THE USE OF BAMBOO MODULARITY AS A LIGHTING DIFFUSER

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ABSTRACT: *The use of bamboo panel modules to reduce indoor light intensity. This study explores the innovative application of bamboo modularity as a sustainable and versatile lighting diffuser in a room. Bamboo, a material with its eco-friendly properties and structural strength, has attracted attention as a material for various construction purposes. In this context, bamboo is examined for its potential to improve aesthetics and lighting efficient method of using bamboo material as a 2x2 panel module that is simulated using software to determine the effectiveness of the panel. Through a combination of empirical experiments and computational simulations, the study evaluates the performance of bamboo modularity in controlling light quality, distribution, and glare reduction. this research explores the environmental benefits of using bamboo as a lighting diffuser, considering its renewable nature, carbon sequestration capacity, and reduced energy consumption compared to traditional materials. The study also examines the economic feasibility and scalability of incorporating bamboo diffusers into architectural projects. The findings of this study contribute to the growing body of knowledge on sustainable design solutions and demonstrate the potential of bamboo modularity as an eco-conscious choice for lighting diffusers in eco living unite. As society continues to prioritize sustainability and energy efficiency, bamboo modularity emerges as a promising solution that combines aesthetics, functionality, and environmental responsibility.*

Keywords: *energy consumption, lighting diffuser, modularity, simulation.*

INTRODUCTION

The choice of environmentally friendly building materials has become a major emphasis in the construction industry in a time of environmental uncertainty and growing awareness of sustainability. Researchers and practitioners in architectural design are interested in bamboo as a fast-regenerating natural material with remarkable strength capabilities for creating robust and eco-friendly environments. With a case study centered on boarding homes in Semarang, this study examines the use of bamboo as a sustainable material in the design of 2x2 room panels. There are many boarding houses in Semarang City, one of Indonesia's educational hubs, where employees and students are housed. But one of the major issues that many boarding houses have is a lack of natural light, particularly during the day.

In order to give the residents a relaxing and productive environment, natural lighting is crucial. In order to solve the issue of inadequate lighting in boarding house rooms, this study suggests using 2x2 bamboo panels. In addition to being a naturally renewable resource, bamboo was chosen for its capacity to absorb light from the outside and provide a bright, cozy interior. This case study intends to assess how bamboo panels affect boarders' comfort and productivity as well as how well they improve daylighting. The features of bamboo, the methods used to make bamboo panels, and how bamboo is used as an indoor daylighting solution are all thoroughly explored in this journal. In order to give readers a concrete grasp of the efficiency and sustainability of using bamboo as a building material in a congested urban setting, the findings of a case study conducted in a boarding house in Semarang will also be given. It is believed that the findings of this research will not only offer a thorough understanding of bamboo's potential as a sustainable building material, but will also offer a practical outlook on its application in actual circumstances. Through this research, it is intended that the general public, in particular boarding house owners and architects, would take into account bamboo as a clever and environmentally responsible solution to interior

lighting problems, resulting in the creation of a healthy, cozy, and long-lasting residential environment in the future. Bamboo is a non-traditional building material that is considered to be capable of addressing

environmental issues, notably in Indonesia. Environmental issues, particularly in overgrown areas such as Indonesia. Bamboo, especially if it can be modernized, should be used more widely as an ecological material (Jurizat & Ramadhan, 2020). Plaster bamboo walls are one of them because they can be erected prefabricated (Suriani, 2017). Natural and artificial lighting are the two types of illumination. Natural lighting is light that originates from nature, most commonly sunshine. Natural lighting is ideal because it provides the widest color spectrum. The passage of sunlight into the space through apertures serves the user by providing natural illumination, which can save electricity. Teori 1 The importance of natural lighting for building users, particularly in providing visual comfort and a sense of security because there is enough light for activities and they can clearly see the objects they are working on. Aside from that, natural lighting can provide psychovisual comfort by emphasizing shape and scale, allowing the beauty of the area to be exhibited. Natural light's warm character can raise the spirit and positively influence mood. As a result, natural lighting planning can play an important practical, architectural, and psychological role (Masrokan et al., 2020).

Natural illumination is distributed into the space by designating the top of the building (top lighting) or the walls (side lighting). Changes in natural conditions will, by chance, affect the temperature on the earth's surface. Changes in natural lighting conditions, particularly in coastal areas, also impact the dispersion of light entering the space. One idea for reducing energy use in buildings is to use renewable energy as a source of natural illumination. Designers utilize space lighting system design techniques as a guide to generate visual space comfort. Climate change affects energy performance in other ways, such as solar radiation (heat and light), which influences AC load requirements and building lighting design (Rahim et al., 2018). The usage of facades on buildings effects natural light distribution, and the model of the building facade influences the value of light intensity in the space. Natural lighting is one of the variables that must be reduced in order to reduce energy use, particularly in buildings, so it is vital to know the proportion of natural light distribution in coastal buildings (Rahim et al., 2018).Natural lighting is thought to be quite high in coastal places, so it is vital to know how the conditions relate to the SNI standard lighting levels.

Natural light utilization is very vital for visual environment conception, especially if the building is old. Better use of daylight may reduce the demand for artificial lighting as well as internal gains from solar energy and electric lighting. Energy efficiency refers to using the least amount of energy possible for heating, cooling, and lighting in order to maintain comfort levels in a structure. Daylighting is an excellent method for producing a pleasing aesthetic environment as well as a useful source of energy savings in commercial buildings. Daylight is regarded as the greatest light source for effective color rendering, and its quality is the only light source that most closely matches human visual reaction. The majority of daylight enters a building through window openings, which serve the dual purpose of not just admitting light to make the internal environment more pleasant and pleasing, but also letting people to retain visual contact with the outside world. People want good natural illumination in their workplaces. (Sharp et al., 2014). There are a few crucial points to consider when considering the usage of natural lighting that may sound apparent and straightforward but are sometimes missed. Building orientation, building position, site location, architectural features, and occupancy classification are examples of these regions. The cost- effectiveness of daylighting controls is determined by various elements, including the architectural aspects of the structure (form, window area, glazing type), as well as the location of the facility. It is critical to evaluate whether or not installing daylighting control

systems is cost-effective during the basic design phase, without the need for a full modelling analysis. Failure to understand how each of these areas affects and interacts with one another can be a disincentive to using daylighting. Furthermore, facility users must be instructed on how to utilize the controls effectively. If users are not educated, they may not reap the full benefits of daylighting. When these factors are taken into account, daylighting can be a vital technology for efficiently harvesting a renewable energy source while also bringing significant environmental benefits. Bamboo, as an industrial material, may replace wood and do so at a reasonable cost. Bamboo has traditionally been taken from Indian forest lands and homesteads that may include a few clumps of one of the various species of bamboo for domestic use, but there has been very little involvement in terms of purposeful planting in the past. In recent years, the demand for bamboo has expanded both within the country and overseas as a raw material for furniture manufacturing, as panel boards that replace wood, as agricultural implements, and for house/construction related uses. Bamboo may be a natural resource with enormous potential as a building material. Its structural characteristics, such as earthquake resistance, strong tensile and compressive strength, and so on, distinguish it. Because the use of bamboo is well consistent with sustainable development, bamboo-based panels will become very competitive construction materials when a variety of aspects are considered. To make bamboo-based panels more widely accepted by people all over the world, widespread popularization of their use is required. If bamboo-based panels can be effectively used in the construction sector, they will significantly contribute to the prefabrication industry's long- term development and environmental protection. Bamboo is gradually becoming recognized as a renewable, fast-growing, and cost-effective staple that, if treated properly, has the potential to replace modern materials. It promotes economic growth while also conserving natural wood resources to protect our ecological environment by providing a wood replacement. Bamboo-based panels are manufactured from raw bamboo using a variety of mechanical and chemical processes such as glue spraying, setting up, and hot pressing. The bamboo-based panels have the benefits of big size, high strength, form and size stabilization, and parallel and perpendicular strength and property that can be modified to meet varied demands.

RESEARCH METHOD

Method of Panel Production

This study uses a quantitative method, by making a model from bamboo apus with a scale of 1:4 as a design exploration then then we will build a 2x2 panel as a material.

Method of Panel Simulation

After making the 2x2 panel, the design will be attached to a commercial building and the effectiveness of the panel will be tested using the VELUX Daylighting Simulator application. To provide an indication that the panel is able to reduce light entering the room and provide comfort to the contents of the room.

RESULT AND DISCUSSION

Bamboo panels are engineered construction materials created from bamboo, a fast-growing, renewable resource. These panels are becoming increasingly popular in various industries, including construction, interior design, and furniture manufacturing, due to their unique properties and sustainability

Design Process.

Room light diffusing panels, often referred to as lighting panels or light diffusion panels, have the main function of leveling and diffusing natural or artificial light in a room. in designing the panel must consider the problem of light in order to produce a design that is

effective in reducing the light entering the room. some design explorations with several considerations

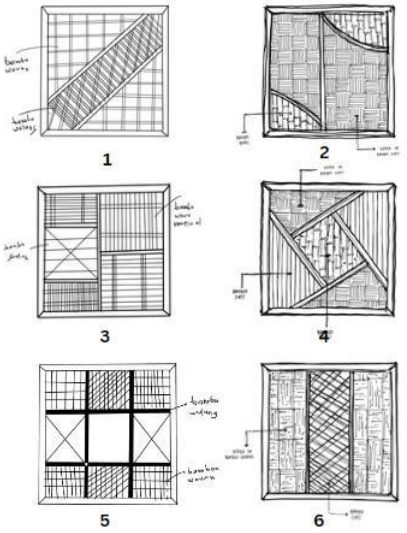


Figure 1. Preliminary bamboo panels design
Source: Author, 2023

The figure above shows several design explorations that have different specifications for the building response. n picture number 1 and 2 are effective for use as ceilings but not for wall panels. the first photo uses galar bamboo material as a panel filling then with a slightly open area in the middle. the second picture has similarities but at the end there is a curved bamboo so this design is not recommended because the construction method will be difficult to make the panel strong. in the third picture as construction is highly recommended because it has a strong straight construction. the filling in the third panel uses woven bamboo in different directions so that it gives a good aesthetic impression and there is also no empty part and light can be reduced. While the design in Figure 4 is not recommended because the main composition of the structure is tilted 30 degrees so that the strength of the panel filling is not there and it is easy to make the panel collapse. then in figure 5 it is highly recommended for the construction structure but not for the panel, because there is an empty area that makes light enter easily and in large quantities. and in figure 6 this design is very effective for ceiling because it can filter the light coming from above and give an aesthetic impression on the contents of the room and in terms of structure it is also qualified.

After seeing some considerations in the exploration design process, this design is used as a wall panel because it has very good criteria. the use of bamboo as construction is also very strong. the filling of this panel is in the form of woven galar bamboo and bamboo said, then the use of bone bamboo as a light circulation area

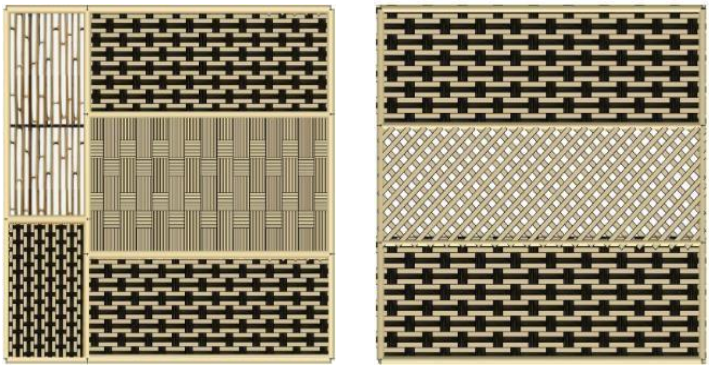


Figure 2. Preliminary bamboo panels design for wall (Left), Preliminary bamboo panels design for Ceilling (Right)
Source: Author, 2023

And the picture above is the result of exploration for ceiling panels. For the construction analysis it is recommended because there are two straight inner frames as supports for the main bamboo frame. To fill the ceiling, we use woven galar bamboo at the top and bottom, then in the middle we use slatted petung bamboo which functions to circulate light and air.

Production Methode

Before assembling the panel, there are several things need to pay attention. Several materials must be used and prepared. When making wall panels, the use of apus bamboo that is still green or freshly cut, because bamboo still has a lot of water content and good fiber so it is easy to shape/weave. The first process is to make an inner frame from 8 apus bamboo sticks with details of 2 slats measuring 2 meters, 2 slats measuring 50 cm, 4 slats measuring 150 cm. After the bamboo stems are cut, start arranging the bamboo stems one by one. Then make 5 bamboo bones 120 cm long making vertically split bamboo with a length of 80 cm, a width of 5 cm, consisting of 9 members making 6 bamboo sticks measuring 150 cm long and 25 cm wide making horizontally fallen bamboo measuring 150 cm long, 3 cm wide, with 36 members.

Construction Methode

The first construction that must be done is to assemble the outer frame using petung bamboo tied with wire (bendrat) so that the bamboo does not shift when stacked. After the main frame has been assembled, assemble the inner frame using apus bamboo tied with wire (bendrat).

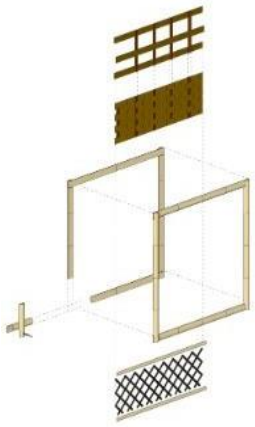


Figure 3. Construction method of the module on the bamboo frame
Source: Author, 2023

This inner frame will be used as a support for the bamboo panel filling. Then assemble bamboo galar which is inserted into the frame of petung bamboo and apus bamboo slats. After the inner and outer frames have been assembled assembling vertical and horizontal woven bamboo which is inserted into a frame of petung bamboo slats which are then locked in apus bamboo. Assemble bamboo bones inserted into the frame of petung bamboo split After all the webbing is installed, the ends of the petung bamboo slat frame are fastened using screw



Figure 4. Construction method of the bamboo panels
Source: Author, 2023

After the panel filling is arranged in the petung bamboo frame and has been attached to the frame frame using hot nails. frame panels are installed using 8mm asdrat. in the area of each corner of the frame is punched using an 8mm drill as an asdrat hole. punching the corner frame area is finished directly inserting the asdrat in each corner frame hole and then tightening it using bolts and washers.

RESULT OF SIMULATION

Existing Building

A simulation analysis on a Semarang boarding house building indicated significant issues with inadequate lighting and uncomfortable room temperatures during the day. To comprehend the dynamics of light and temperature in the room, the simulation employed the Velux application



Figure 5. Existing boarding house
Source: Author, 2023

The findings indicate that the building's current layout lacks natural illumination, which makes the rooms feel dim and gloomy even in the presence of bright sunlight. Low air flow

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also dramatically raises the temperature inside, which makes it uncomfortable for those within. This research gave us a thorough understanding of these issues, which helped us come up with a suitable solution. This boarding house building can be improved to provide its tenants with a cozy, healthy, and productive atmosphere by upgrading the lighting and ventilation system



Figure 6. Existing boarding house
Source: Author, 2023

A room in the extreme west end of a Semarang boarding house building was the centre of a simulation research that included five other rooms. When it comes to air ventilation and daylighting, this location provides unique difficulties. There is only one little window in the room, and two vents lead to the bathroom. The space was gloomy and uncomfortable for the residents to use due to the limited daylighting, which made it impossible to obtain enough sunshine. The two vents that were attached to the bathroom were also insufficient to enable adequate air circulation, which made the space feel stuffy and less fresh. Through simulation, this study thoroughly identified these problems, giving designers a solid foundation on which to build the required adjustments. The best course of action is to optimize natural lighting, maybe by adding additional windows or setting up bright artificial light sources, and to improve the ventilation system to give those occupying this space a healthy and comfortable amount of air circulation. As a result, persons who reside in these rooms can considerably improve their quality of life

Before Simulatin

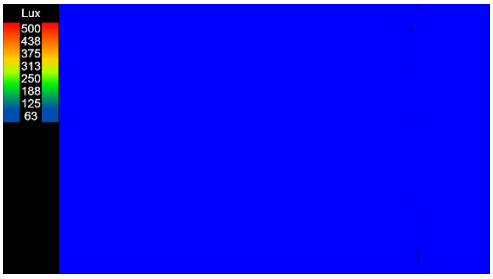


Figure 7. Result of Simulation of Existing Boarding House
Source: VELUX, 2023

A simulated analysis of a Semarang boarding house structure revealed very poor conditions there prior to the renovations. The interior of the building was extremely dark with lighting levels as low as 63 lux before the bamboo panels were put. The absence of lighting made the inside dark and uncomfortable for the residents. The absence of natural light in the area also made artificial illumination necessary throughout the day. In addition to impacting the inhabitants' comfort, these conditions may also be harmful to their productivity and well-being. This simulation study served as a crucial foundation for implementing the necessary corrective actions, such as installing bamboo panels to let more light into the room. These adjustments can greatly enhance the indoor environment, giving inhabitants a brighter, more comfortable, and healthier living place.

Buildings must be designed to be energy efficient. Building energy savings can be obtained through reducing energy use for heating, ventilation, and artificial lighting. Buildings that are designed with regard to solar radiation and daylighting have the potential to be energy efficient. Saving electric energy for permanent artificial lighting is a significant technical issue in internal areas of buildings that lack daylighting. Modern technology hasmade it possible to solve these issues. In this study, the energy saving can be done through utilizing natural daylighting more than artificial lighting.

According to the result of the simulation, it clearly can be seen that the installation of bamboo panels gives the adequate natural lighting into the room without the necessity of having the artificial ones.

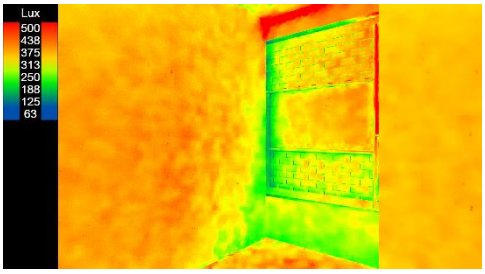


Figure 8. VELUX simulation result toward the room with bamboo panel installed on January
Source: VELUX, 2023

At the beginning of the year, the amount of sunlight that illuminates the room is quite high which is ranging from 313-438 lux.

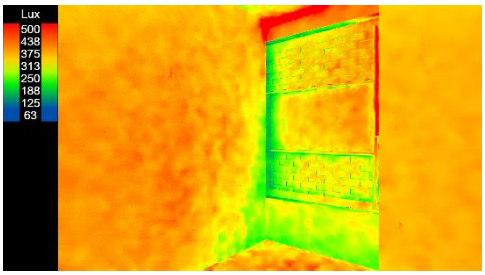


Figure 9. VELUX simulation result toward the room with bamboo panel installed on February
Source: VELUX, 2020

On February, the room continues to be well- illuminated, typically falling withing the 313-438 lux range.

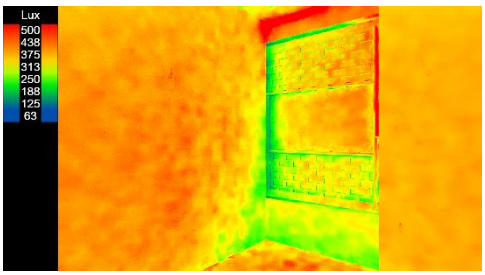


Figure 10. VELUX simulation result toward the room with bamboo panel installed on March
Source: VELUX, 2023

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The room remains brightly illuminated in March, usually falling withing the 313-438 lux range.

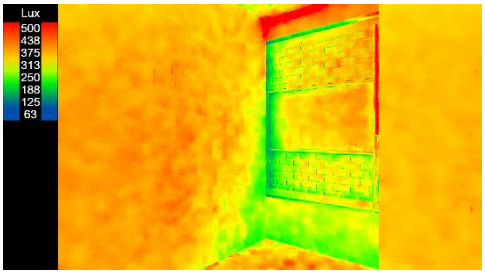


Figure 11. VELUX simulation result toward the room with bamboo panel installed on April
Source: VELUX, 2023

Continue to April, the room experiences a significant influx of sunlight with the same levels of lux with previous months that is ranging from 313-438 lux.

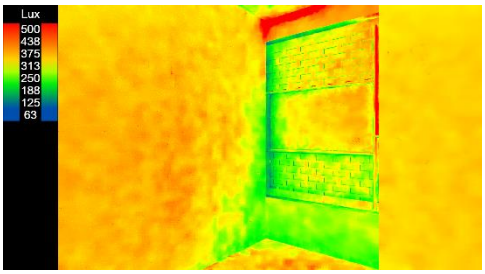


Figure 12. VELUX simulation result toward the room with bamboo panel installed on May
Source: VELUX, 2023

During May, the room continues to be illuminated with the same amount of daylight, measured between 313-438 lux.

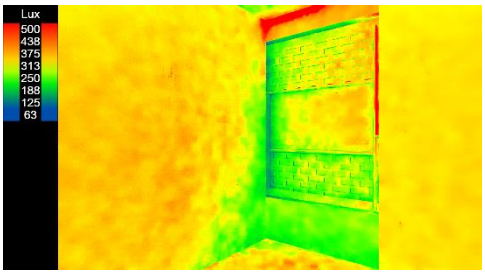


Figure 13. VELUX simulation result toward the room with bamboo panel installed on June
Source: VELUX, 2023

On June, the room continues to be illuminated with the same amount of daylight, measured between 313-438 lux.

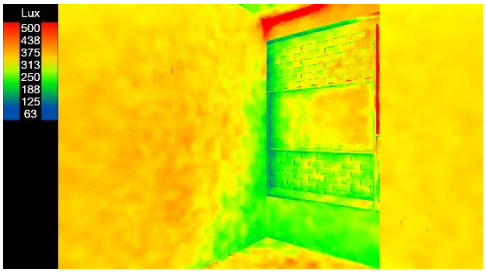


Figure 14. VELUX simulation result toward the room with bamboo panel installed on July
Source: VELUX, 2023

In the month of July, the room continues to enjoy good lighting, typically within the 313-438 lux range.

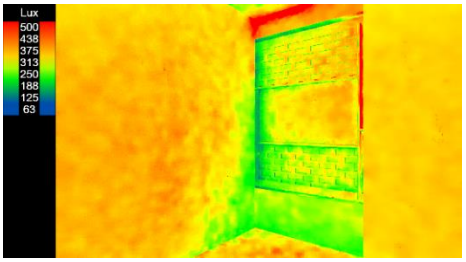


Figure 15. VELUX simulation result toward the room with bamboo panel installed on August
Source: VELUX, 2023

In August, the room consistently upholds a radiant illumination, usually encompassing the 313-438 lux range, promoting an atmosphere of focus.

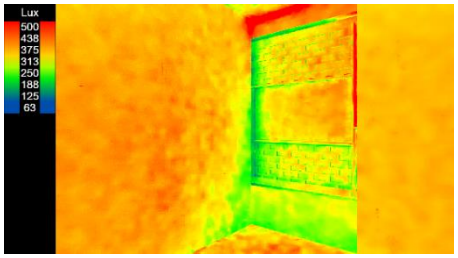


Figure 16. VELUX simulation result toward the room with bamboo panel installed on September
Source: VELUX, 2023

Throughout September, the room consistently offers a well-illuminated space due to the panel bamboo which resulted in between 313-438 lux range.

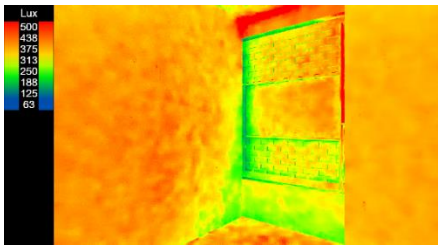


Figure 17. VELUX simulation result toward the room with bamboo panel installed on October
Source: VELUX, 2023

Over the duration of October, the room consistently maintains a well-lit atmosphere, attributed to the large windows, resulting in lux levels typically between 313 and 438.

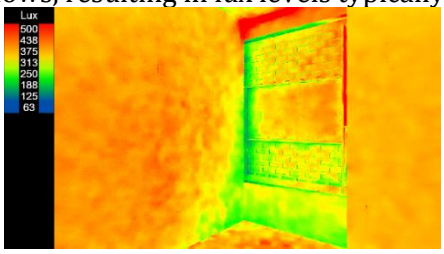


Figure 18. VELUX simulation result toward the room with bamboo panel installed on November
Source: VELUX, 2023

During November, the room consistently provides ample illumination, thanks to its high-quality LED lighting system, resulting in lux levels typically within the 313-438 range.

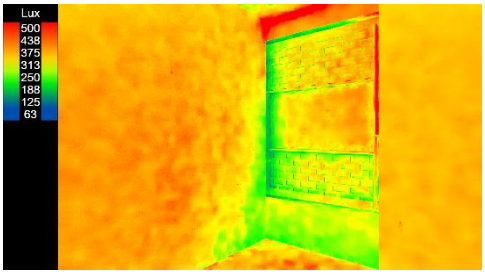


Figure 19. VELUX simulation result toward the room with bamboo panel installed on December
Source: VELUX, 2023

Throughout December, the room consistently enjoys a bright ambiance, courtesy of the skylights, which typically results in lux levels ranging between 313-438.

The lighting changed significantly after bamboo panels were simulated and installed on a Semarang boarding house building. With illumination levels exceeding 375 lux, the interior space of the building now provides a considerably more comfortable setting. The addition of bamboo panels has successfully enhanced the amount of natural sunlight in the space, giving the occupants a bright and energizing environment. The area feels brighter and has a better ambience thanks to the increased lighting levels. Additionally beneficial to people' physical and mental health, adequate lighting enhances daily comfort and productivity. These modifications demonstrate the significance of redesigning residential areas to make effective use of natural resources and offer demonstrable proof that careful design may improve the environment for those who live there.

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