side.

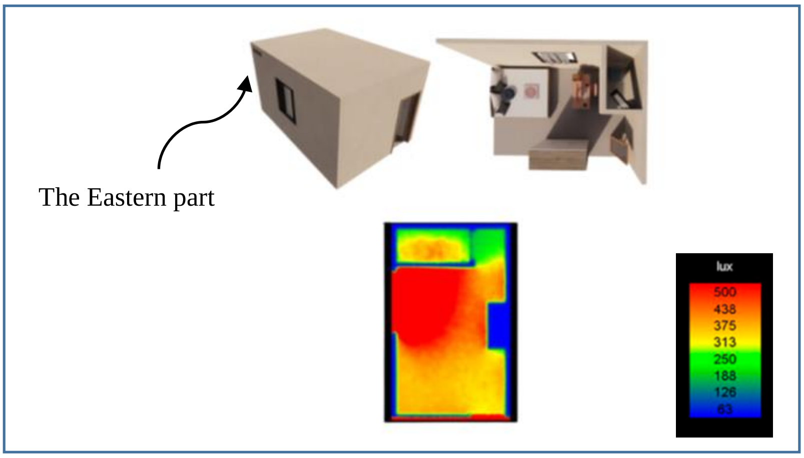

Figure 10 Parameter of lux measurement in VELUX simulations (a), Illuminated room of the existing building (b)

This is the result of the simulation when it is still simulated with the existing opening. From the result above, it looks like the room is having too much glare and illumination inside the room which can also make the users feel not really comfortable of over-lighting. Indoor lighting quality relies on natural and artificial factors. According to the AAAS, a space receiving more natural light tends to have better illumination. In this case, direct sunlight, especially through east-facing windows, significantly influences illumination levels. Simulation with the VELUX program shows illumination surpassing recommended standards (375 to 500+ LUX) for daily activities. The lack of insulation in the walls allows solar energy to impact lighting conditions and contributes to elevated thermal levels indoors (Figure 10).

To enhance natural illumination, a designer needs to consider daylighting as a primary factor. Without artificial lighting, a space might seem dim, primarily due to the absence of natural light. However, excessive sunlight can lead to glare issues. In regions like the tropics, daylighting is employed for indoor lighting from 8 AM to 6 PM. Leveraging daylighting in construction offers several benefits, such as reducing the reliance on electrical energy and providing occupants with a sense of both physical and psychological comfort. For effective daylighting, a room should have openings covering at least 9% of its floor area, allowing sunlight to filter in. Experts recommend this approach to mitigate the exposure to intense sunlight, typically around 1500 lux, and adhere to criteria for optimal eye comfort by strategically limiting aperture size.

The activities within the kost, such as eating, reading, and sleeping typically require around 250–300 lux, aligning with the lighting engineering principle that advocates for controlled illumination to avoid glare. Oversized apertures are cautioned against for this reason. The bamboo panels, functioning as a year-round source of daylighting for the Kost. While the National Environmental Quality Standard (NEQS) suggests an indoor lighting standard of 300 lux, the Occupational Safety and Health Administration (OSHA) sets a limit of 250 lux. The panel size is tailored to match the existing opening dimensions of 3 x 2 mete.

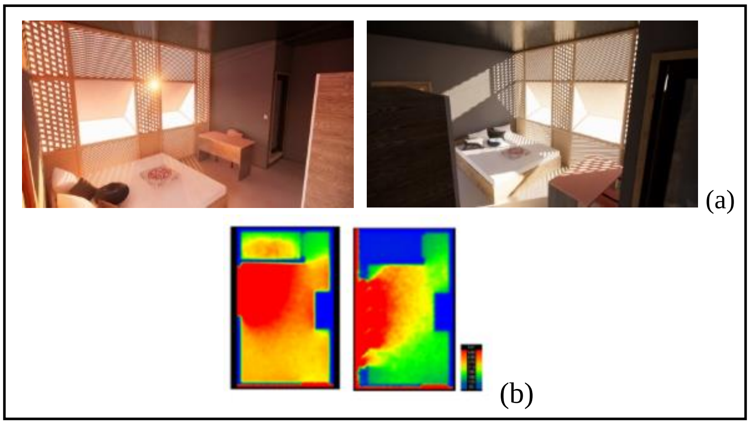

Figure 11 (a)Atmosphere of the room with bamboo panels (b) VELUX simulations before/after adding up the bamboo panel

According to VELUX simulation results, the average brightness reaching the kost area within a radius of 1 to 5 meters from the bamboo panels ranges between 313 and 438 lux, contingent on the simulation settings. Meanwhile, other sections of the room are naturally illuminated, falling within the 125-250 lux range. This outcome illustrates that the bamboo panels effectively enable natural daylighting to meet lighting standards. The simulation suggests that replacing traditional glass windows with bamboo panels provides the room with more suitable and ample lighting for its activities (Figure 11).

Bamboo atmosphere encapsulates the holistic environment and mood engendered by the presence of bamboo within a given space. This includes not only the visual appeal of bamboo, with its towering, slender stems and verdant foliage but also encompasses the auditory and olfactory dimensions associated with bamboo. This distinctive atmosphere is discernible in outdoor settings like gardens and parks where bamboo thrives, as well as within indoor spaces where bamboo is intentionally integrated as a design feature.

The impact of bamboo atmosphere on human well-being is noteworthy, fostering emotions of serenity, tranquility, and a profound connection with nature. Scientific studies underscore the positive effects of being in proximity to nature, particularly in the presence of bamboo, on mental and physical well-being, as well as cognitive function. As highlighted in the Journal of Indoor Air Quality and Climate, the strategic use of bamboo in indoor spaces not only enhances air quality but also contributes to an overall sense of well-being through its inherent aesthetic qualities. The utilization of bamboo as a deliberate architectural element thus emerges as a multifaceted approach to enriching indoor environments, creating spaces that not only visually resonate but also positively influence the experiential and physiological aspects of human habitation.

4. Conclusion

In conclusion, this comprehensive research has delved into the multifaceted impact of bamboo panels on both the daylighting considerations and the overall ambiance, unraveling their profound effects on human well-being. The study not only establishes the positive influence of bamboo ambiance on individuals but also underscores its role in fostering feelings of tranquility, serenity, and a profound connection with nature. The ambient qualities of bamboo extend beyond mere aesthetics; they play a pivotal role in shaping the experiential quality of indoor and outdoor spaces.

The research has elucidated the significance of incorporating bamboo ambiance in the design of spaces, emphasizing its potential to enhance thermal comfort and contribute to the overall well-being of occupants. The presence of bamboo in indoor environments emerges as a catalyst for positive emotions, reducing stress and promoting an atmosphere of calm and relaxation. Moreover, the study identifies the noteworthy impact of bamboo on air quality, positioning it as a holistic contributor to a healthier indoor environment.

The versatility of bamboo panels, as revealed by this research, goes beyond their thermal properties it extends to encompass a holistic improvement in the quality of human experience within built environments. The innate connection between bamboo and enhanced well-being is highlighted, offering a compelling argument for the integration of bamboo panels in future architectural endeavors. As a sustainable and aesthetically pleasing alternative to traditional building materials, bamboo panels emerge not only as contributors to thermal comfort but as transformative elements that positively shape the ambiance, fostering spaces that prioritize human well-being. The insights garnered from this study present actionable considerations for designers and architects, paving the way for the widespread application of bamboo panels to create spaces that not only meet functional requirements but also elevate the overall atmosphere and emotional resonance of the built environment.

5. Acknowledgements

We are grateful for the ongoing support and collaboration of the Kedaireka Matching Fund 2022, which has been instrumental in the success of this program. We would also like to express our immense appreciation to Bambooland Indonesia for their guidance and encouragement as the organizers of the Bamboology program, which has been invaluable in enabling the completion of this research.

6. Conflict of Interest

The authors whose names are listed below certify that the manuscript does not have a conflict of interest. Rania Ababssi

This statement is signed by all the authors to indicate agreement that the above information is true and correct (a photocopy of this form may be used if there are more than 10 authors):

Author's name (typed)	Author's signature
Rania Ababssi	

References

[1] Adier M, Sevilla M, Valerio D, Ongpeng J. (2023). Bamboo as Sustainable Building Materials: A Systematic Review of Properties, Treatment Methods, and Standards.

[2] Yun G, Kim J (2014). Creating sustainable building through exploiting human comfort.

[3] Sarah S, Irfan K, Immaculata M, Winandari R, Tundono S. (2023). THE USE OF SECONDARY SKIN MATERIALS FOR NATURAL LIGHTING IN HOTELS RESORTS USE OF SECONDARY SKIN MATERIALS FOR NATURAL LIGHTING IN HOTELS RESORTS.

[4] Ghonimi I. (2017). Assessing Daylight Performance of Single vs. Double Skin Façade in Educational Buildings: A Comparative Analysis of Two Case Studies.

[5] Ghavami K, Seixas M, Alves Ripper L. (2016). Bamboo: Low cost and energy saving construction materials Deployable bamboo structure for sustainable architecture.

[6] Manzano-Agugliaro F, Montoya F, Sabio-Ortega A, García-Cruz A. (2015). Review of bioclimatic architecture strategies for achieving thermal comfort.

[7] Manandhar R, Kim J, Kim J. (2019). Environmental, social and economic sustainability of bamboo and bamboo-based construction materials in buildings.

[8] Larasati D, Ihsan M, Mawardi H. (2019). How Far Can You Go with Bamboo? Compromising Traditional and Contemporary Methods in Bamboo Product Design and Production in Tasikmalaya, West Java.

[9] Jit Kaur P. (2018). Bamboo availability and utilization potential as a building material.

[10] Sahoo S, Sil A, Ghosh A. (2021). Structural analysis of bamboo wall framed structure - an approach.

[11] URL: https://en.wikipedia.org/wiki/Bamboo_construction

[12] URL: https://inhabitat.com/great-bamboo-wall/

[13] URL: https://www.scirp.org/journal/paperinformation?paperid=63365

[14] URL: https://www.themomentum.com/articles/bamboo-as-a-building-material

[15] URL: https://academic.oup.com/aobpla/article/9/1/plw078/2737454?login=false