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National Academic Journal of Architecture
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Journal Home Page: http://journal.uin-alauddin.ac.id
DOI: https://doi.org/10.24252/nature.v12i2a9

Review of Daylighting Strategies in Tropical Vertical Residential Buildings

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Submitted:18-03-2025
Revised: 31-07-2025
Accepted: 25-08-2025
Available online: 04-12-2025

How To Cite: Setiawan, S. A., & Elsiana, F. Review of Daylighting Strategies in Tropical Vertical Residential Buildings. Nature: National Academic Journal of Architecture, 277–288. https://doi.org/10.24252/nature.v12i2a9

Abstrak_ *Makalah ini mengeksplorasi efektivitas strategi pencahayaan alami pada bangunan hunian vertikal tropis, dengan fokus pada peningkatan performa pencahayaan alami untuk mendukung kesejahteraan fisik dan mental penghuni. Seiring meningkatnya waktu yang dihabiskan di rumah pasca pandemi, perancangan ruang hunian dengan akses cahaya matahari yang optimal menjadi sangat penting. Tinjauan literatur dilakukan secara sistematis melalui basis data Science Direct, IOP Science, dan Research Gate, menghasilkan enam studi dalam lima tahun terakhir yang memenuhi kriteria: pencahayaan alami, hunian vertikal, dan konteks tropis. Strategi utama yang dikaji meliputi side lighting, atrium, dan perangkat peneduh, dengan evaluasi berdasarkan Daylight Factor (DF), Spatial Daylight Autonomy (sDA), dan indeks silau. Side lighting merupakan strategi paling umum, ditingkatkan dengan light shelf dan peneduh yang dapat disesuaikan. Strategi ini meningkatkan Target Daylight Illuminance (TDI) hingga 300%, Illuminance Uniformity Ratio (IUR) hingga 180%, dan mengurangi iluminasi berlebih hingga 86%. Atrium juga menunjukkan potensi, meningkatkan pencahayaan ruang 0,9–19,2% dan menurunkan over lighting koridor hingga 57%. Efektivitas bergantung pada tipologi dan iklim bangunan. Kontribusi utama makalah ini adalah memberikan panduan desain berbasis performa yang relevan secara kontekstual bagi arsitek dalam menciptakan hunian tropis yang sehat dan lingkungan hunian tropis yang lebih berkelanjutan.*

Kata kunci*: Pencahayaan Alami; Performa Pencahayaan Alami; Hunian Vertikal; Iklim Tropis*

Abstract_ This paper explores the effectiveness of daylighting strategies in tropical vertical residential buildings, focusing on enhancing daylight performance to improve the physical and mental well-being of the dwellers. With more time spent indoors post-pandemic, optimizing daylight access is essential. A systematic review was conducted using databases such as Science Direct, IOP Science, and Research Gate, resulting in six studies that met the criteria of daylighting, vertical residential, and tropical context. These studies were analyzed to identify key strategies side lighting, atriums, and shading devices evaluated through metrics like Daylight Factor (DF), Spatial Daylight Autonomy (sDA), and glare indexes. Findings show that side lighting is the most common strategy, enhanced by innovations such as light shelves and adjustable shading. This approach improved Target Daylight Illuminance (TDI) by up to 300%, increased Illuminance Uniformity Ratio (IUR) by 180%, and reduced over-illumination by 32–86%. Atriums, though less frequent, showed potential in deeper layouts, increasing indoor illuminance by 0.9–19.2% and reducing corridor over lighting by 41–57.1%. Effectiveness varies by building type and climate, reinforcing the need for context-specific design. The main contribution of this paper lies in synthesizing quantitative evidence into actionable, climate-responsive design insights, providing architects with a concise reference for creating healthier and more sustainable tropical residential environments.

Keywords: Daylighting; Daylight Performance; Vertical Residential; Tropical Climate

INTRODUCTION

The Covid-19 pandemic has changed our way of living. The amount of time spent doing activities at home is one of the variables that had a huge impact due to the pandemic. Residential buildings hold an important role in daily life. Based on Our World in Data, the duration spent at home has increased up to 30% compared to before the pandemic. In Indonesia, the changes reached up to 13.14% (*Residential Areas*, n.d.)(Figure 1). The increases in time spent at home are affected by various factors in different countries. In general, the post-pandemic phenomenon allows people to work at home rather than working at the common office which increases the time spent at home (McPhail et al., 2024). This occurred due to the shifting of habits through the pandemic and the changes in flexibility supported by the technological advancement that allows everything done remotely (Kismono, n.d.).

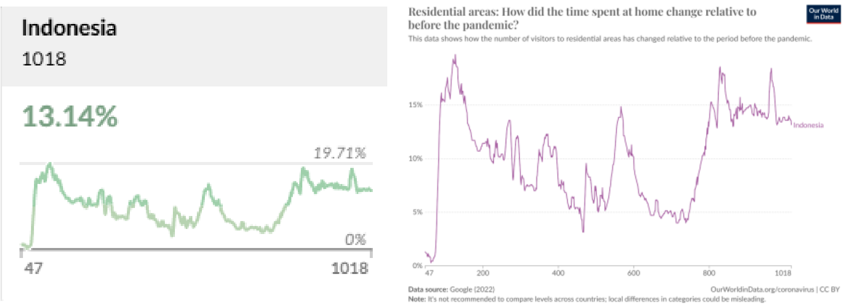

Figure 1. Time spent at home change relative to before the pandemic in Indonesia
Source: https://ourworldindata.org/grapher/changes-residential-duration-covid?tab=table&country=~IDN (2024)

Daylight holds an important role in enhancing comfort, health, and energy efficiency in tropical vertical residential buildings. Despite high outdoor illuminance availability, which often exceeds 80,000 lux at noon (Lim & Heng, 2016), daylighting is frequently underutilized due to issues like glare, heat gain, and non-uniform distribution caused by fully glazed facades and poor shading strategies (Lim & Heng, 2016; Loro et al., 2024). The predominance of intermediate sky conditions in tropical regions further complicates daylight control (Lim & Heng, 2016). These problems often lead occupants to block daylight entirely and rely on artificial lighting all day. Therefore, responsive daylighting strategies are crucial to balance daylight sufficiency, visual comfort, and thermal performance, especially in tropical vertical residential building contexts.

Daylight holds a vital role in regulating the circadian rhythm and supporting overall health by enhancing mood, alertness, and immune function (Volf et al., 2024). Exposure to daylight enables vitamin D synthesis and provides UV radiation that helps protect against infections and cardiovascular diseases (Liu et al., 2014; Weller, 2016). In contrast, artificial lighting might impact negatively for human health mostly when it is used excessively during night time by suppressing the production of melatonin and disturbs sleep (Volf et al., 2024). Generally, artificial lighting has no positive impact biologically and may disrupt circadian rhythm (Cain et al., 2020). This shows how important daylight in residential buildings since the time spent at home has increased generally. Both physical and mental well-being can be improved by creating a well-designed daylight accessibility for the users.

Daylighting strategies in tropical climates are unique compared to any other climates. Rather than just maximizing daylight accessibility, there are other aspects to be considered such as avoiding glares and direct heat radiation to avoid visual and thermal discomfort (Edmonds & Greenup, n.d.). These aspects can be achieved by implementing strategies such as glazing's, louvres, light shelves, and any other form of shadings that partially block the excessive radiation.

There are various types of daylighting strategies implemented in buildings generally. Side lighting, top lighting, core lighting and atrium are the main strategies typically implemented. Side lighting utilizes the walls of buildings as the location of apertures to admit daylight. Top lighting utilizes the opening from the top of the room through skylights or roof monitors (Gherri, 2015)(Figure 2). Core lighting has a different approach in transporting light indirectly through a device that reflects the light. Atrium utilize the form of a building that forms an atrium to admit daylight to the living spaces (Ander, n.d.).

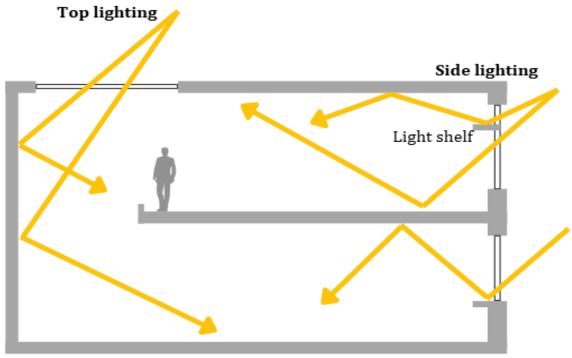

Figure 2. Top lighting and side lighting strategies visualization
Source: Adapted from https://esource.bizenergyadvisor.com/article/daylighting-systems (2024)

This study aims to explain daylighting strategies implemented in vertical residential buildings and their resulting daylighting performance. By investigating various daylighting strategies and their efficacy in different literature discussed, this research seeks to contribute to the field of architectural design. Specifically, it aims to provide architects with insight about daylighting strategies and their performance in vertical residential buildings, empowering them to make design decisions that optimize daylight utilization and enhance the overall quality of architecture design.

METHODS

A literature study is performed in order to review about daylighting strategies and its performance indicators in tropical vertical residential. Throughout the process, it is found that most of the recent literature discusses daylighting in office buildings and some on residential buildings. Vertical residential is discussed more compared to low rise residential in recent years, not because they dominate existing research, but due to the extensive needs of vertical residential nowadays. The urgency to discuss daylighting in tropical vertical residential buildings also occurs due the post-pandemic phenomenon. The form of vertical residential discussed commonly are apartments leaning on the low-cost apartments for the study cases and general apartments are assumed for the computational simulations discussed.

Furthermore, literature from the past 5 years discussing daylighting in tropical vertical residential buildings are reviewed to achieve the findings of the strategies implemented and the performance outcome. To ensure methodological consistency, the literature review followed a three-stage process: (1) search, by using the keywords “daylighting,” “vertical residential,” and “tropical” across databases including Science Direct, IOP Science, and Research Gate; (2) screening, by applying inclusion criteria such as relevance to high-rise residential buildings, tropical climate, and publication within the past five years; and (3) data extraction, where each selected study was analyzed for its daylighting strategy and performance metric. The search was conducted between August to November

2024. This multi-step filtering was essential to ensure that the studies addressed all three main aspects relevant to this paper: daylighting strategies, high-rise residential buildings, and tropical climate conditions. While many studies discuss daylighting in vertical buildings, most are based in temperate climates or focus on office and institutional buildings rather than residential ones. Similarly, research on daylighting in tropical regions often centers on low-rise housing typologies. As a result, only a limited number of studies (six) were found that directly aligned with all three criteria, highlighting a significant research gap in the field of daylighting performance for tropical vertical residential buildings.

These steps are done to make sure all the data used are valid in order to compose this article. Literature discussing daylighting in tropical vertical residential is then analyzed in order to find the methods, daylight strategies, daylight performance, results discussed and summary of the literature. A tabulation approach was used to systematically identify key themes across the literature, focusing on the type of daylighting strategies implemented, performance metrics adopted, and resulting daylight performance in tropical high-rise housing. The data are processed and analyzed to investigate the relationship between the daylighting strategies towards its performance. The inclusion criteria for selecting literature were: (1) the study must focus on daylighting strategies implementation, (2) the building type must be vertical residential (e.g., apartments, flats), and (3) the climatic context must be tropical. Studies published between 2018 and 2023 were prioritized to reflect recent developments. Exclusion criteria included studies that: (1) focused solely on non-residential typologies such as offices or schools, (2) were conducted in temperate or non-tropical climates, and (3) lacked quantifiable performance metrics related to daylighting such as DF, sDA, or glare indexes.

Table 1. Previous research about Daylighting Strategies in Tropical Vertical Residential Building

No	Title	Author, Year	Purpose	Daylighting Strategies	Daylighting Performance
1.	Study on Daylight Performance and Spatial Configuration of Low-cost Apartment Building in Indonesia through Computational Simulation	Suryo, 2022	To analyze daylight performance in low-cost apartments based on spatial layout using simulation.	Side lighting (windows)	Daylight Level (DF) & Daylight Uniformity (Daylight Distribution)
2.	Daylight Analysis in Low-Cost Apartments in Jakarta	Susanto et al., 2018	To measure the Daylight Factor before and after occupancy in 3 low-cost apartments in Jakarta	Side lighting (windows)	Daylight Level (DF)
3.	Daylight performance of courtyard wall design at low-cost flat in the tropics	Elsiana et al., 2018	To assess the effect of courtyard wall design on daylighting performance.	Atrium (courtyard), louvres to light shelf	Daylight Level (DF) & Daylight Uniformity (IUR)
4.	The Impact of Folding Shutter on the Daylighting Performance in Tropical Climate	Ghufrona et al., 2021	To examine how folding shutters, light shelves, and overhangs affect daylight performance in flats.	Side lighting (windows with folding shutters, overhang and light shelves)	Daylight Level (DF) & Daylight Uniformity (Daylight Distribution)
5.	Adjustable Internal Shading for Home Office Daylighting in Tropical Climates	Mousavi et al., 2021	To test design layouts and shading configurations for visual comfort in tropical home offices.	Side lighting (windows), internal shadings	Daylight Level (EWPI, TDI), Daylight Uniformity(IU

					R) Glare Index (DGP, CGI)
6.	A parametric approach to optimize solar access for energy efficiency in high-rise residential buildings in dense urban tropics	Jayaweera et al., 2021	To optimize daylight and heat gain balance for energy efficiency in high-rise tropical housing.	Side lighting (windows)	Daylight Level (sDA)

RESULTS AND DISCUSSION

Daylighting performance analysis has evolved in the past years. Various variables are used to analyze the visual comfort for daylights. Daylight Factor (DF) is a form of static daylight performance metric which is defined as the ratio of the internal illuminance at a point in a building to be unshaded, external horizontal illuminance under a CIE overcast sky (Reinhart et al., 2006). Another form of static daylight performance discussed is Illuminance Uniformity Ratio (IUR). IUR is the ratio of minimum illuminance to mean illuminance and longitudinal uniformity is the ratio of minimum illuminance to maximum illuminance (Kayakuş & Üncü, 2020). These indicators are commonly used due to their simplicity and ease of implementation, especially for low-cost housing simulations (Suryo, 2022; Susanto et al., 2018).

Another form of metric used other than static daylight performance metric is dynamic daylight performance metric. Spatial Daylight Autonomy (sDA) is a metric describing the annual sufficiency of ambient daylight levels in interior environments. It is defined as the percent of the analysis area (where illuminance is calculated) that meets a minimum daylight illuminance level for a specified fraction of the operating hours per year (Ershov et al., 2022). Glare indexes such as Daylight Glare Probability (DGP) and CIE Glare Index (CGI) are also used as daylight performance metrics in tropical climates (Mousavi et al., 2021). The increasing adoption of dynamic metrics reflects a shift toward occupant-centered design and performance-based daylighting, especially in post-pandemic housing models (Volf et al., 2024).

Daylight strategies implementation specifically on vertical residential buildings are various. The most common strategy used is Side lighting in the form of a side window. Based on Table 1, side lighting strategy is discussed in 5 out of 6 literature analyzed. The other strategy discussed is atrium meanwhile core lighting and top lighting is not discussed (Figure 3). This shows that Side lighting is the most common strategy used in the daylighting design in vertical residential buildings. Atrium might be an alternative but it is not commonly used depending on the typology of the building. Core lighting and Top lighting are not common in this case due to the low accessibility to allow daylight inside the living space through these strategies which are not efficient.

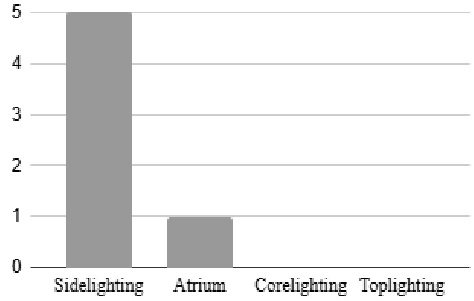

Figure 3. Number of literature discussing each daylight strategies

Daylighting performance approached differently in every case. Based on Table 1, 83% of the reviewed studies rely solely on static metrics such as Daylight Factor, highlighting a methodological limitation in assessing occupant-centric comfort parameters like glare or daylight autonomy. Daylight Factor is used the most in the literature discussed in which 4 out of 6 papers uses DF as the indicator. Followed by IUR used in 2 out of 6 papers with sDA and glare indexes discussed in 1 out of 6 papers. This shows that Daylight Factor is the most used performance indicator in research of vertical residential daylight due to its short period of time and convenience in collecting the data. However, its dominance also reveals a methodological limitation. DF is a static metric based on overcast sky conditions, which does not account for real-world variability or occupant experience throughout the year. The lack of dynamic metrics such as sDA and glare indexes in most studies suggests a research gap in capturing holistic daylight quality in tropical contexts. IUR is starting to be a concern in tropical vertical residential building contexts as well as the glare indexes to ensure visual comfort (Figure 4). Dynamic daylight performance metric in form of sDA is starting to be considered to obtain a more accurate daylight performance measurement.

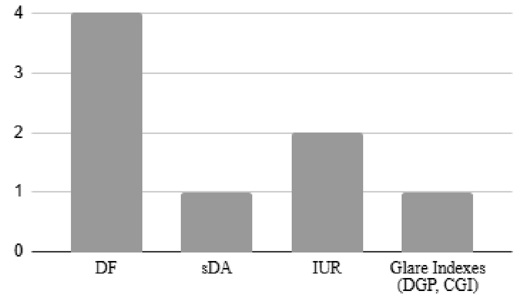

Figure 4. Number of literature discussing each daylight performance indicator

A. Side lighting

Side lighting holds an important role in controlling the daylight performance in tropical vertical residential buildings. Side lighting strategy directly affects the static and dynamic daylight performance metric. Some aspects such as window wall ratio (WWR) and layout of the residential unit also impact the daylight performance. However, design elements like light shelf, shading, and glazing's holds an important role in the tropical climate context.

Daylight Factor in this case indicates how the side lighting provides daylight access for the dwellers. However, excessive side lighting can lead to uneven illuminance distribution, resulting in lower IUR values. This can cause discomfort and visual discomfort, especially in areas with high contrast tasks . This issue is commonly observed in tropical climates with high solar exposure, where glare and overlie zones near the window are frequently reported (Lim & Heng, 2016).

Side lighting allows the achievement of higher sDA levels. This indicates better access to adequate daylight for a significant portion of the day (Jayaweera et al., 2021). Better access of adequate daylighting might help in boosting the wellbeing of the dwellers both physically and mentally due to the impact of the daylight directly and how it provides visual comfort.. However, it is important to balance daylight availability to ensure a good glare control to optimize dweller's comfort and wellbeing.

Side lighting daylight accessibility compared to the window wall ratio (WWR) is directly proportional which is shown through the value of its Daylight Factor. In this context, the accessibility of the window wall ratio is not fully functional due to the goods of the occupants blocking the window area. The number of goods blocking is also determined by the number of occupants of the units (Susanto et al., 2018). This phenomenon indicates that post-occupancy factors must be considered in daylight design for vertical housing (Suryo, 2022).

Light shelf allows the daylight to diffuse around the room through the reflected light through the ceiling of the room. This strategy reduces glare generally which increases the comfort of the dwellers. The IUR result with the light shelf also improves as the daylight is distributed well through the reflections and diffusions (Mousavi et al., 2021). Light shelf is commonly used to ensure a better distribution of illuminance towards the deeper area of the living spaces from the side lighting openings. It is especially effective in narrow or elongated units where direct sunlight cannot reach deeper zones.

Shading holds an important role in preventing glares and direct heat radiation from the sun (Mousavi et al., 2021). These allow daylight to be accessible to the living spaces while maintaining visual and thermal comfort for the dwellers. Shading comes in different forms and installation places. Generally it is divided into 2 categories, internal and external shadings. Internal shadings are shading devices installed in the interior part of the openings which allows direct access for the dwellers. External shadings are shading devices installed in the exterior part of the openings which are usually used to reduce the amount of daylight and direct heat radiation penetrating the openings or windows.

Figure 5 demonstrates how various combinations of folding shutters, light shelves, and overhangs can be integrated into side lighting designs to enhance daylight distribution while mitigating glare and overheating, especially in tropical climates. Configurations of the shading also impact the result of the daylight performance obtained. Various design elements can be implemented both individually and collaboratively. Exterior folding shutters allow less daylight to penetrate depending on the angle of the shutters. Rotating the slats to 0° and 45° was most effective in diffusing daylight evenly and blocking direct sunlight. Angles greater than 90° caused uneven light distribution and excessive brightness, leading to visual discomfort (Ghufrona et al., 2021) (Figure 5). The reflectance of the folding shutters acts as mini light shelves which reflect the daylight into the room.

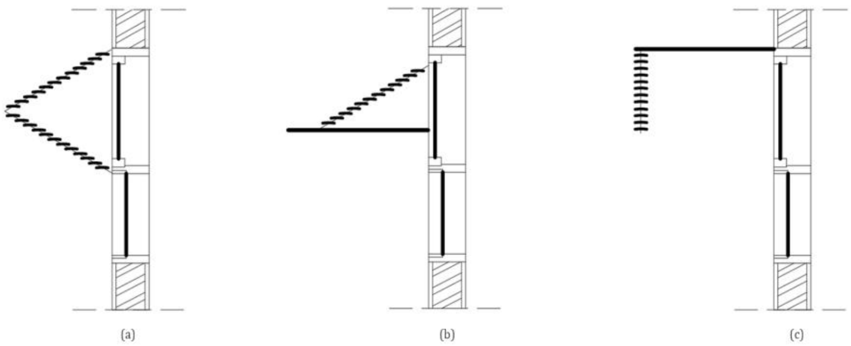

Figure 5. (a) Basic model of folding shutter; (b) Integration folding shutter with light shelf; (c) Integration folding shutter with overhang.
Source: Adapted from Mousavi et al., (2021)

Other forms of shading are venetian blind, louvre, and overhang. Venetian blind is a controllable internal shading which works like the folding shutter. It can't be configured as in the arrangement but can be opened and closed by changing the angles of the blind to control the daylight penetrating into the living spaces (Mousavi et al., 2021). Louvre and overhang both work as exterior shading which helps in filtering and blocking the daylight penetrating. Both have different configurations and shapes. However it works similarly to prevent glare and provide visual and thermal comfort.

Glazing is another strategy to prevent glares and direct radiation heat. Using a certain glazing such as tinted glazing, could help in adapting efficiently to varying sun positions and sky conditions in tropical climates. It helps in reducing the direct heat radiation penetrating into the living spaces and reduces glare. Another strategy that can be done is by installing window films. It helps in optimizing visual comfort for spaces with direct daylight (Mousavi et al., 2021). Adjustable internal shading—consisting of Venetian blinds, horizontal light shelves, and tinted glazing—was shown to reduce excessive indoor illuminance by 32% to 86%, while significantly improving Target Daylight Illuminance (TDI) by up to 300% and Illuminance Uniformity Ratio (IUR) by up to 180%. This strategy also reduced glare from intolerable to imperceptible levels, enhancing overall visual comfort in tropical ERABs (Mousavi et al., 2021).

Other than the openings and daylight diffusion strategies, the layout also holds an important role in creating a well distributed daylight in the living spaces through side lighting. Figure 6 illustrates how spatial configuration plays a key role in optimizing daylight penetration through side lighting, especially in compact apartment units where furniture placement and room depth can obstruct or facilitate light flow. The proper layout configuration allows each living space to obtain a well proportioned opening that allows daylight access which ensures a well distributed daylight throughout every living space (Suryo, 2022) (Figure 6). This provides a better visual comfort and better access to daylight which boosts the wellbeing of the dwellers. In vertically stacked units, this becomes crucial to ensure lower-floor occupants are not disadvantaged by obstructed daylight paths.

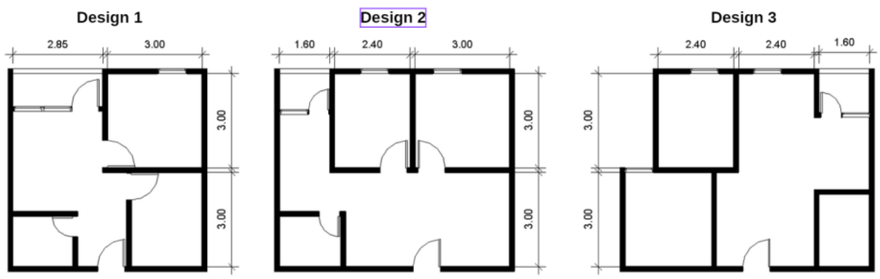

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Figure 6. Space configuration (layout plan) of the low-cost apartment unit
Source: Adapted from Suryo, (2022)

B. Atrium

Atrium is another strategy implemented in vertical residential buildings. It is not as common as daylighting due to the typology of the building should form an atrium. In general, an atrium could provide adequate daylighting towards the living space, but it has some problems in reaching the deeper building configuration.

Figure 7 shows how atrium-based daylighting can be improved through passive shading elements like light shelves and louvres, which help to diffuse incoming light, reduce corridor glare, and improve light distribution in deeper residential zones. There are various ways that can be done to improve daylight performance. Louvres can be used to reduce glare and direct heat radiation towards the inner corridor of the atrium. Light shelves in the inner corridor of the atrium performs better in reducing excessive light penetration which reduces glare in the corridor area (Elsiana et al., 2018). This occurs due to the more diffused light through the light shelf and it acts also as an overhang. The residential units have a slight improvement in IUR and Daylight Factor due to the light shelf which allows a better visual comfort and enhances the wellbeing of the dwellers (Figure 7). However, due to geometric constraints, atria often require advanced simulation and daylight modeling to ensure effectiveness in high-density housing (Gherri, 2015).

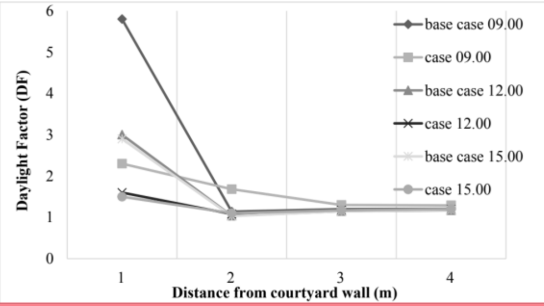

Figure 7. Space configuration (layout plan) of the low-cost apartment unit
Source: Elsiana et al., (2018)

Atrium strategies are rarely used in tropical vertical residential buildings due to the conflict between daylighting and thermal performance. Large exterior surfaces and glazed areas of typical atriums increase solar heat gain, which leads to higher cooling loads mostly in hot-humid climates (Ghasemi et al., 2015). Moreover, sufficient daylight in the atrium can only be achieved with an optimized proportions which is often impractical in compact vertical residential building layouts (Ghasemi et al., 2015). These limitations reduce the viability of atriums as a daylighting strategy in practice and also research discussing the tropical vertical residential building design. Modifying courtyard walls with sloped light shelves increased dwelling room illuminance by 0.9% to 19.2%, while reducing over-illumination in adjacent corridors by 41% to 57.1%. The intervention also improved daylight uniformity, making it a balanced strategy for both private and communal apartment spaces (Elsiana et al., 2018).

C. Other Design Parameter

Another design parameter which might be a major consideration in daylight performance is orientation. Orientation in this case refers to opening orientation of the residential units. North and South-facing units generally showed lower daylight autonomy compared to east and west-facing units. This occurs due to the angles covered at the east and west orientation are more compared to the north and south. Based on the data, annual energy savings ranged from 28%-36% in east-west orientations and 8%-12% in north-south orientations for cooling and lighting combined (Jayaweera et al., 2021).

In a vertical residential context, building setbacks hold an important role affecting daylight accessibility. Building setbacks need to be considered as part of daylight accessibility since the height of the building might block the access of daylight towards the lower levels (Jayaweera et al., 2021). As the building gets higher, more setbacks are needed to ensure effective access to daylight to maintain adequate daylight conditions .

In comparing both strategies, side lighting emerges as a more adaptable and scalable solution in tropical vertical residential buildings. It allows for the integration of responsive elements such as shading and glazing, which enhance user comfort while minimizing energy consumption. In contrast, atrium-based strategies require significant design interventions, including careful proportioning, integration of light shelves, and thermal mitigation elements such as shadings. This makes atrium-based strategies less feasible for compact housing typologies in dense urban settings.

Side lighting is the most efficient and flexible daylighting strategy in tropical vertical residential buildings. Elements such as adjustable shading devices, folding shutters, light shelves, and glazing treatment enhance its adaptability, which allows dynamic control over daylight levels, glare, and heat gain. The proper configuration allows good visual and thermal comfort while improving energy performance. Side lighting is also easy to integrate into various unit layouts with minimal structural changes and lower costs, making it a suitable option for standard and low-cost vertical housing (Ghufrona et al., 2021; Mousavi et al., 2021).

Although side lighting remains the most commonly adopted daylighting strategy in tropical vertical residential buildings due to its adaptability and cost-effectiveness, it also presents some disadvantages in terms of visual comfort. Large, unshaded side openings can result in excessive illuminance near windows, creating high-contrast zones that reduce Illuminance Uniformity Ratio (IUR) and cause glare discomfort for occupants (Lim & Heng, 2016). In tropical climates with high solar exposure, the combination of strong direct sunlight and reflective interior surfaces can exacerbate glare, often leading residents to block daylight entirely and rely on artificial lighting during the day (Loro et al., 2024; Mousavi et al., 2021). Such conditions not only compromise visual comfort but can also deny the potential energy savings from natural lighting, this highlights the importance of integrating shading devices, glazing treatments, or light shelves to mitigate these negative effects.

In contrast, atriums can improve daylight in deeper layouts but are less flexible and more complex to implement. Effective performance requires precise proportions and additional shading elements such as louvres or light shelves to avoid glare and overheating while allowing an ideal visual comfort for users. Their large glazed surfaces often lead to higher cooling loads in tropical climates, making them less practical for compact residential designs (Ghasemi et al., 2015; Elsiana et al., 2018). Thus, while both strategies enhance daylight access, side lighting remains more adaptable, cost-effective, and suitable for tropical residential applications.

The findings of this review directly address the research gap identified in the introduction, where studies on daylighting in tropical vertical residential buildings remain scarce and fragmented, particularly in comparing different strategies and performance metrics. By synthesizing quantitative results from the six selected studies, this paper clarifies the relative strengths and weaknesses of side lighting and atrium strategies within the tropical context, and highlights the predominant reliance on static metrics such as Daylight Factor. This comparative perspective not only fills a void in the existing literature but also underscores the necessity of integrating dynamic daylight metrics and post-occupancy evaluations in future research to better capture occupant comfort and long-term performance.

CONCLUSION

Based on the reviewed literature, daylighting strategies contribute significantly to enhancing the quality of life in tropical vertical residential buildings, particularly by improving daylight distribution, visual comfort, and energy efficiency. These strategies are especially relevant in the post-pandemic context where people spend more time indoors, making daylight access crucial for physical and mental well-being.

Side lighting emerged as the most widely discussed and flexible approach. Its effectiveness increases with the integration of design elements such as light shelves, glazing treatments, and adjustable shading devices (e.g., folding shutters, louvres, overhangs) that help optimize daylight levels while minimizing glare and heat gain. This strategy is not only energy-efficient but also highly adaptable to various unit layouts with minimal structural changes, making it particularly suitable for low-cost vertical housing projects.

In contrast, atrium strategies, while beneficial for improving daylight penetration in deeper building layouts, are more complex and less adaptable. They require precise geometric proportions and additional components such as internal shading or light shelves to reduce glare and ensure comfort. Moreover, atriums can increase cooling loads in tropical climates due to their larger glazed surfaces, making them less suitable for compact residential designs.

Other contextual factors such as building orientation (e.g., east-west vs. north-south) and setback configuration also play critical roles in influencing daylight performance, especially for lower floors where light access may be limited.

This paper contributes by addressing a notable gap in the literature, where tropical vertical residential daylighting remains underexplored, especially in terms of strategy comparison and metric selection. By synthesizing findings from recent studies, it provides a structured reference for context-sensitive such as tropical vertical residential design decisions. The analysis also emphasizes the need for wider adoption of dynamic performance indicators to more accurately reflect user comfort and energy impacts.

In conclusion, by understanding the strengths and limitations of each strategy—supported by performance metrics such as Daylight Factor (DF), Spatial Daylight Autonomy (sDA), and glare indexes—architects can make more informed and effective design decisions. This synthesis reinforces the importance of applying context-specific and performance-based daylighting approaches, especially in tropical vertical residential environments where design efficiency, user comfort, and sustainability must be carefully balanced.

Despite offering valuable insights, this study is limited by the small number of relevant literature (n=6) and the reliance on simulated data rather than post-occupancy evaluations. Future research should explore occupant-centered evaluations, apply more dynamic daylighting metrics, and investigate daylight performance in diverse building forms and socioeconomic contexts, particularly in affordable vertical housing across tropical climate contexts.

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