Optimization of Fin Shading Design on the Regional Secretariat Building of the Central Java DPRD in terms of Visual Comfort Aspect

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Abstract

This study aims to evaluate the effectiveness of fin-type shading devices in improving visual comfort in tropical office buildings and to determine the optimal shading dimensions based on daylight illuminance and glare control. The analysis was conducted through a quantitative evaluative approach using field measurements and daylight simulations in DIALux Evo. Three typical room sizes from the Setwilda DPRD Jawa Tengah office building were simulated under different shading configurations, referencing the SNI standard (300–3000 lux) for daylight and using a contrast ratio method and Daylight Glare Probability simplified (DGPs) approach for glare assessment. Results showed that medium-length shading (around 1.68 m) offered the best balance for small rooms, while moderate combinations with ceiling modifications (1.42 m) were most effective in medium rooms. In contrast, large rooms benefited most from no shading at all due to their greater daylight needs, as long as glare remained within tolerable limits. The study concludes that shading design should consider room size and orientation, with excessive shading reducing daylight quality. The findings provide practical guidance for future designs, particularly in adapting similar shading strategies in nearby buildings such as the BPKAD office.

INTRODUCTION

According to (BMKG, 2020), Indonesia is located on the equator and dominated by warm waters covering approximately 81% of its territory. This results in relatively stable average temperatures year-round, ranging from 28°C in lowlands to 23°C in highlands, without extreme seasonal temperature differences. Furthermore, Indonesia's climate is determined by three main rainfall patterns: monsoon, equatorial, and local, which influence weather variations and humidity across regions. Climate, comprising elements such as sunlight, rainfall, wind direction, and air temperature, significantly influences the form and style of architecture in a region. Lippsmeier (1994), as cited in Alghifary & Indraswara (2019) and quoted in (Bambang & Sari, 2021), states that tropical regions present several challenges for architectural design. A primary challenge is high air temperature, which creates unpleasant heat sensations for building occupants. Therefore, implementing design strategies like tropical architecture is necessary. Tropical architecture is a design approach that adapts buildings to the climatic and weather conditions of the site. Its design aims to respond to and overcome various problems caused by the tropical climate, such as high temperatures and humidity levels affecting user comfort (Bambang & Sari, 2021).

Based on (Bambang & Sari, 2021), sun shading, as one tropical architectural strategy, functions to reduce direct light, minimize glare, and enhance visual comfort. Additionally, this element also helps maintain comfortable room temperatures and saves energy, with potential savings of up to 20–30% in tropical office buildings. Adequate lighting creates visual comfort, whereas insufficient or excessive light causes visual discomfort and disrupts activities within a room. Each activity requires different lighting levels, influenced by the number, size, and location of openings or windows (Widiyantoro et al., 2017).

Visual comfort is crucial for creating a healthy and productive environment inside buildings. According to (SNI, 2001), natural lighting should be evenly distributed within a room, not just near windows, and there should be no excessive contrast in light levels to avoid visual disturbance. Furthermore, according to (Kapoor et al., 2021), visual comfort is influenced by natural lighting, appropriate illuminance levels, uniform light distribution, and light color, where inadequacy in any of these can cause glare, harsh shadows, and visual discomfort for room users. Meanwhile, based on (Fakhari et al., 2021), visual comfort is influenced by eight main factors: actual illuminance levels and users' perception of lighting, outside views, light distribution, the presence of windows, glare levels,

thermal satisfaction, and temperature perception. Therefore, comprehensive visual evaluation must combine technical data with occupant perception to enhance productivity and energy efficiency. Whereas according to (Zomorodian et al., 2015), visual comfort is influenced by the quality of natural lighting, assessed using static metrics like daylight factor, illuminance, and lighting uniformity representing instantaneous conditions, as well as dynamic metrics like daylight autonomy and annual sunlight exposure, which account for daily and seasonal lighting variations. However, this study only used static metrics for visual evaluation.

The Central Java BPKAD DPRD Building is situated within the same complex as the historic Setwilda Building, designed by Soejoedi Wirjoatmodjo with tropical architectural principles and sun-shading features to mitigate solar heat. The fin-type sun shading of the BPKAD Building was designed with reference to the Setwilda Building but scaled down due to budget constraints and Building Setback Line (GSB) regulations. Architectural surveys indicate that the Setwilda Building's interiors are dim and require artificial lighting throughout the day, necessitating a reevaluation of the fin shading's effectiveness through visual simulations. This ensures that design decisions for the BPKAD Building are grounded in accurate data.

Previous research primarily focused on solar radiation ingress in the Setwilda Building, revealing persistently dark interiors and heavy reliance on artificial lighting—highlighting the need for further investigation (Patiunus, 1997). The building's facade combines dark glass, ceramic-clad reinforced concrete, and ceramic-coated concrete shading. Consequently, this study centers on evaluating the effectiveness of the fin-shading design at the Setwilda Building as the primary case study. The findings aim to provide optimal fin-shading design recommendations applicable to the BPKAD Building while prioritizing visual comfort.

Based on the background outlined, this research addresses key questions: how consultants' claims and prior studies regarding visual comfort compliance can be verified through analysis and simulation; how fin-shading dimensions affect visual comfort relative to established standards; and what minimum fin-shading size or ratio achieves optimal visual comfort in the Central Java DPRD Setwilda Building. The objectives include analyzing visual comfort claims using technical data and prevailing standards, examining the impact of fin-shading dimensions on visual comfort, and determining optimal minimum fin-shading specifications for the building.

According to Giarma et al. (2017), several standardized parameters measure visual comfort performance, with four predominant frameworks: BREEAM, LEED, SBTool, and CASBEE. These standards are analyzed specifically for tertiary-sector buildings (particularly offices), as their design, construction, and operational characteristics exhibit global consistency. Unlike residential structures—which are influenced by regional conditions, traditions, and local customs—using office buildings as a baseline ensures more consistent and reliable analysis. In Indonesia, natural lighting design in buildings follows the Indonesian National Standard (SNI), specifically SNI 03-2396-2001 concerning Design Procedures for Natural Lighting Systems in Buildings. This standard guides architects and designers in fulfilling visual needs, energy efficiency, and occupant health by stipulating minimum daylight factor (DF) values, opening orientations, and glare control. Collectively, both national (SNI) and international standards (BREEAM, LEED, CASBEE, SBTool) employ core parameters—daylight factor, minimum illuminance, uniform light distribution, glare control, and opening orientation/size—to ensure optimal natural lighting and visual comfort. These metrics simultaneously support energy efficiency and spatial quality, enhancing occupant health and productivity.

Table 1. Visual Comfort Standards

BREEAM	LEED	CASBEE	SBTool	SNI 03-2396-2001
Glare Control	Interior lighting	Cahaya Alami yang masuk	Cahaya Alami	Daylight Factor
Cahaya Alami yang masuk	Cahaya Alami yang masuk	Anti-glare	Glare	Silau
View Ke luar	Kualitas pandangan ke luar	Level iluminasi	Tingkat pencahayaan	Iluminasi Cahaya Alami
Intensitas cahaya dalam dan luar ruang,	-	Pengendalian cahaya	Kemampuan pengendalian cahaya	-
-	-	Ruang untuk melihat ke luar	View Ke luar	-

Source: Giarma et al., 2017

Although the previously outlined standards include many components affecting visual comfort, Saraswati & Mandala (2017) state that illuminance level and glare are key indicators of visual performance – the eye's ability to identify tasks. Glare is an occasional problem in lighting installations, representing a light effect that causes discomfort or impaired vision. Meanwhile, Giarma et al. (2017) note that within international rating systems, daylighting and glare are the primary focus in visual comfort aspects. Furthermore, Stranks (2006) as cited in Andarini & Listiani (2017) emphasizes lighting as a crucial element in creating optimal work environments. In designing lighting systems, two main components require attention: light intensity levels (measured in lux) needed to support specific visual activities, and lighting quality aspects including light distribution and glare control.

According to LEED (2019), natural lighting (illuminance) calculations can be performed through computer simulations to prove that illumination levels fall within the 300–3,000 lux range at 9:00 AM and 3:00 PM under clear sky conditions on equinox days. Simulations cover regularly occupied areas, with points awarded if 75% or 90% of these areas meet the requirement. Calculations are performed on March 21st and September 21st. Movable blinds or shades are excluded, but permanent obstructions must be included. For projects with unfinished interiors, standard reflectance values are applied: 80% for ceilings, 20% for floors, and 50% for walls.

Additionally, based on Chaloeytoy et al. (2020), glare potential from extensive natural light sources like glass facades is assessed using glare indices such as Daylight Glare Index (DGI) and Daylight Glare Probability (DGP). However, DGP is considered superior to DGI, especially under bright sunlight conditions. Research by Wymelenberg shows DGP has a stronger correlation with subjective glare perception than DGI. Furthermore, studies by Jakubiec indicate DGP provides the most realistic results compared to other visual comfort indices. Consequently, Wienold proposed the simplified daylight glare probability (DGPs) concept – a streamlined version of the DGP metric that only considers vertical illuminance in its calculation. This approach is based on findings that vertical illuminance strongly correlates with subjective glare perception. It should be noted that this DGPs model delivers accurate results only when no direct sunlight enters the field of view. The DGPs formula was subsequently developed as a simplification of the full DGP calculation. This formula is used in spaces with fixed shading devices, while for spaces without shading, visual comfort can alternatively be assessed using the 3:1 lighting contrast ratio between task areas and their immediate surroundings – an approach for evaluating glare potential outlined in EN 12464 (2002).

$$DGPs = 6.22 \times 10^{-5}Ev + 0.184$$

Figure 1. Simplified DGPs formula
Source: Chaloeytoy et al., 2020

To analyze the potential for glare based on visual contrast, simulations were performed by comparing the illuminance in the task area with the immediate surroundings as stipulated in the EN 12464-1:2002 standard. This approach is based on the principle that extreme differences in illuminance between the center of visual activity and the immediate surroundings can cause visual discomfort or glare.

RESEARCH METHODOLOGY

This study employs a quantitative evaluative approach utilizing field measurement data, visual observation, and natural lighting simulations in DiaLUX software to assess the effectiveness of fin shading on visual comfort according to applicable standards. The research subjects comprise two Central Java provincial government office buildings: the Setwilda Building and the Central Java BPKAD DPRD Building. Both implement fin shading systems with distinct designs and orientations, enabling direct comparative analysis of effectiveness. Data collection involved field surveys measuring illuminance distribution (lux) and natural light intensity using a lux meter positioned at 75 cm height facing incoming sunlight direction. Based on IES (1947) as cited by Kristanto (2004), measurement points were determined using the *Determination of Average Illuminance on a Horizontal Plane from General Lighting Only* method, employing a grid with a maximum 1-meter spacing consistent with DiaLUX simulation standards. For data validation, the *Regular Area With Symmetrically Spaced Luminaires in Two or More Rows* method was applied. This approach, suitable for spaces with symmetrically arranged luminaires, involved representative point measurements across work zones corresponding to each facade orientation to capture peak natural lighting conditions at specific solar positions (IES, 1947 in Kristanto, 2004).

Beyond light intensity measurements, existing building conditions were verified by comparing potential material alterations, spatial layouts, and opening elements against initial Detailed Engineering Design (DED) documents. This ensured simulation models accurately reflected on-site conditions. Glare potential was analyzed through illuminance contrast ratios between the brightest and darkest points in each room. Secondary data from DED documents informed the creation of natural lighting simulation models mirroring actual building conditions. Data analysis compared measurement and simulation results to evaluate compliance with visual comfort standards, identify glare-prone areas, and calculate effective fin-shading-to-glass-opening dimension ratios for each facade orientation.

Simulation timing and natural lighting surveys were scheduled based on solar position data (azimuth and altitude) for May, calculated using the Curic Sun tool in SketchUp for all orientations of both buildings. This timeframe represents periods of maximum direct sunlight exposure, allowing optimal evaluation of shading performance under conditions.

RESULTS AND DISCUSSION
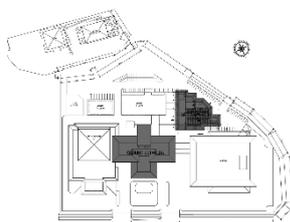
Figure 2. Situation of the Central Java DPRD Area
Source: PT Pola Dwipa, 2025

The Setwilda Building and BPKAD Building form part of the Central Java DPRD office complex, situated within a strategically positioned and integrated precinct. According to the site plan, the Setwilda Building occupies a central position in the southern sector, directly adjacent to the main southern access point. Its north-facing orientation and symmetrical massing establish it as the primary orientation landmark within the complex. Meanwhile, the BPKAD Building (Regional Financial and Asset

Management Agency) is located in the northeastern sector, featuring a diagonally aligned orientation that follows the site contours and surrounding road boundaries. This positioning makes the BPKAD Building more exposed to eastern and southeastern directions, resulting in higher direct sunlight exposure particularly during morning to midday hours.
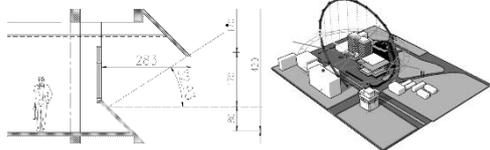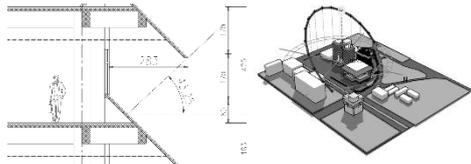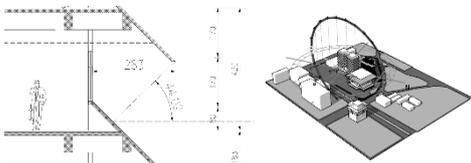
Both buildings coexist within a precinct surrounded by other government structures including secretariat offices, meeting halls, and support facilities. While visual connections and circulation paths between the Setwilda and BPKAD Buildings are clearly established, deliberate spatial boundaries ensure functional privacy for each. Their distinct site configurations create contrasting natural lighting characteristics, making them highly relevant for comparative analysis of light control potential – particularly regarding shading implementation and varied glass material applications.

Simulating and surveying natural lighting conditions in specific Setwilda Building spaces is essential to analyze its visual comfort performance. This building warrants detailed examination because its fin-shading design approach served as the reference for the Central Java BPKAD Building, both developed by the same planning consultant. Consequently, a comprehensive evaluation of this shading element's effectiveness is imperative. To illustrate shading performance, the BPKAD Building is included as a comparative case study. Analysis focuses on how the BPKAD's implementation of shading elements – inspired by Setwilda but featuring different dimensions and materials – impacts interior visual comfort quality.

Curic Sun simulations in SketchUp identified three orientations receiving the most intense direct sunlight. Simulations were conducted at specific hours corresponding to the azimuth and altitude values of each room's orientation, as detailed below.

Table 1. Simulation Results of the Setwilda Building in Curic Sun SketchUp

Orientation	Clock Visualization	Visualization	Azimuth	Altitude
Utara-Timut Laut	08.00 WIB		96.98°	44.02°
Selatan- Barat Daya	15.00 WIB		109.52°	43.52°
Timur-Tenggara	09.00 WIB		108.67°	44.02°

Source: Author, 2025

Material identification of interior and exterior building elements is necessary because surface reflectance significantly influences illumination simulation results and glare levels. The following are the material identification results for a sample room in the Regional People's Representative Council (DPRD) Setwilda Building.

Table 2. Room Material Identification Table

Setwilda Building Materials			
Location	**Material Type**	**Reflectance/Transmittance Value**	**Source**
Interior			
	Acoustic fiberglass panel (ceiling)	85%	Similar product (4x2 lightweight acoustic ceiling panel)
	White interior paint (walls)	88%	(Dewanto et al., 2024)
	Dark ceramic tile (floor)	30%	(Kristanto, 2018)
	Black painted aluminum (window frame)	50%	(IES, 1947)
	5mm clear glass (partition)	Visible Transmittance: 88% Reflectance: 8%	Product info (Clear Glass 5mm)
	White painted gypsum board (partition)	80%	Similar product
	Black finished solid wood (door)	18%	Similar product
Exterior			
	Ceramic-coated concrete	60%	(Kristanto, 2018)
	White exterior paint (walls)	88%	(Dewanto et al., 2024)
	Aluminum ceiling panel	60%	(IES, 1947)
	5mm black tinted glass	Visible Transmittance: 51% Reflectance: 6%	Similar product (Black Tinted Glass 5mm)

Sumber: Penulis,2025

Based on the results of the solar path simulation in the table above, it can be concluded that each data collection time is on DiaLUX Evo and directly. The simulation was carried out using DiaLUX Evo software by adding the appropriate reflectance value data, while the actual data was taken through field measurements at the same time and with sky settings close to the clear sky standard (CIE Clear Sky). The selection of time is adjusted to the characteristics of the opening orientation of each room. For rooms with openings in the East-Southeast and North-Northeast directions, simulations and surveys were carried out in the morning when the intensity of incoming sunlight is greatest. Meanwhile, for other rooms with different orientations, the time is adjusted to the solar path relevant to the opening direction.

Table 3. Results of Room Illumination and Glare Measurements in the Setwilda Building

Head of Section 1

Task Area (Lux)	Surrounding Area (Lux)	Sky Model	Glare Result	Task Area (Lux)	Surrounding Area (Lux)	Glare Result	Mark Relative Glare Error
312	291	Clear Sky (CIE Standard)	1,07	330	310	1,06	0,72%
	322		0,97		402	0,82	18,04%
	320		0,98		390	0,85	15,23%

Meeting Room 2

Task Area (Lux)	Surrounding Area (Lux)	Sky Model	Glare Result	Task Area (Lux)	Surrounding Area (Lux)	Glare Result	Relative Glare Error
89	118	Clear Sky (CIE Standard)	0,75	130	210	0,62	21,84%
	59		1,51		76	1,71	11,81%
	72		1,24		102	1,27	3,01%

Meeting Room 1T

Task Area (Lux)	Surrounding Area (Lux)	Sky Model	Glare Result	Task Area (Lux)	Surrounding Area (Lux)	Glare Result	Relative Glare Error
312	291	Clear Sky (CIE Standard)	1,07	330	310	1,06	0,72%
	322		0,97		402	0,82	18,04%
	320		0,98		390	0,85	15,23%

Meeting Room 2T

Task Area (Lux)	Surrounding Area (Lux)	Sky Model	Glare Result	Task Area (Lux)	Surrounding Area (Lux)	Glare Result	Relative Glare Error
35	38	Clear Sky (CIE Standard)	0,92	56	45	1,24	25,99%
	30		1,17		38	1,47	20,83%
	25		1,40		36	1,56	10,00%

Meeting Room 2K

Task Area (Lux)	Surrounding Area (Lux)	Sky Model	Glare Result	Task Area (Lux)	Surrounding Area (Lux)	Glare Result	Relative Glare Error
40	55	Clear Sky (CIE Standard)	0,73	57	71	0,80	9,41%
	60		0,67		102	0,56	19,30%
	54		0,74		82	0,70	6,56%

| Work Room							
Simulation (Contrast Ratio)				Field Survey			Relative Glare Error
Task Area (Lux)	Surrounding Area (Lux)	Sky Model	Glare Result	Task Area (Lux)	Surrounding Area (Lux)	Glare Result	
120	138	Clear Sky (CIE Standard)	0,87	154	167	0,92	5,70%
	172		0,70		164	0,94	25,70%
	105		1,14		154	1,00	14,29%

Source: Author, 2025

The table above presents the evaluation results of visual comfort in five workspaces at the Central Java DPRD Building, based on simulations using DiaLUX software and field measurements. The assessment covers illumination (natural lighting levels), glare potential, and relative error values between simulation and field results. Overall, the findings indicate that all rooms have natural illumination levels below the minimum standard of 300 lux as recommended by SNI 03-2396-2001 for workspaces. This suggests that natural lighting across all rooms is classified as low or dim, though glare remains within tolerable limits.

To provide a more comprehensive overview of visual conditions in each space, visual documentation is included featuring actual room photographs alongside natural lighting simulation results from DiaLUX. Room photos were captured during measurement sessions to demonstrate real-world natural lighting conditions experienced by users. Meanwhile, the DiaLUX simulations visually represent the distribution of natural light intensity within spaces at the same time and sky conditions as data collection. This combination of field photographs and simulation visualizations aims to give readers clearer understanding of how natural light disperses throughout rooms, and how opening designs and shading elements impact visual comfort. By examining these visuals, interpretation of the previously presented quantitative data becomes more accessible and contextually grounded.

Table 4. Visualization of Fin Shading Types

Simulation	**Shading Type**
	Shading 0 No Existing Shading A condition where there are no fins or additional protection above the window. The entire glass surface is exposed directly to the outside with no protection from direct sunlight.
	Shading 1 (1.29 m) 0.5x Existing (Ceiling Model Change 40 cm) The horizontal slanted fins are 1.29 meters long, or 50% of the existing shading length. Maintaining the same slant angle, they provide minimum protection. Combined with a 40 cm drop in the ceiling, they reduce indirect glare from inside the room.
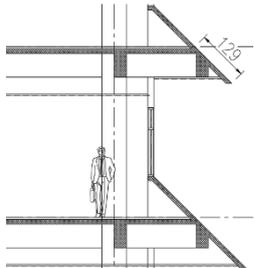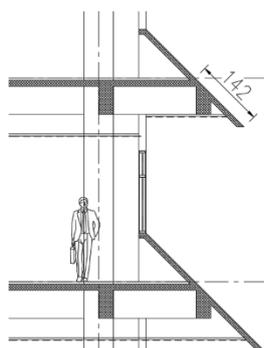
	Shading 2 (1.42 m) 0.8x Existing (40 cm Ceiling Model Change)
	Slightly longer than Shading 1, this shading measures 1.42 meters, or 55% of the existing size. The slope and shape remain the same, and it also uses a 40 cm dropped ceiling to support the visual boundary of the interior.
	Shading 3 (1.68 m) 0.65x Existing
	At 1.68 meters long, or 65% of the existing length, this shading provides better protection than the previous two models. It still maintains the 40 cm drop in the ceiling and is starting to approach the length of the window proportionally.
	Shading 4 (2.06 m) 0.8x Existing
	The shading is 2.06 meters long, equivalent to 80% of the existing length. It was used without modifications to the interior ceiling. The angle and shape of the blades remain beveled, and their proportions begin to resemble the main architectural design of the facade.
	Existing Shading 5 (2.58 m)
	This is the existing shading currently in use, measuring 2.58 meters long. With its long, upward-sloping fins, this shading protrudes far from the exterior wall and provides maximum protection from direct sunlight. This shading is also the most prominent visual element on the building's facade.
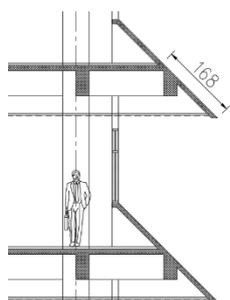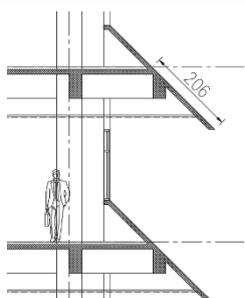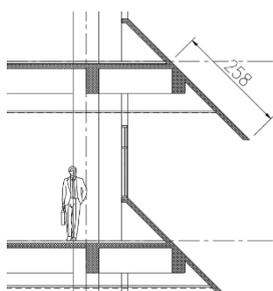
Source: Author, 2025

Table 5. Dimensions of the Base Case Model for the Setwilda Building Simulation

SETWILDA SHADING MODEL SIMULATION							
	Room Size			WWR	*Shading (m)*	Window Height (m)	Window Area (m)	Aperture Area (m)
Ket.	**P**	**L**	**T**					
Shading 0 (No Existing Shading)								
small	4	4,5	3	51%	0	1,7	3,8	6
currently	7	8	3	51%	0	1,7	6,6	11
Big	15	19	3	51%	0	1,7	13,5	23
Shading 1 (1.29 m) 0.5x Existing (Ceiling Model Change 40 cm)								
small	4	4,5	3	51%	1,29	1,7	3,8	6

currently	7	8	3	51%	1,29	1,7	6,6	11
Big	15	19	3	51%	1,29	1,7	13,5	23
Shading 2 (1.42 m) 0.8x Existing (Ceiling Model Change 40 cm)								
small	4	4,5	3	51%	1,42	1,7	3,8	6
currently	7	8	3	51%	1,42	1,7	6,6	11
Big	15	19	3	51%	1,42	1,7	13,5	23
Shading 3 (1.68 m) 0.65x Existing								
small	4	4,5	3	51%	1,68	1,7	3,8	6
currently	7	8	3	51%	1,68	1,7	6,6	11
Big	14	19	3	51%	1,68	1,7	12,6	21
Shading 4 (2.06 m) 0.8x Existing								
small	4	4,5	3	51%	2,06	1,7	3,8	6
currently	7	8	3	51%	2,06	1,7	6,6	11
Big	14	19	3	51%	2,06	1,7	12,6	21
Existing Shading 5 (2.58 m)								
small	4	4,5	3	51%	2,58	1,7	3,8	6
currently	7	8	3	51%	2,58	1,7	6,6	11
Big	14	19	3	51%	2,58	1,7	12,6	21

Source: Author, 2025

Table 6. Dimensions of the Base Case Model for the Setwilda Building Simulation

Visualization of the Base Case Space Plan for the Setwilda Building Simulation
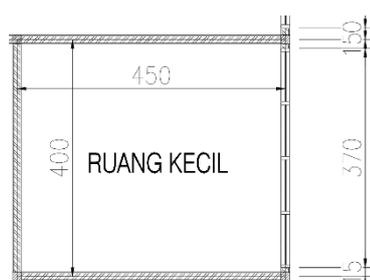
Small Space

This base case simulation plan represents a small space measuring 4.00 m x 4.50 m, commonly found in existing Setwilda buildings, primarily used as workspaces and meeting rooms. This space was chosen because of its relatively common and representative size, and because it serves as a primary activity area requiring optimal natural lighting and visual comfort.

Medium Space

This medium-sized space, measuring 7.00 m x 8.00 m, is generally used as a medium-scale meeting room or section head office in the existing Setwilda building. Its medium size makes it a valuable simulation model, representing the natural lighting requirements of a private, yet intensively used space, with potential glare that needs to be controlled to maintain visual comfort.

Large Space

This large space, measuring 15.00 m x 19.00 m, represents the area in the existing Setwilda building used as a large meeting room or open workspace. Its large size made it crucial for analyzing natural lighting and glare potential simulations..

Source: Author, 2025

The three floor plans above represent the simulation base cases for three common room size categories found in existing Setwilda buildings: small, medium, and large. Each base case was simulated with a standard window configuration according to existing conditions to evaluate natural lighting performance and potential glare. The results of this simulation were used as a reference for testing various types of shading designs, so that the most optimal and most appropriate type of shading can be determined for each room size type, both in terms of natural lighting efficiency and visual comfort of the room users.

Natural Light Intensity Simulation Results

Based on (LEED, 2019), computer modeling demonstrates that illuminance levels are within the range of 300 lux to 3,000 lux at 9 a.m. and 3 p.m. on a clear day at the equinox. The following are the simulation results using DiaLUX Evo.

Table 7. Natural Light Intensity Simulation Results for March 21

SETWILDA SHADING MODEL SIMULATION					
21-Mar	09.00 WIB		**21-Mar**	15.00 WIB	
Room Type	Results		Room Type	Results	
	Light Intensity (Lux)	Indicatoion		Light Intensity (Lux)	Indication
Shading 0 (No Existing Shading))					
Small	5393	Uncomfortable	Small	762	Comfortable
Currently	4715	Uncomfortable	Currently	555	Comfortable
Big	2161	Comfortable	Big	269	Uncomfortable
Shading 1 (1.29 m) 0.5x Existing (Ceiling Model Change 40 cm)					
Small	867	Comfortable	Small	602	Comfortable
Currently	653	Comfortable	Currently	432	Comfortable
Big	336	Comfortable	Big	214	Uncomfortable
Shading 2 (1.42 m) 0.8x Existing (Ceiling Model Change 40 cm)					
Small	816	Comfortable	Small	524	Comfortable
Currently	629	Comfortable	Currently	383	Comfortable
Big	306	Comfortable	Big	189	Uncomfortable
Shading 3 (1,68 m) 0,65x Existing					
Small	659	Comfortable	small	420	Comfortable
Currently	477	Comfortable	Currently	306	Comfortable
Big	238	Uncomfortable	Big	155	Comfortable
Shading 4 (2,06 m) 0,8x Eksisting					
Small	580	Comfortable	small	375	Comfortable
Currently	418	Comfortable	Currently	272	Uncomfortable
Big	210	Uncomfortable	Big	138	Uncomfortable
Shading 5 Eksisting (2,58 m)					
Small	407	Comfortable	small	271	Uncomfortable
Currently	294	Uncomfortable	Currently	198	Uncomfortable
Big	120	Uncomfortable	Big	81,5	Uncomfortable

Source: Author, 2025

Table 8. Natural Light Intensity Simulation Results for September 21

SETWILDA SHADING MODEL SIMULATION					
21-Sep	09.00 WIB		**21-Sep**	15.00 WIB	
Room Type	Results		Type Room	Results	
	Light Intensity (Lux)	Indicator		Light Intensity (Lux)	Indicator

Shading 0 (Without Existing Shading)

Small	979	Comfortable	**Small**	674	Comfortable
Medium	710	Comfortable	**Medium**	490	Comfortable
Large	343	Comfortable	**Large**	239	Uncomfortable

Shading 1 (1.29m) 0.5x Existing (Ceiling Model Change 40cm)

Small	729	Comfortable	**Small**	551	Comfortable
Medium	520	Comfortable	**Medium**	396	Comfortable
Large	222	Uncomfortable	**Large**	197	Uncomfortable

Shading 2 (1.42m) 0.8x Existing (Ceiling Model Change 40cm)

Small	623	Comfortable	**Small**	485	Comfortable
Medium	454	Comfortable	**Medium**	356	Comfortable
Large	306	Comfortable	**Large**	176	Uncomfortable

Shading 3 (1.68m) 0.65x Existing

Small	487	Comfortable	**Small**	397	Comfortable
Medium	312	Comfortable	**Medium**	289	Uncomfortable
Large	157	Uncomfortable	**Large**	147	Uncomfortable

Shading 4 (2.06m) 0.8x Existing

Small	431	Comfortable	**Small**	356	Comfortable
Medium	418	Comfortable	**Medium**	259	Uncomfortable
Large	210	Uncomfortable	**Large**	132	Uncomfortable

Shading 5 Existing (2.58m)

Small	308	Comfortable	**Small**	260	Uncomfortable
Medium	223	Uncomfortable	**Medium**	189	Uncomfortable
Large	91	Uncomfortable	**Large**	78	Uncomfortable

Source: Author, 2025

Simulations were conducted across three room sizes (small, medium, large) to evaluate the performance of various shading models in achieving natural light intensity within the comfort standard range (300–3,000 lux), using the existing 2.58m shading as reference. The no-shading scenario (Shading 0) yielded the highest illumination but far exceeded the upper comfort threshold – for instance, small rooms reached 5,393 lux at 09:00.

Based on daylight simulations, shading 0 (unprotected) produced excessive illumination on March 21 at 09:00, with lux values ranging from 2,161 to 5,393 across all room types. Small and medium rooms experienced extreme, uncomfortable lighting. By contrast, at the same time on September 21, illumination values entered the comfort range, indicating equinox dates represent neutral daylight distribution conditions. For Shading 1 and 2 (0.5x and 0.8x modifications of existing shading), simulations showed small and medium rooms largely achieved comfortable lighting levels. However, large rooms remained substandard, demonstrating that shorter shading effectively serves small-to-medium spaces but fails to meet lighting requirements in larger volumes. Meanwhile, shading 3 to 5

(approaching or matching existing shading) showed illumination in small/medium rooms dropping below comfort thresholds (<300 lux). This was particularly pronounced in large rooms with critically low lighting (91.4–120 lux), confirming that oversized shading significantly reduces natural light and causes visual discomfort, especially in light-demanding spaces.

Glare Potential Simulation Results

According to Chaloeytoy et al. (2020), Wienold proposed simplified daylight glare probability (DGPs) – a streamlined version of DGP metric calculating only vertical illuminance. This approach leverages the strong correlation between vertical illuminance and subjective glare perception. Notably, the DGPs model delivers accurate results exclusively when no direct sunlight enters the field of view. The DGPs formula was developed as a simplification of full DGP calculations and applies only to shaded spaces. For unshaded spaces, visual comfort can be assesed via lighting contrast ratios between task areas and immediate surroundings – an established glare evaluation method per EN 12464 (2002).

To analyze glare potential through visual contrast, simulations compared illuminance at task areas versus immediate surroundings following EN 12464-1:2002 standards. This method recognizes that extreme illuminance differences between visual task centers and their surroundings cause visual discomfort or glare. The simulation protocol included:

- Small/medium rooms: 4 surrounding sample points + 1 central task point
- Large rooms: 6 surrounding points + 1 task point (accounting for wider fields of view)

All simulations ran at 09:00 during clear-sky equinox conditions.

Table 9. Glare Intensity Simulation Results

GLARE SIMULATION RESULTS IN THE SETTWILA BUILDING							
Shading 0 (No Existing Shading)							
Surrounding Points		Task Area Point		Glare Results (Contrast Ratio Method)		Glare Results (DGP Method)	
Point	Illumination (Lux)	Point	Illumination (Lux)	Mark	Indicator	Mark	Indicator
Small Space							
Point 1	1667	Point 1	1124	0,674	Not Recommended	-	-
Point 2	1157			0,971	Not Recommended	-	-
Point 3	1191			0,944	Not Recommended	-	-
Point 4	930			1,209	Ideal	-	-
Medium Space							
Point 1	1390	Point 1	925	0,665	Not Recommended	-	-
Point 2	880			1,051	Ideal	-	-
Point 3	894			1,035	Ideal	-	-
Point 4	658			1,406	Ideal	-	-
Large Room							
Point 1	454	Point 1	317	0,698	Not Recommended	-	-
Point 2	454			0,698	Not Recommended	-	-
Point 3	295			1,075	Ideal	-	-
Point 4	285			1,112	Ideal	-	-
Point 5	234			1,355	Ideal	-	-
Point 6	233			1,361	Ideal	-	-
Shading 1 (1.29 m) 0.5x Existing (Ceiling Model Change 40 cm)							
Surrounding Points		Task Area Point		Glare Results (Contrast Ratio Method)		Glare Results (DGP Method)	
Point	Illumination (Lux)	Point	Illumination (Lux)	Mark	Indicator	Mark	Indicator

	Small Space							
Point 1	1218	Point 1	756	-	-		0,260	Disturbing–Intolerable
Point 2	745			-	-		0,230	Perceptile Disturbing
Point 3	896			-	-		0,240	Perceptile Disturbing
Point 4	657			-	-		0,225	Perceptile Disturbing
	Medium Space							
Point 1	1390	Point 1	756	-	-		0,270	Intolerable
Point 2	880			-	-		0,239	Perceptile Disturbing
Point 3	894			-	-		0,240	Perceptile Disturbing
Point 4	658			-	-		0,225	Perceptile Disturbing
	Large Room							
Point 1	454	Point 1	317	-	-		0,212	Imperceptible Perceptible
Point 2	454			-	-		0,212	Imperceptible Perceptible
Point 3	295			-	-		0,202	Imperceptile
Point 4	285			-	-		0,202	Imperceptile
Point 5	234			-	-		0,199	Imperceptile
Point 6	233			-	-		0,198	Imperceptile

Shading 2 (1.42 m) 0.8x Existing (Ceiling Model Change 40 cm)

Surrounding Points		Task Area Point		Glare Results (Contrast Ratio Method)		Glare Results (DGP Method)	
Point	Illumination (Lux)	Point	Illumination (Lux)	Mark	Indicator	Mark	Indicator
Point 1	1009	Point 1	967	-	-	0,247	Imperceptible Perceptible
Point 2	924			-	-	0,241	Imperceptible Perceptible
Point 3	927			-	-	0,242	Imperceptible Perceptible
Point 4	783			-	-	0,233	Perceptile Disturbing
			Medium Space				
Point 1	1078	Point 1	776	-	-	0,251	Imperceptible Perceptible
Point 2	746			-	-	0,230	Perceptile Disturbing
Point 3	742			-	-	0,230	Perceptile Disturbing
Point 4	551			-	-	0,218	Imperceptile
			Large Room				
Point 1	909	Point 1	406	-	-	0,241	Perceptile Disturbing
Point 2	615			-	-	0,222	Perceptile Disturbing
Point 3	617			-	-	0,222	Perceptile Disturbing
Point 4	372			-	-	0,207	Imperceptile
Point 5	359			-	-	0,206	Imperceptile
Point 6	277			-	-	0,201	Imperceptile

Shading 3 (1,68 m) 0,65x Eksisting

Surrounding Points	Task Area Point	Glare Results (Contrast Ratio Method)	Glare Results (DGP Method)

Point	Illumination (Lux)	Point	Illumination (Lux)	Mark	Indicator	Mark	Indicator
Point 1	1156	Point 1	720	-	-	0,256	Imperceptible Perceptible
Point 2	697			-	-	0,227	Perceptile Disturbing
Point 3	687			-	-	0,227	Perceptile Disturbing
Point 4	554			-	-	0,218	Disturbing Intolerable
			Medium Space				
Point 1	850	Point 1	588	-	-	0,237	Perceptile Disturbing
Point 2	561			-	-	0,219	Disturbing Intolerable
Point 3	559			-	-	0,219	Disturbing Intolerable
Point 4	469			-	-	0,213	Disturbing Intolerable
			Large Room				
Point 1	744	Point 1	355	-	-	0,230	Perceptile Disturbing
Point 2	522			-	-	0,216	Disturbing Intolerable
Point 3	514			-	-	0,216	Disturbing Intolerable
Point 4	325			-	-	0,204	Imperceptile
Point 5	320			-	-	0,204	Imperceptile
Point 6	247			-	-	0,199	Imperceptile
			Shading 4 (2,06 m) 0,8x Eksisting				
Surrounding Points		Task Area Point		Glare Results (Contrast Ratio Method)		Glare Results (DGP Method)	
Point	Illumination (Lux)	Point	Illumination (Lux)	Mark	Indicator	Mark	Indicator
Point 1	1209	Point 1	785	-	-	0,259	Imperceptible Perceptible
Point 2	753			-	-	0,231	Perceptile Disturbing
Point 3	753			-	-	0,231	Perceptile Disturbing
Point 4	648			-	-	0,224	Perceptile Disturbing
			Medium Space				
Point 1	905	Point 1	683	-	-	0,240	Perceptile Disturbing
Point 2	664			-	-	0,225	Perceptile Disturbing
Point 3	646			-	-	0,224	Perceptile Disturbing
Point 4	518			-	-	0,216	Disturbing Intolerable
			Large Room				
Point 1	754	Point 1	374	-	-	0,231	Perceptile Disturbing
Point 2	569			-	-	0,219	Imperceptile
Point 3	563			-	-	0,219	Imperceptile
Point 4	343			-	-	0,205	Imperceptile
Point 5	333			-	-	0,205	Imperceptile
Point 6	256			-	-	0,200	Imperceptile
			Shading 5 Eksisting (2,58 m)				

Surrounding Points		Task Area Point		Glare Results (Contrast Ratio Method)		Glare Results (DGP Method)	
Point	Illumination (Lux)	Point	Illumination (Lux)	Mark	Indicator	Mark	Indicator
Point 2	886	Point 1	637	-	-	0,239	Perceptile Disturbing
Point 3	607			-	-	0,222	Perceptile Disturbing
Point 4	601			-	-	0,221	Perceptile Disturbing
Point 1	445			-	-	0,212	Disturbing Intolerable
Medium Space							
Point 1	774	Point 1	461	-	-	0,232	Perceptile Disturbing
Point 2	454			-	-	0,212	Disturbing Intolerable
Point 3	433			-	-	0,211	Disturbing Intolerable
Point 4	329			-	-	0,204	Imperceptile
Large Room							
Point 1	649	Point 1	204	-	-	0,224	Perceptile Disturbing
Point 2	353			-	-	0,206	Imperceptile
Point 3	306			-	-	0,203	Imperceptile
Point 4	220			-	-	0,198	Imperceptile
Point 5	210			-	-	0,197	Imperceptile
Point 6	168			-	-	0,194	Imperceptile

Source: Author, 2025

Glare simulation was performed using two approaches: illuminance contrast ratios based on the EN 12464-1:2002 standard and Daylight Glare Probability (DGP) calculations. Assessments were conducted in three types of rooms (small, medium, and large) for various shading models, ranging from no shading to existing shading (2.58 m in length). In small and medium rooms, four points were selected as the surrounding area and one point as the task area, while in large rooms, six points were used as the surrounding area.

For small rooms, shading with a depth of 1.68 meters (Shading 3) performed best, with low and stable DGP values across all points. However, shading with a depth of 1.42 meters (Shading 2) was quite effective in preventing glare, making it an efficient choice under limited design conditions. In medium rooms, shading with a depth of 2.58 meters (Shading 5) provided the best level of glare protection, with all observation points showing DGP values below 0.22. However, 1.68-meter shading (Shading 3) is also considered quite efficient and can be a viable alternative if there are design or construction limitations. Meanwhile, for large spaces, only 2.58-meter shading (Shading 5) can consistently provide glare protection. This size is the only option that keeps all viewing points within the visual comfort threshold, making it highly recommended for spaces with large volumes and wide openings.

Based on the above results, it can be concluded that using Multi-Criteria Decision Making (MCDM) with an evaluative scoring approach based on (Talmor, 2021) and (Kangazian & Razavi, 2023) by assigning points to each criterion (points 1-5) used in the assessment (light intensity, DGPs, and the room contrast ratio approach) is as follows.

Table 10. Evaluative Scoring Results

Type of Room	Light Intensity	Glare	Final Score
Shading 0 (No Existing Shading)			
Small	5	1	3
Medium	5	1	3
Large	5	5	5
Shading 1 (1.29 m) 0.5x Existing (Ceiling Model Change 40 cm)			
Small	5	2	3,5
Medium	5	2	3,5
Large	1	5	3
Shading 2 (1.42 m) 0.8x Existing (Ceiling Model Change 40 cm)			
Small	5	2	3,5
Medium	5	3	4
Large	1	4	2,5
Shading 3 (1,68 m) 0,65x Eksisting			
Small	5	3	4
Medium	5	3	4
Large	1	4	2,5
Shading 4 (2,06 m) 0,8x Eksisting			
Small	5	3	4
Medium	5	3	4
Large	1	4	2,5
Shading 5 Eksisting (2,58 m)			
Small	5	2	3,5
Medium	1	4	2,5
Large	1	5	3

Source: Author, 2025

CONCLUSIONS AND SUGGESTIONS

Based on the analysis of the final scores for each shading scenario on visual comfort in three types of rooms (small, medium, and large), the results showed variations in shading effectiveness based on room dimensions. In small rooms, the highest score, 4, was achieved in Shading 3 scenarios (1.68 m or 0.65x the existing), Shading 4 (2.06 m or 0.8x the existing), and Shading 5 (2.58 m existing). This indicates that for small spaces, the use of medium to full-dimension shading tends to provide the best combination of natural lighting and glare control. Meanwhile, in medium-sized rooms, the highest score (4) was obtained in Shading 2 scenarios (1.42 m or 0.8x the existing with a 40 cm ceiling modification), Shading 3, and Shading 4. This indicates that optimal performance for visual comfort in medium-sized spaces is achieved within the middle range of shading dimensions, especially when combined with ceiling design modifications. Unlike the previous two room types, in large spaces, the highest score was achieved with Shading 0, or the absence of any shading elements. This indicates that in large spaces, more natural lighting is needed, and the presence of shading tends to reduce the ideal lighting level. Therefore, in large spaces, an open facade design actually provides the best visual performance as long as glare remains within tolerable limits.

As a recommendation, natural light intensity simulations should be conducted initially on the equinox date (March 21st or September 21st), in accordance with general guidelines as applied in the LEED standards. These dates were chosen because they represent neutral and balanced light distribution conditions in tropical regions, making them suitable for initial daylight evaluations. However, to obtain more comprehensive results, particularly in anticipation of extreme conditions, such as low morning or afternoon sunlight that can cause excessive lighting or glare, additional simulations should be conducted outside the equinox, particularly during times with sharper solar angles. This will allow for a more comprehensive visual comfort evaluation and allow for consideration of lighting conditions throughout the space's usage.

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