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Optimization of Natural Lighting in Workspaces Through Velux Daylight Visualizer Simulation. Case Study: Hepta Design Office

Wandi Guntara [1], Reza Phalevi Sihombing [2]*

[1, 2] Architecture Department, Institute Technology National, Bandung, Indonesia

*Correspondence: E-mail: wandi.guntara@mhs.itenas.ac.id

A B S T R A C T

Natural lighting is a crucial element in workspace design that influences comfort, productivity, and energy efficiency. However, suboptimal lighting can lead to light imbalance, glare, and visual discomfort, thereby affecting user productivity. This study aims to optimize natural lighting in the Hepta Design (Segara Ide) office using Velux Daylight Visualizer simulation. The research process began with field data collection, including room dimensions, the position and size of openings, and furniture layout that affects light distribution. These data were used to create a three-dimensional model of the workspace, which was then analyzed through lighting simulations at various times and weather conditions. The simulation results showed that the average Daylight Factor (DF), luminance, and illuminance exceeded recommended standards, necessitating design adjustments. Modifications such as adding shading elements (sunshades) and altering openings successfully improved natural light distribution while reducing excessive intensity. The optimized design proved to enhance visual comfort, energy efficiency, and workspace quality, serving as a reference for other workspace designs.

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1. INTRODUCTION

Natural lighting is a vital aspect of workspace design, as it significantly impacts users' visual comfort, productivity, and well-being. Studies have shown that optimal natural lighting in work environments can reduce stress, enhance mood, and decrease reliance on artificial lighting, thus contributing to energy savings (Edwards & Torcellini, 2002). The role of natural lighting for building users, in particular, provides visual comfort and a sense of security by ensuring sufficient light for activities, enabling clear visibility of objects being worked on. Additionally, natural lighting offers psychovisual comfort by enhancing the perception of form and scale, thereby highlighting the aesthetic qualities of a space. The warm qualities of natural light can uplift spirits and positively influence mood. Therefore, the planning of natural lighting can function optimally in functional, architectural, and psychological aspects (Pangestu, 2019).

An office, as a workspace, requires adequate natural lighting to ensure that users can perform activities smoothly and maintain high productivity. Visual comfort can be achieved when key aspects of visual comfort are optimally implemented, including compliance with recommended lighting standards and proper room layout aligned with light distribution (Wisnu & Indarwanto Muji, 2017). This is particularly relevant for Hepta Design, a company specializing in design and architecture, which requires a work environment that supports creativity and work efficiency. Challenges in maximizing natural lighting often arise due to building shape limitations, room orientation, and interior elements that affect light distribution.

This study aims to optimize natural lighting in the workspace of Hepta Design's office using Velux Daylight Visualizer, a simulation software that enables detailed analysis of natural lighting distribution. The research method includes field data collection, such as room dimensions, the position and size of openings, and furniture layout affecting light distribution. This data is used to create a three-dimensional model of the workspace, which is then analyzed through lighting simulations at various times and seasonal conditions.

2. LITERATURE REVIEW

2.1. The Importance of Natural Lighting in Workspace Design

Natural lighting is crucial in workspace design as it enhances productivity and occupant satisfaction. Properly implemented natural light systems improve energy efficiency and create high-quality interior environments. However, controlling glare is essential to prevent visual discomfort and maintain visibility. In tropical climates like Indonesia, architectural design must consider solar responses to mitigate excessive heat and glare, ensuring a comfortable and productive environment for occupants in offices, SOHOs, and apartments (Hendro Wahyu Purwanto et al., 2024).Natural lighting plays a vital role by improving physical comfort, supporting biological health, and enhancing psychological well-being. The principles of design for natural lighting emphasize these benefits, advocating for environments that mimic natural light experiences to enhance overall user satisfaction (Thursfield & Vd Ven, 2022).

2.2. Impact of Natural Lighting on Visual Comfort and Work Performance in Office Environments

Numerous studies highlight the critical role of natural lighting in shaping occupants' visual comfort and cognitive performance in office environments. (Sun et al., 2018) found a strong correlation between daylight quality and improved work efficiency, citing enhanced task accuracy and reduced eye fatigue. Furthermore, (Al Horr et al., 2016) suggest that daylight

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quality influences user mood and psychological well-being, both of which are linked to sustained productivity. (Giovannini et al., 2025) emphasized that integrating simulation data with field measurements enables a more comprehensive evaluation of lighting comfort, especially under seasonal variations. In addition, (Kim & Kim, 2015) demonstrated how proper control of daylight through window treatments significantly mitigates glare and improves user satisfaction. As such, ensuring optimal daylight performance goes beyond quantity—it involves deliberate control over light distribution, intensity, and visual perception to support productivity and comfort.

2.3. Factors Influencing the Optimization of Natural Lighting

Factors influencing the optimization of natural lighting include building orientation, sufficient sky illumination, seasonal variations, and weather conditions. Additionally, a preference for artificial lighting over natural sources can hinder the effective utilization of sunlight in interior spaces (Pasau et al., 2024). Factors such as the height and type of openings, glass transmission, reflectance levels of architectural elements, and workspace depth all impact the quality and distribution of sunlight (Radevski et al., 2022). The amount of incoming light, window-to-wall ratio (WWR), wall materials and colors, and overall design collectively affect users' visual comfort and productivity (Vicaningrum & Marcillia, 2024).

2.4. Design Considerations that Support the Optimization of Natural Lighting

Design considerations for the optimization of natural lighting include facade optimization, the use of shading devices, and an understanding of climate patterns. These strategies enhance visual comfort, reduce glare, and improve user productivity (Md Amin et al., 2022). This includes advanced glazing systems, geometric formation of building envelopes, appropriate self-shading properties, and optimized fenestration systems, all aimed at improving visual comfort and maximizing sunlight exploitation in the environment (Bhai et al., 2022). It also involves adjusting window placement, ensuring proper lighting installation, and utilizing natural light recognition devices such as solar panels or light pipes to enhance visual comfort, reduce energy consumption, and improve user well-being (Wu & Kim, 2020).

2.5. Standard Performance Indicators for Natural Lighting in Workspaces

To achieve the optimization of natural lighting in workspaces, it is essential to have performance indicators that can be used to evaluate the quality of natural lighting in the workspace. These indicators include various parameters, such as Daylight Factor (DF), Luminance (cd/m²), and Illuminance (Lux). This study uses relevant standard references for each of these parameters as a basis for analyzing natural lighting in the workspace as follows:

Daylight Factor (DF)

According to (Rizal et al., 2016), the Daylight Factor (DF) is the ratio between the illuminance at a point inside a room and the illuminance at a point outside the room. The DF values, as a reference for natural lighting conditions, are grouped based on the function of the space as follows:

- DF value for residential activities ranges from 1% to 2%,
- DF value for office building activities ranges from 2% to 4%.

Luminance (cd/m2)

Luminance is the intensity of light emitted, reflected, and transmitted by a unit area that is illuminated, measured in Candela/m². According to guidelines issued by various organizations such as the International Commission on Illumination (CIE) and national standards like SNI 03-6572-2001 (for Indonesia), the recommended average luminance for general work areas is around 300–500 cd/m². This value ensures visual comfort for workers typically engaged in tasks such as typing or reading documents (Standar Nasional Indonesia, 2001).

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Illuminance (Lux)

In Indonesia, the recommended standards are based on SNI 03-6575-2001, which provides guidelines for designing artificial lighting systems in buildings. The lighting recommendations issued by SNI (2001) are based on the function of the space. For example, for office buildings, the recommended illuminance for the director's room, workspaces, and computer rooms is 350 lux; for meeting rooms, it is 300 lux; for drawing rooms, it is 750 lux; for archive storage rooms, it is 150 lux; and for active archive rooms, it is 300 lux (Kuruseng & Jamala, 2016).

2.6. The Role of Simulation Tools in Natural Lighting Optimization

Lighting simulation has become a crucial approach in designing energy-efficient and visually comfortable workspaces. A study by (Kontadakis et al., 2016) demonstrated that simulation-based light redirection systems can significantly improve daylight factor metrics and reduce glare in deep-plan spaces. Moreover, the choice of simulation software greatly influences the accuracy of the evaluation, with Velux Daylight Visualizer proving to be an efficient and practical tool (Giovannini et al., 2025)Parametric design integrated with climate-based simulation also enables a performance-driven design approach. (Ratajczak et al., 2023) as well as (Soltani & Atashi, 2023) advocate the use of iterative simulations in facade modeling to enhance natural lighting quality throughout the year.

3. METHODOLOGY

This study adopts a quantitative simulation-based approach to analyze and optimize natural lighting performance in the workspace of Hepta Desain Office, located on the second floor of the Segara Ide Building, Jl. Cikutra Baru VII No.19, Neglasari, Cibeunying Kaler District, Bandung City, West Java.

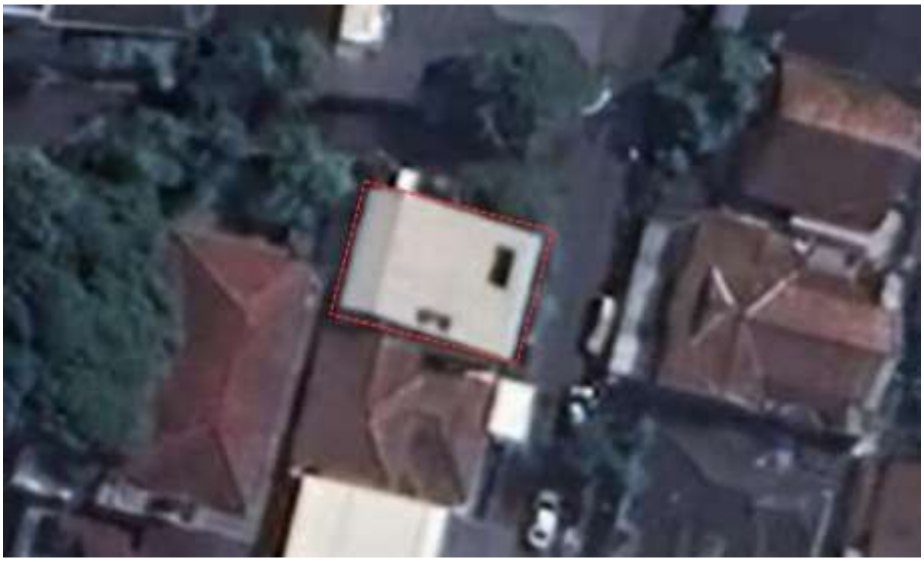

Figure 1: The location of the Hepta Desain office
Source: Author, 2024

The research is structured into four systematic stages: field survey, 3D modeling, natural lighting simulation, and analysis with design recommendations. These stages are designed to ensure accurate data representation, valid simulation outputs, and applicable architectural insights. The overall methodology is summarized in the flowchart below.

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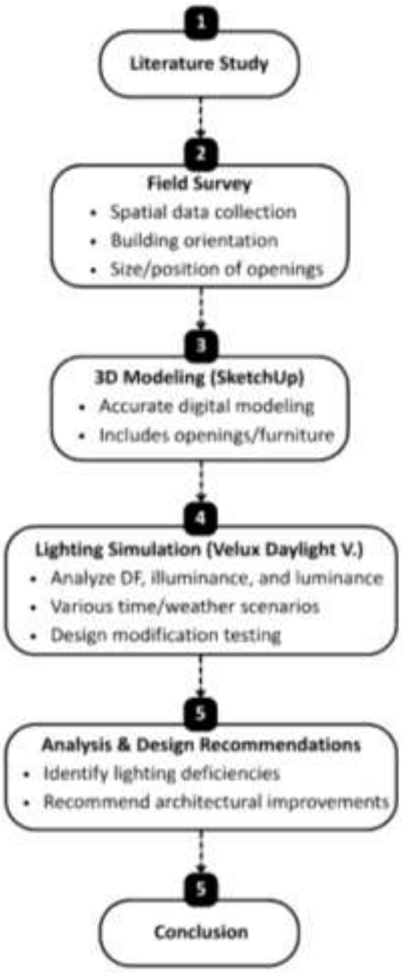

Figure 2: Flowchart of Research Methodology
Source: Author, 2024

3.1. Field Survey

The first stage involves a field survey to collect data on the existing conditions of the workspace. The data collected includes the dimensions of the space, the building's orientation relative to the cardinal directions, and the position and size of openings (windows or doors).

Figure 3: Hepta Desain office and Hepta workspace
Source: Author, 2024

3.2. 3D Modeling Using SketchUp Software

Based on the field data, the Hepta Desain office workspace model was created digitally using SketchUp software. This model includes all physical elements of the workspace, such as walls, ceilings, openings, and furniture, which influence light distribution. The model was created to accurately represent the existing conditions, ensuring that the simulation results closely reflect the real-world situation.

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Figure 4: 3D model of the exterior and interior of the Hepta Desain office
Source: Author, 2024

3.3. Natural Lighting Simulation Using Velux Daylight Visualizer Software

After the 3D model was created, a natural lighting simulation was conducted to analyze the distribution of natural light in the workspace at different times of the day (morning, noon, and afternoon) and under overcast weather conditions. The parameters analyzed include daylight factor (DF), luminance, and illuminance levels at specific points in the workspace. The simulation was also carried out with several design modification scenarios to evaluate the potential for optimizing natural lighting.

3.4. Analysis and Design Recommendations

Based on the simulation results, an analysis of the natural lighting levels in the workspace was conducted. Areas with insufficient or excessive lighting were identified, and design recommendations were provided to improve the quality and comfort of the natural lighting. These recommendations include adding or rearranging openings, as well as modifying the furniture layout to potentially enhance the distribution of natural light in the workspace.

4. EVALUATION FINDINGS AND INSIGHTS

The simulation was conducted during two seasonal events, namely in March and December. In March, the Equinox occurs around March 21st. During the Equinox, the sun is directly above the equator. This is the time when day and night have almost equal durations worldwide (Chairunnisa et al., 2023). The sun rises exactly in the east and sets exactly in the west. Because the sky is without direct sunlight, the Solar Component has no effect on the illuminance levels in the space (Mahaputri, 2010).In December, the Solstice occurs around December 21st. At this time, the sun reaches its farthest point north or south in the sky relative to the equator. This results in an extreme difference in day and night lengths (Raisal et al., 2020).

Based on the digital simulation using Velux Daylight Visualizer, the workspace located on the second floor was measured for daylight factor (DF), luminance (cd/m²), and illuminance (lux) levels. The digital simulation using VELUX Daylight Visualizer was conducted at three different times: 09:00, 13:00, and 16:00.

4.1. Simulation in March

a. Measurement of Daylight Factor (DF)

The Daylight Factor (DF) value for the office space shows an average DF of 6.22%, as shown in the image below. The recommended average DF for office buildings is between 2% and 4%. Since the DF value for the workspace is 6.22%, which exceeds the recommended range for office buildings (2%-4%), optimization steps are required in the opening areas to reduce the intensity of incoming natural light and create a work environment that aligns more closely with visual comfort standards.

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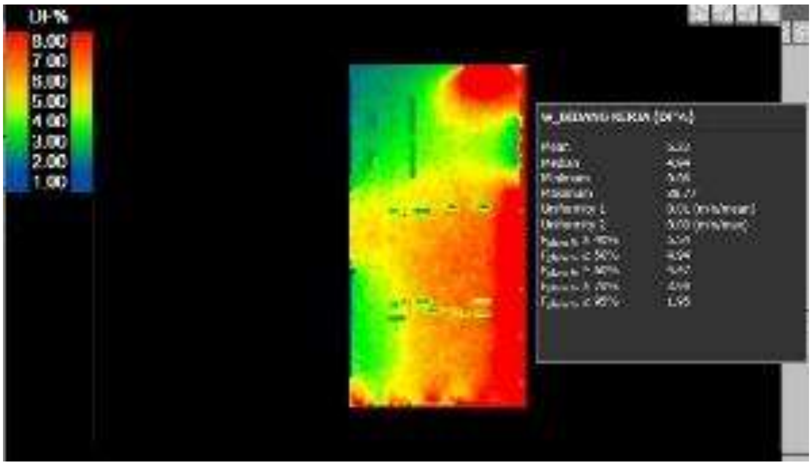

Figure 5: Simulation Daylight Factor
Source: Author, 2024

b. Measurement of Luminance (cd/m2)

The simulation results for luminance in March show a significant difference in the distribution of sunlight at the three observed times, with the pattern of distribution following the direction of incoming natural light. At 09:00 AM (Figure 5a), sunlight is concentrated near the window area due to direct reflection, resulting in high luminance levels in that area. At 01:00 PM (Figure 5b), the lighting is more evenly distributed across the room, with an average luminance reaching 700 cd/m². At 04:00 PM (Figure 5c), the intensity of natural light decreases throughout the room, although the area near the window still receives adequate lighting, with a minimum luminance of around 400 cd/m². Based on these results, the luminance in the workspace exceeds the standards set by SNI 03-6572-2001, which recommends a range of 300–500 cd/m² for work areas. Therefore, optimization steps are needed in the design of openings to reduce the intensity of natural light reflection, allowing for more controlled light distribution and ensuring the workspace meets visual comfort standards optimally.

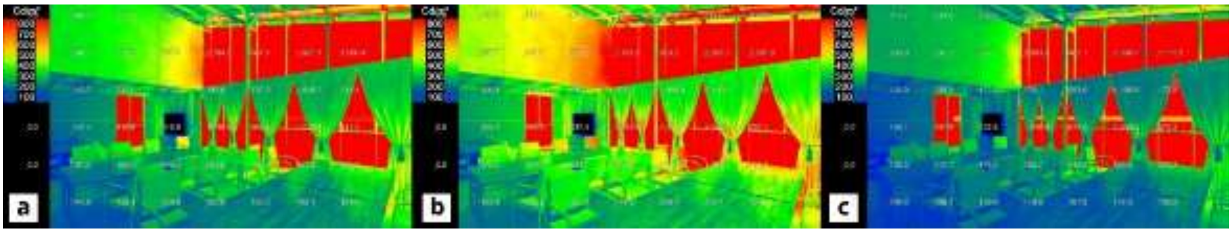

Figure 6: Luminance Simulation at 09:00, 13:00, 16:00 WIB in March
Source: Author, 2024

c. Measurement of Iluminance (Lux)

The illuminance simulation in March shows a high distribution of lighting in the workspace at three different times. At 09:00 WIB (Figure 6a), the illuminance near the window reaches 900–1,400 lux. At 13:00 WIB (Figure 6b), the lighting distribution increases with illuminance levels between 1,200–1,800 lux. At 16:00 WIB (Figure 6c), the illuminance decreases to 600–900 lux. These illuminance levels exceed the standard lighting requirements for office spaces, which are 350–1,000 lux (SNI 03-6572-2001), indicating the need for optimization in the opening areas. This adjustment aims to control the intensity of incoming natural light and ensure a more balanced lighting distribution, creating a work environment that supports visual comfort according to standards.

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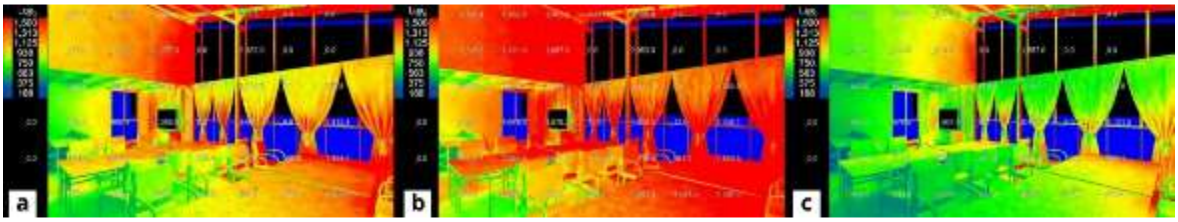

Figure 7: Illuminance Simulation at 09:00, 13:00, and 16:00 WIB in March
Source: Author, 2024

4.2. Simulation in December

a. Measurement of Luminance (cd/m2)

The results of the luminance simulation in December show that the differences in simulation are not as significant. At 09:00 WIB (Figure 7a), 13:00 WIB (Figure 7b), and 16:00 WIB (Figure 7c), the average values are similar to those observed in March. Based on the results of the December simulation, optimization steps are still needed for the window design to reduce the intensity of natural light reflection. This will help control the light distribution more effectively, ensuring that the work environment meets visual comfort standards optimally.

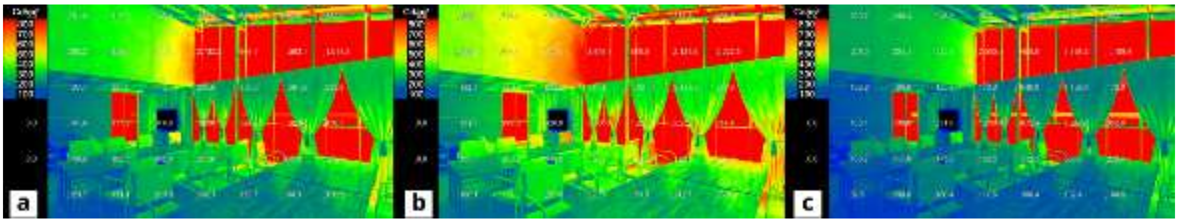

Figure 8: Luminance simulation at 09:00, 13:00, and 16:00 WIB in December
Source: Author, 2024

b. Measurement of Iluminance (Lux)

The illuminance simulation in December shows that the differences in the simulation are not very significant at three different times. At 09:00 WIB (Figure 8a), 13:00 WIB (Figure 8b), and 16:00 WIB (Figure 8c), the illuminance levels exceed the standard lighting requirements for office spaces, which are 350–1,000 lux (SNI 03-6572-2001). This indicates that optimization in the window areas is still necessary in December to create a work environment that supports visual comfort in accordance with the standards.

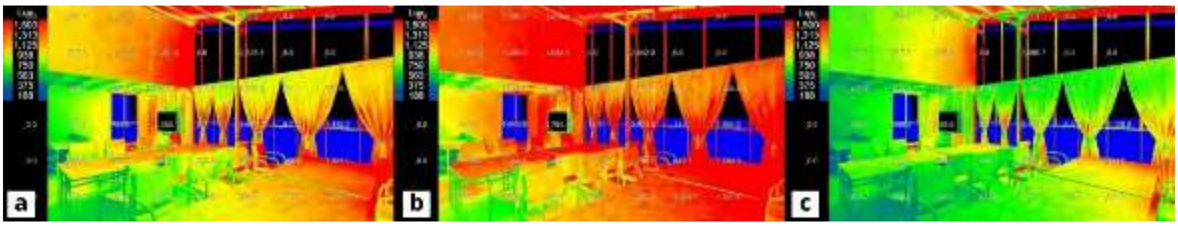

Figure 9: Illuminance Simulation at 09:00, 13:00, and 16:00 WIB in December
Source: Author, 2024

DESIGN RECOMMENDATIONS

In this study, the author provides design recommendations as shown in Figure 9. These recommendations include the addition of sunshading elements on the facade to reduce the intensity of direct sunlight entering the room, with the aim of achieving visual comfort for users. Additionally, it is suggested that part of the upper openings be closed using materials similar to those of the other sides, such as wood. This approach aims to create visual uniformity while also enhancing protection against weather conditions. These

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recommendations are designed to support energy efficiency without compromising the aesthetic value of the previously designed layout.

Figure 10: 3D model of the modified facade area of Hepta Design Office
Source: Author, 2024

4.3. Simulation of the Design Recommendations in March

a. Measurement of Daylight Factor (DF)

After modifications were made to the building's facade area, the Daylight Factor (DF) value in the workspace showed an average DF of 3.92%, as shown in Figure 10. This value meets the standards for office buildings, with the recommended average DF ranging from 2% to 4%. Therefore, the modifications made are in line with creating a workspace environment that meets visual comfort standards.

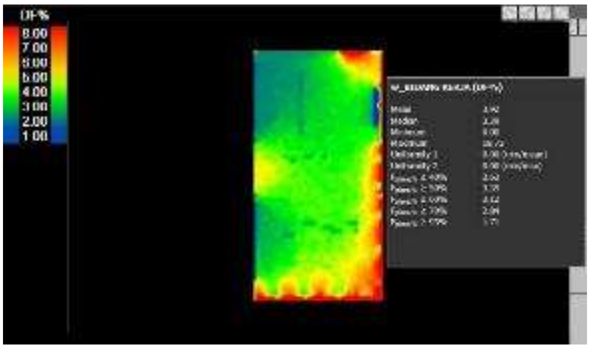

Figure 11: Daylight Factor design recommendation simulation
Source: Author, 2024

b. Measurement of Luminance (cd/m2)

The results of the modified luminance simulation in March show a uniform distribution of sunlight throughout the room, similar to the previous simulation results. Based on Figure 11, simulations were conducted at three different times, with the average luminance reaching 400 cd/m². This value complies with the SNI 03-6572-2001 standard, which recommends luminance for office buildings to be in the range of 300–500 cd/m². Therefore, the modifications applied have met visual comfort standards and successfully created an optimal workspace environment, supporting user productivity in the workspace.

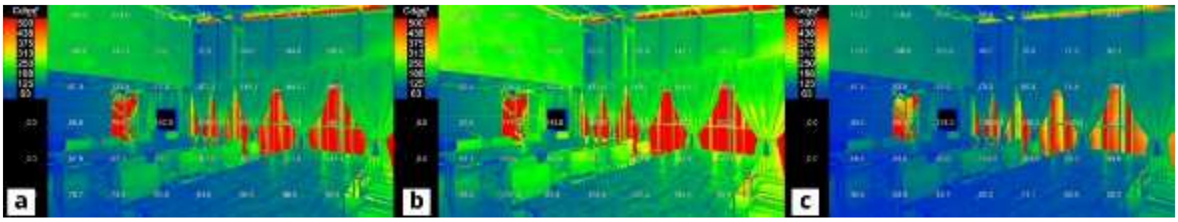

Figure 12: Luminance design recommendation simulation at 09.00, 13.00, 16.00 WIB in March
Source: Author, 2024

c. Measurement of Iluminance (Lux)

The results of the natural lighting simulation in March show a relatively high distribution of illuminance in the workspace at three different times. At 09:00 WIB, the illuminance level

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at the desk area ranges from 400 to 570 lux (Figure 12a). At 13:00 WIB, the illuminance increases to between 515 and 760 lux (Figure 12b). At 16:00 WIB, the illuminance decreases to a range of 320 to 400 lux (Figure 12c). Based on these results, the natural lighting in the workspace meets the lighting requirements for office spaces, which is between 350 and 1,000 lux. Therefore, the modifications made have successfully created a workspace environment that complies with visual comfort standards, improving the quality of natural lighting and supporting user productivity.

Figure 13: Iluminance design recommendation simulation at 09.00, 13.00, 16.00 WIB in March
Source: Author, 2024

4.4. Design Recommendation Simulation in December

a. Measurement of Luminance (cd/m2)

The results of the luminance simulation after modifications in December show similarities to the simulation results in March. The average luminance level achieved is 400 cd/m², which complies with the SNI 03-6572-2001 standard, recommending luminance levels for office buildings to fall within the range of 300–500 cd/m². Therefore, the modifications made in December have met the established visual comfort standards, demonstrating consistency in achieving optimal natural lighting quality

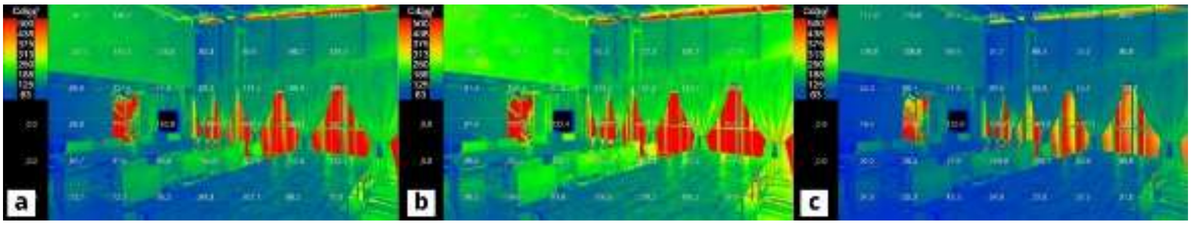

Figure 14: Luminance design recommendation simulation at 09.00, 13.00, 16.00 WIB in December
Source: Author, 2024

b. Measurement of Iluminance (Lux)

The results of the natural lighting simulation in December show no significant difference compared to the simulation in March at three different times, with lighting levels ranging from 400 to 700 lux. These lighting levels meet the lighting requirements for office workspaces, which are 350 to 1,000 lux, as recommended for creating a visually comfortable work environment. This indicates that natural lighting in the workspace in December remains consistent in supporting the required visual comfort standards.

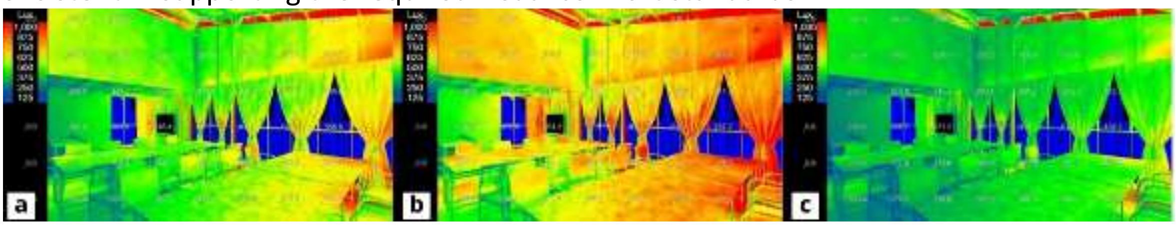

Figure 15: Iluminance design recommendation simulation at 09.00, 13.00, 16.00 WIB in December
Source: Author, 2024

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5. CONCLUSION

Based on the results of this study, it can be concluded that the simulation using Velux Daylight Visualizer revealed that the average Daylight Factor (DF) in the Hepta Desain office exceeds the recommended range for office buildings, indicating an excess of natural lighting. This requires design modifications to optimize the lighting levels. The simulation shows that luminance levels vary significantly throughout the day, with peak values exceeding the recommended standards. Similarly, illuminance levels consistently exceed acceptable ranges, requiring adjustments to prevent glare and ensure visual comfort. Based on the simulation results, this study proposes several design modifications, including the addition of sunshading elements and adjustments to window openings. These changes aim to control the intensity of incoming natural light and achieve a balanced distribution throughout the workspace. Post-modification simulations demonstrate that the adjusted design successfully meets the recommended standards for Daylight Factor, luminance, and illuminance, proving that the proposed solutions are effective in improving the quality of natural lighting in the office. The findings from this study not only benefit the Hepta Desain office but also serve as a reference for other work environments facing similar challenges in optimizing natural lighting. This research emphasizes the importance of thoughtful design in achieving energy efficiency and enhancing user comfort in office spaces.

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