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Natural Lighting Performance in the Service Room of a Three-Story Office Building in West Bandung Regency

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A B S T R A C T

Service rooms ini existing office buildings are often overlooked in natural lighting evaluations, even though these spaces are used regularly and contribute to user comfort and safety. This study aims to assess the effectiveness of natural lighting in the service areas of the PT. Sipatamoda office building in the industrial area of West Bandung Regency, focusing on toilets, janitor's rooms, wudhu rooms, and other service areas that do not have direct access to light. The approach in this study uses a quantitative descriptive method that focuses on natural lighting simulation with the help of DIALux evo 13.2 software. The simulation was conducted under clear skies at three different times, to illustrate the variation in the position of the sun. The evaluation parameter is lighting intensity (lux), which is then compared with the SNI 6197: 2020 standard. Research shows that all service areas have low natural light intensity and consistently fail to meet minimum lighting standards at every level and time of observation. The low performance of natural lighting is mainly influenced by the absence of direct openings to the outside, the position of service rooms in the interior zone of the building mass, and the dependence on indirect openings whose contribution is limited. This study concludes that service areas tend to be overlooked in the evaluation of natural lighting in existing office buildings, and emphasizes the need for a more realistic understanding of the limitations of natural lighting in existing buildings.

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1. INTRODUCTION

Natural lighting is one of the crucial aspects in evaluating a building's performance because it is directly related to energy efficiency, visual comfort, and indoor environmental quality (Sabtalistia, 2017). In office buildings, the role of natural lighting is becoming increasingly significant because work activities take place almost all day long (Siena Farizi & Aqli, 2021). Therefore, the quality of natural light entering a room must not only be carefully planned, but also quantitatively evaluated to ensure it meets applicable visual comfort standards (Altomonte, 2009). Studies of natural lighting in office buildings generally focus on main spaces, such as staff rooms, meeting rooms, managerial rooms, and internal public spaces (Nugraha Witama & Saliya, 2024). Evaluations of these spaces are often conducted through field measurements and simulations using software, such as DIALux evo, by comparing the resulting illumination levels with established lighting standards (Jannah, 2022; Thojib et al., 2013).

The dominance of studies on primary workspaces indicates that these spaces are considered a priority in natural lighting evaluations because they have long usage durations and high visual comfort requirements (Abidin et al., 2021). As a result, service areas such as toilets, janitor's rooms, and ablution rooms are often positioned as secondary spaces and receive less attention in natural lighting studies. In fact, these spaces are still used regularly by all occupants of the building and play a functional role that is inseparable from the overall office space system (Ragilyani & Dewi, 2021). Functionally, the service space is part of the building and contributes to the user's spatial experience (Santosa et al., 2022). Inadequate natural lighting conditions in service areas can potentially increase dependence on artificial lighting, even during daylight hours, and cause visual discomfort for users of the space. In the long term, this condition also affects energy efficiency and environmental quality in buildings (Purnama et al., 2022).

Natural lighting issues in service areas tend to be more prominent in office buildings, especially those located in industrial areas. These buildings are generally designed with limited space and close proximity between buildings. This condition makes the opportunity to provide natural openings directly to the service area very limited (Oguntosin et al., 2019). This condition is reflected in the case study of the PT. Sipatamoda office in West Bandung Regency. The results of natural lighting simulations using DIALux evo software show that several service rooms, such as toilets, janitor rooms, and wudhu rooms, have illumination levels that are far below the minimum standard. In fact, in some rooms, illumination values were recorded at 0 lux at various observation times.

The low level of natural lighting in the service area did not only occur at certain times, but appeared consistently throughout the entire floor and throughout the simulation, namely at 9:00 a.m., 12:00 p.m., and 4:00 p.m. (Matalata et al., 2024). These results indicate that the problem is not only caused by low sunlight levels, but is more related to the design of the service area in the PT. Sipatamoda office building, which has no direct openings to the outside and relies solely on indirect lighting elements, such as bovenlicht. Based on previous literature reviews, research on natural lighting using DIALux evo simulation has been conducted extensively on various building functions and room types (Rohman & Kusumawati, 2025). However, studies that specifically focus on the performance of natural lighting in office building service spaces, especially in the context of tropical industrial areas, are still relatively limited. This indicates a research gap that needs to be further explored (Khoirunnisa et al., 2023; Rahmayanti et al., 2024). Thus, this study is relevant because it places service spaces as an important part of evaluating the natural lighting performance of office buildings.

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The issue raised in this study is how natural lighting performs in service areas of existing office buildings, based on simulations conducted using DIALux evo software, and what design factors cause service areas to fail to meet natural lighting standards even though the buildings are already functioning as offices and exhibition spaces. This study aims to evaluate how well natural light enters service areas, including toilets, janitor rooms, and ablution rooms, in the PT. Sipatamoda office building using DIALux evo version 13.2 simulation. In addition, this study also aims to identify problems in the design of service spaces that impact the fulfillment of natural lighting standards in PT. Sipatamoda office buildings. It is hoped that this study can provide empirical insights into the efficiency of natural lighting in service areas, which has received little attention in architectural studies, especially in office buildings (Khoirunnisa et al., 2023).

2. RESEARCH METHOD

2.1 Research Approach

This study applies a quantitative descriptive approach using simulation methods to analyze natural lighting as the primary tool (Matalata et al., 2024; Rahmayanti et al., 2024). A quantitative approach was chosen because the performance of natural lighting in buildings can be assessed objectively through light intensity (lux), which is then compared with applicable lighting standards (BSN, 2020). In this way, the lighting conditions of a room are not only described qualitatively, but can also be measured and evaluated quantitatively (Altomonte, 2009). The use of simulation methods in this study is based on the fact that the building under review is an existing office building that has been in operation since 2015. Simulation allows researchers to assess the performance of natural lighting without having to make physical changes to the building. This approach has been widely used in natural lighting research, especially when direct measurements face limitations in terms of time, space access, or building operational conditions that do not allow for intensive field testing (Jannah, 2022; Thojib et al., 2013).

2.2 Research Location and Object

This research was conducted on an existing office building in the industrial area of PT. Sipatamoda Indonesia with an area of 18,966.6 m2, located on Jl. Raya Batujajar No. 3 Km 2, RW. 2, Giriasih Village, Batujajar District, West Bandung Regency, West Java. The building is located in an industrial area with relatively high building density and limited open space. This condition has the potential to affect the distribution of natural light, especially in rooms located inside the building (Oguntosin et al., 2019). The building is located at coordinates 6°53'42.0"S 107°30'08.9"E. The existing building was constructed in 2015 on land that was formerly used as a fabric warehouse. Based on West Bandung Regency Regulation No. 2 of 2024, industrial activities are located in industrial areas with a maximum KDB of 60% = 11,379.96 m², a minimum KDH of 10% = 1,896.66 m², and a maximum KLB of 1.2 = 13,656 m² (Bandung Barat, 2024).

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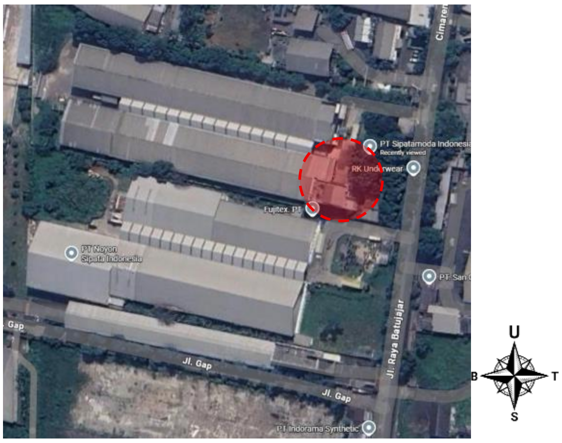
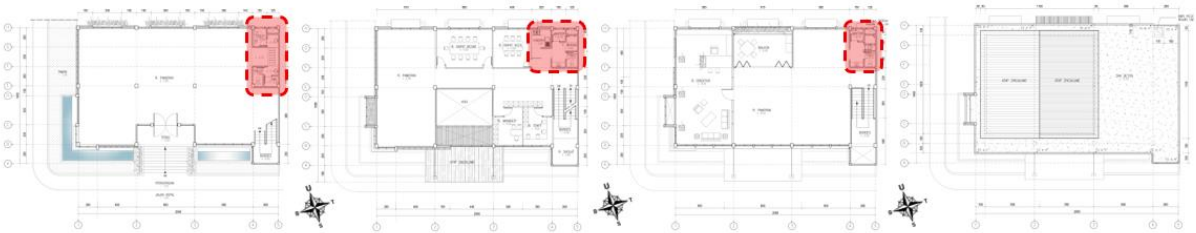


Figure 1. Location of Research Object
(Source: https://www.google.com/maps/place/PT+Sipatamoda+Indonesia/, 2026)

The object of the study was an office building with a height of 3.5 floors and a total floor area of 1,024.4 m². This building serves as an operational office and a fabric product exhibition hall. The first floor, covering an area of 288.5 m², is used as an exhibition hall, lobby, entrance area, and supporting facilities such as toilets and janitor's room. The second floor, with an area of 286.4 m², accommodates additional exhibition space, large and small meeting rooms, manager's office, staff room, prayer room, pantry, and service room. The third floor, covering an area of 279.2 m², is used as the director's office, exhibition hall, balcony area, and service facilities, while the roof floor, covering an area of 170.3 m², is used as a utility room and roof area of the building.



First Floor Second Floor Third Floor Roof Floor

Figure 2. Research Object Layout
(Source: Author's Illustration, 2026)

Figure 3. Exterior Perspective of the Research Object
(Source: Author's Illustration, 2026)

The study focuses specifically on service areas, including toilets, janitor's rooms, ablution rooms, and other service areas that do not have direct access to the outside. The selection of service rooms as the object of analysis was based on preliminary findings indicating that these rooms tend to have lower levels of natural lighting compared to main rooms. In addition, service spaces are relatively rarely the main focus of research on natural lighting in office buildings, even though their existence is inseparable from the overall building space system (Ragilyani & Dewi, 2021).

Figure 4. Photo of Research Object
(Source: https://www.google.com/maps/place/PT+Sipatamoda+Indonesia/, 2026)

2.3 Software and Simulation Parameters

Natural light simulation in this study was conducted using DIALux evo version 13.2 software. This software was chosen because it is capable of modeling buildings in three dimensions and calculating natural light distribution based on geographical location, building orientation, and specific observation times. DIALux evo has also been widely used in research on natural lighting and artificial lighting in buildings (Pratiwi & Djafar, 2021). The type of lighting analyzed focuses on natural lighting (daylight) with the assumption of clear sky conditions. The time zone used is (UTC+07.00) Bangkok, Hanoi, Jakarta. The simulation was conducted on January 6, 2026, with three observation points, namely at 09:00, 12:00, and 16:00 WIB, to show the change in the position of the sun in the morning, afternoon, and evening. This timing was chosen to observe the performance trends of natural lighting in the service area throughout the building's operating hours, while also identifying any consistency or variation in lighting that occurred.

As a benchmark for assessment, the simulation results were compared with SNI 6197:2020 regarding minimum lighting levels for various room functions. The lighting intensity (lux) values obtained from the simulation were used to determine whether the service rooms met or did not meet the required natural lighting standards (BSN, 2020).

2.4 Research Stages

The research stages are arranged sequentially and limited to evaluating existing conditions, without covering the optimization or redesign stages of the building. The research began with modeling existing buildings based on floor plan data from working drawings. This stage is carried out to ensure that the simulation model accurately represents the condition of the building. After modeling was completed, service areas were determined as the focus of analysis, including toilets, janitor's rooms, ablution rooms, and other service areas. The designation of these spaces is based on the characteristics of the space's function and preliminary findings regarding the low performance of natural lighting in these spaces (Ragilyani & Dewi, 2021).

The next step is to simulate natural lighting using DIALux evo 13.2 on January 6, 2026, at three observed times, namely 9:00 a.m., 12:00 p.m., and 4:00 p.m. Western Indonesian Time (WIB), under clear sky conditions. From the simulation results, lighting intensity (lux) data was

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collected in each service room as the main quantitative data for the study (Hangga et al., 2022; Pratiwi & Djafar, 2021). The final stage of the research is to compare the simulation results with the SNI 6197:2020 standard to assess the level of conformity of natural lighting performance in service rooms in existing office buildings. All of these stages are designed to provide a clear and measurable picture of the natural lighting conditions in the service area, while keeping the scope of the study focused and preventing it from shifting to aspects of redesign or design intervention (BSN, 2020).

3. RESULTS AND DISCUSSION

3.1 Natural Lighting Simulation Results for Service Rooms

The results of natural lighting modeling conducted with the help of DIALux evo 13.2 software show a fairly clear trend. Almost all service areas in the PT. Sipatamoda office building have low levels of natural lighting intensity. This condition did not only occur on one floor or at a specific time, but repeatedly occurred on all floors and at all observation times, namely at 9:00 a.m., 12:00 p.m., and 4:00 p.m. WIB.

On the first floor, service areas such as restrooms and janitor's rooms have the most limited lighting conditions. The simulation results show that most of the measurement points in the service area are dark in color. Even during the daytime, when the sun is at its strongest, the amount of natural light entering this room is still very limited. This finding indicates that the service area on the first floor receives almost no direct natural lighting through exterior openings. The color bar diagram below shows color indicators. The further to the right, the greater the lux value; conversely, the further to the left, the smaller the lux value (Yusvita, 2021).

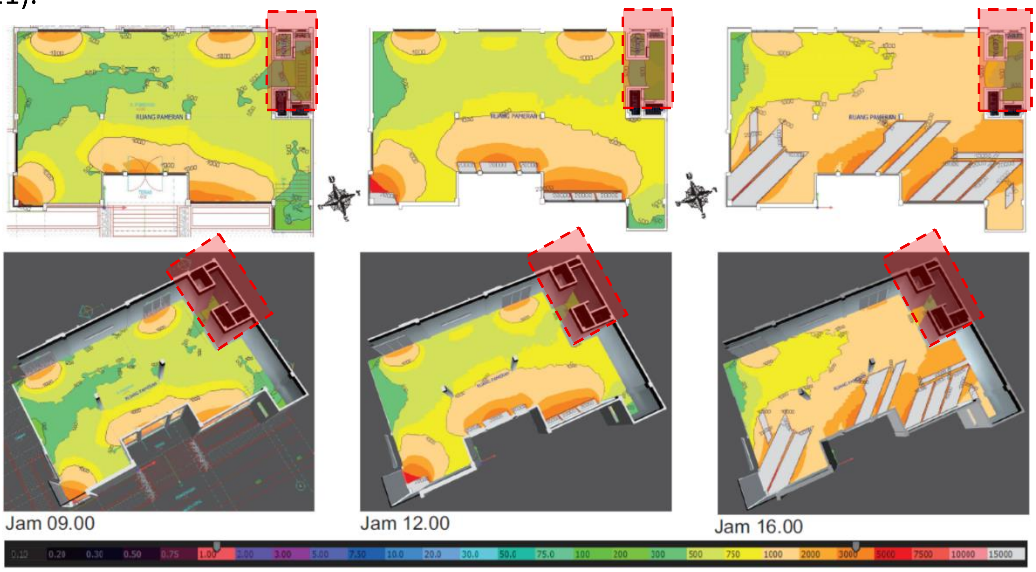

Figure 5. Simulation Results of Natural Lighting Intensity on the 1st Floor
(Source: DIALux evo Simulation, 2026)

Similar conditions were found on the second floor. The ablution room and toilet showed insignificant lighting intensity, with the toilet receiving no natural lighting at all during the entire observation period. Although this floor is at a higher elevation than the first floor, the difference in height does not have a significant impact on increasing the natural lighting in the service area. This is because these rooms still do not have direct access to the outside of the building (Jannah, 2022).

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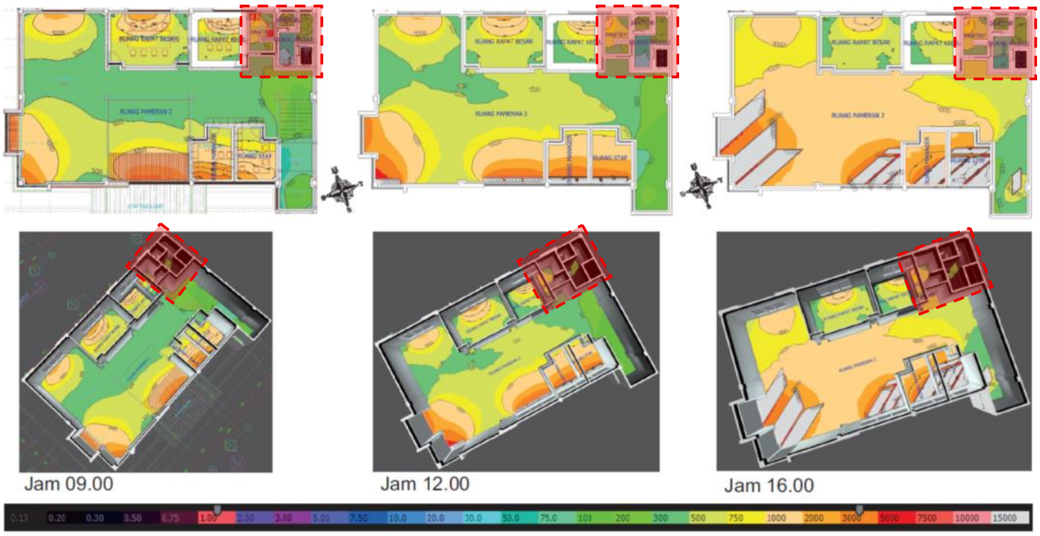

Figure 6. Simulation Results of Natural Lighting Intensity on the 2nd Floor
(Source: DIALux evo Simulation, 2026)

On the third floor, the simulation results show that the natural lighting conditions in the service room are still in the low category. The toilet did not receive any natural lighting during the entire observation period, and other service areas such as the powder room and shower room received only a small amount of natural lighting. These findings show that natural lighting problems in service areas are not only concentrated on the lower floors, but occur evenly throughout all floors of the building (Khoirunnisa et al., 2023).

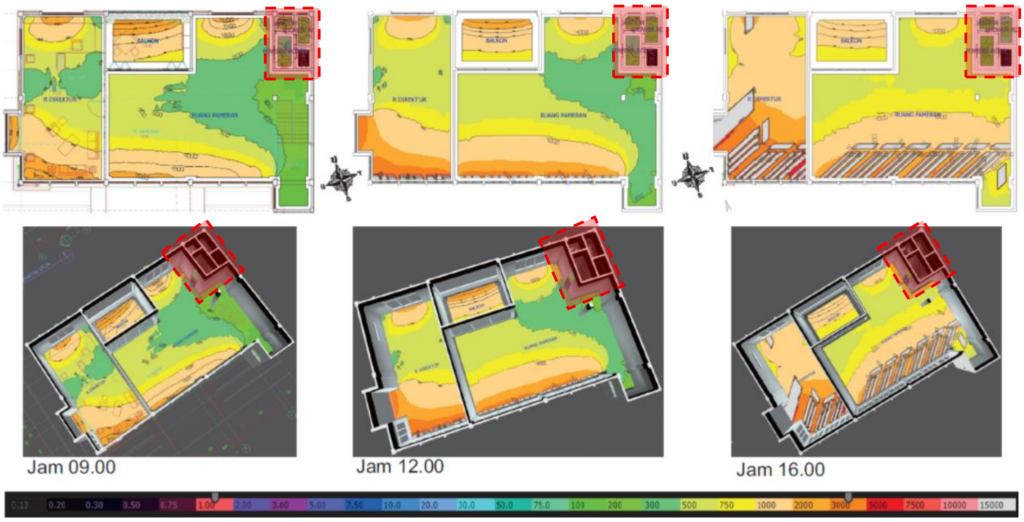

Figure 7. Simulation Results of Natural Lighting Intensity on the 3rd Floor
(Source: DIALux evo Simulation, 2026)

Overall, the simulation results show that service rooms are the group of rooms with the lowest natural lighting performance compared to other rooms in the building. This condition is mainly influenced by the absence of direct openings to the outside and the dependence of the service space on indirect lighting elements, such as shafts or skylights, whose contribution to natural lighting is relatively limited (Kartika Pratiwi et al., 2021).

3.2 Comparison with SNI 6197: 2020

The simulation results were then compared with SNI 6197: 2020 regarding minimum lighting levels. In this standard, service areas such as toilets and ablution rooms still have minimum lighting requirements that must be met to ensure visual comfort and user safety (Vidiyanti et al., 2020).

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Table 1. Lighting Levels and Color Rendering

Room Function	Minimum Average Lighting Level (lux)	Minimum Color Rendering
Exhibition/ sales room	300	80
Toilet	200	80
Janitor	100	80
Meeting room	300	80
Manager's room	350	80
Staff room	350	80
Director's room	350	80
Pantry	250	90
Wudhu room	200	80
Balcony	40	80
Laundry room	200	80
Bathroom	200	80
Shaft	40	80

(Source: SNI 6197: 2020, 2026)

The comparison results show that most service rooms do not meet minimum lighting standards. Rooms with illumination values well below the threshold, even reaching 0 lux, are categorized as rooms that are completely dependent on artificial lighting, even during daytime working hours. Only a small number of service rooms come close to the standard value, and even then, they are at the minimum limit and do not show consistency throughout the observation period.

Table 2. Compliance of Natural Lighting Performance on the 1st Floor with SNI 6197: 2020

Room Name (1st floor)	SNI 6197: 2020 (lux)	Calculation Results at 09.00 a.m. (lux)	Calculation Results at 12.00 p.m. (lux)	Calculation Results at 04.00 p.m. (lux)	Description
Janitor	100	0	0	0	Does not meet standards
Exhibition room	300	832	1020	5222	Meets standards
Shaft	40	505	631	319	Meets standards
Toilet 1	200	384	461	251	Meets standards
Toilet 2	200	0	0	0	Does not meet standards

(Source: Author's Analysis, 2026)

The results of the analysis and modeling of the first floor at three different times: 9:00 a.m., 12:00 p.m. and 4:00 p.m. following the parameters of SNI 6197: 2020 regarding minimum average lighting levels, there are still two rooms on the first floor in the service area that do not meet SNI 6197: 2020, namely the janitor's room and the toilet, each with 0 lux.

Table 3. Compliance of Natural Lighting Performance on the 2nd Floor with SNI 6197: 2020

Room Name (2nd floor)	SNI 6197: 2020 (lux)	Calculation Results at 09.00 a.m. (lux)	Calculation Results at 12.00 p.m. (lux)	Calculation Results at 04.00 p.m. (lux)	Description
Janitor	100	258	236	171	Meets standards
Pantry	250	569	628	635	Meets standards

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Room Name (2nd floor)	**SNI 6197: 2020 (lux)**	**Calculation Results at 09.00 a.m. (lux)**	**Calculation Results at 12.00 p.m. (lux)**	**Calculation Results at 04.00 p.m. (lux)**	**Description**
Manager's room	350	1797	6937	7422	Meets standards
Exhibition room 2	300	672	1463	4148	Meets standards
Large meeting room	300	892	790	665	Meets standards
Small meeting room	300	874	732	681	Meets standards
Staff room	350	1253	6417	17805	Meets standards
Wudhu room	200	93.6	90.8	95.7	Does not meet standards
toilet	200	0	0	0	Does not meet standards

(Source: Author's Analysis, 2026)

The results of the analysis and modeling of the second floor at three different times (9:00 a.m., 12:00 p.m., and 4:00 p.m.) in accordance with the parameters of SNI 6197: 2020 regarding minimum standards for average lighting, there are still two rooms on the second floor of the service area that do not meet SNI 6197: 2020, namely the wudhu room with a lux value of 93.6, 90.8, and 95.7 lux, which should meet the minimum standard of 200 lux, and the toilet with a lux value of 0, which should meet the minimum standard of 200 lux.

Table 4. Compliance of Natural Lighting Performance on the 3rd Floor with SNI 6197: 2020

Room Name (3rd floor)	**SNI 6197: 2020 (lux)**	**Calculation Results at 09.00 a.m. (lux)**	**Calculation Results at 12.00 p.m. (lux)**	**Calculation Results at 04.00 p.m. (lux)**	**Description**
Balcony	40	1674	1471	1227	Meets standards
Janitor	100	258	231	169	Meets standards
Laundry room	200	103	113	155	Does not meet standards
Director's office	350	1050	2373	6684	Meets standards
Exhibition room 3	300	651	1440	3522	Meets standards
Bathroom	200	133	127	98	Does not meet standards
Toilet	200	0	0	0	Does not meet standards

(Source: Author's Analysis, 2026)

The results of the analysis and modeling of the third floor at three different times (9:00 a.m., 12:00 p.m., and 4:00 p.m.) in accordance with the parameters of SNI 6197: 2020 regarding the minimum average lighting limit show that there are still three rooms on the third floor of the service area that do not meet SNI 6197: 2020, namely the powder room with lux values of 103, 113, and 155, which should follow the minimum standard of 200 lux; the shower room with lux values of 133, 127, and 98, which should follow the minimum standard of 200 lux; and the toilet with a lux value of 0, which should follow the minimum standard of

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200 lux. These results are consistent with previous studies which state that service rooms are often given the lowest lighting priority in office building design. This condition is even more pronounced in existing buildings that were not originally designed with a comprehensive natural lighting approach (Rahadian et al., 2021).

3.3 Lighting Performance Patterns in Service Rooms

Further analysis of the simulation results shows consistently low natural lighting performance in service areas. These results are based on floor differences and variations in observation times. No significant increase in lighting was observed during the three simulation observation times. This confirms that the issue of natural lighting in service rooms is not solely influenced by time, but is closely related to the configuration of the room and the design of the building itself (Sokhibi & Ajeng, 2020). When compared in general with main spaces, such as workspaces or exhibition spaces, the difference in natural lighting performance is quite striking. Main spaces still receive natural light through facade openings, while service spaces are located in interior areas of the building that do not receive direct sunlight. This comparison is not analyzed in depth in this study, but is presented as context to clarify the position of service spaces within the office building space system (Hasanuddin et al., 2024; Purnama et al., 2023).

Overall, the results of this study indicate that the failure of natural lighting in service spaces is systemic, not incidental. The design patterns of service spaces in existing office buildings in industrial areas tend to neglect access to natural light, resulting in consistently low and repetitive lighting conditions throughout the building.

3.4 Analysis of Natural Lighting Performance in Service Rooms

The results of natural lighting simulations in the service rooms of the PT. Sipatamoda office building show that these rooms fail to meet minimum lighting standards. This failure does not occur at specific times, but rather repeatedly throughout the entire floor and during the entire observation period. This fact points to the issue that natural lighting in service spaces is not related to changes in solar intensity, but rather to the way these spaces are designed and positioned within the building (Ahmad Rifai, 2021).

The absence of direct openings to the outside of the building is the most decisive factor. Service spaces such as toilets, janitor's rooms, and ablution rooms in this building are generally located in the center of the building mass. In such conditions, sunlight has no clear path to enter. Even during the day, when natural light potential should be at its highest, the service area remains poorly lit. This situation highlights how crucial direct openings are in supporting natural lighting performance (Al’Fiqri et al., 2024).

The location of the service rooms in the interior zone of the building further reinforces this condition. These rooms are surrounded by other rooms and do not directly face the facade. This type of configuration is quite common in existing office buildings, especially in industrial areas. In this context, spatial efficiency and utility placement are often prioritized over the quality of natural lighting in service areas (Susanto & Shadiqa, 2021).

3.5 Service Rooms as Blind Spots in Natural Lighting Design

In design practice and academic studies, attention to natural lighting generally focuses on main spaces, such as workspaces, meeting rooms, or exhibition halls (Abdi Hasanuddin et al., 2024). These spaces are considered to have higher visual demands and deserve design priority. In contrast, service spaces are often positioned as supporting spaces that are assumed to be adequately served by artificial lighting (Umar, 2023). In the case of the PT. Sipatamoda office building, this condition is even more apparent. Limited land area, high

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density of buildings, and the demand for space efficiency have led to the placement of service spaces in interior areas far from the facade. In situations like this, natural lighting in service areas is no longer part of the design strategy (Pahlevi & Muliadi, 2022). The simulation results at the PT. Sipatamoda office show that this condition is not an isolated case. Low natural lighting intensity throughout the service area occurs consistently and repeatedly. This indicates a tendency in existing office building design, where service spaces are not positioned as an important part of the building's natural lighting plan from the outset.

4. CONCLUSION

Based on analysis and discussion, this study concludes that the service area in the PT. Sipatamoda office building has consistently low natural lighting performance and does not meet the minimum standards of SNI 6197: 2020. Low natural lighting performance is an inherent characteristic of the service space system in the case study building. This is not an incidental condition, but rather the result of a space configuration that has been established from the outset, limiting the achievement of natural lighting standards in this existing building.

All service areas (toilets, janitor's rooms, ablution rooms) on all floors failed to meet the minimum lighting intensity (lux) standards at all observation times (9:00 a.m., 12:00 p.m., and 4:00 p.m.). Some rooms even recorded a value of 0 lux, indicating absolute dependence on artificial lighting during the day. The root of the problem lies in the limitations of the space configuration design, including the absence of direct openings, where the service space is located inside the building mass without direct access to the exterior facade, and the ineffectiveness of indirect openings, where reliance on indirect openings (such as bovenlicht) has proven unable to provide adequate natural illumination. This case study reflects a common trend in office building design in industrial areas, where service spaces are often overlooked in the evaluation of natural lighting performance. Design and research tend to focus on main spaces, while service spaces are considered to be fully replaceable with artificial lighting.

Based on these findings, this study recommends two strategic paths for further study and intervention. First, Recommendations for Existing Buildings: For buildings with similar configurations, a realistic approach is to optimize artificial lighting systems that are efficient and contextual. This includes the selection of luminaires, placement, and control systems (such as sensors) that can ensure visual comfort and energy efficiency, given the limited opportunities for natural light acquisition. Second, Recommendations for Future Design: there is a need for early integration of service spaces into natural lighting design strategies, especially on limited sites. Exploring designs that can provide access to natural light, even if limited (e.g., through light shelves, light tubes, or more strategic indirect openings), should be considered from the conceptual phase to avoid lighting “blind spots”.

Overall, this study emphasizes the importance of inclusive evaluation of all types of spaces, including service areas, in assessing the environmental performance of buildings. These findings provide a conceptual and empirical basis for the development of more comprehensive design guidelines and further studies on strategies to improve the quality of lighting in office building service areas, both in existing and new contexts.

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