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Analysis of Natural Day Lighting Concepts in Al-Raudhah Mosque in Medan, North Sumatra, Indonesia

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A B S T R A C T

The Al-Raudhah Mosque in Medan demonstrates a good application of natural lighting, considering its function as a place of worship requiring optimal lighting. The aim of the research is to understand the lighting concept in the Al-Raudhah Mosque, Medan. This qualitative research uses a descriptive-explorative method. Primary data were obtained through direct surveys of the object being studied. Secondary data collection was sourced from literature studies. The results of the research show that the natural lighting concept in the Al-Raudhah Mosque involves four strategies: 1) Building Orientation, 2) Design of Openings (Doors, Windows, Ventilation), 3) Use of Reflective Materials, and 4) Use of Bright Colors. The building's orientation takes into account its position relative to surrounding elements and structures.

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INTRODUCTION

Natural lighting is a type of illumination obtained directly from sunlight. This type of lighting system provides visual comfort for indoor activities. Natural lighting systems are essential in the planning and design of all types of buildings. This is important to ensure that the designed buildings are more energy-efficient. The same is expected for the design of places of worship, particularly mosques. Research related to natural day lighting has been conducted several times with different objectives and methods. Some of these studies were carried out by Vidiyanti and Suherman (2020), Kelrey et al. (2023), Pratomo et al. (2023), Ulfirah et al. (2020), and Hakim et al. (2024). Vidiyanti and Suherman (2020) also conducted research to determine the visual comfort perceived by respondents at the Jami'e Darussalam Mosque. The results of Vidiyanti and Suherman's (2020) study showed that the use of skylights, although producing high levels of illumination, did not have the potential to cause glare. Meanwhile, Kelrey et al. (2023) evaluated the level of natural ventilation in the Nur Inka Mosque using Dialux software. The results of Kelrey et al.'s (2023) study showed differences between direct measurements with an environmental meter, particularly in terms of light intensity levels..

Another study by Pratomo et al. (2023) aimed to determine the extent to which openings affect the quality of natural light. Pratomo et al. (2023) revealed that the design and orientation of the window openings in the Amir Hamzah Mosque still have a deficit in terms of natural lighting. Ulfirah et al. (2020) analyzed the natural lighting in a mosque using a lux meter. The study by Ulfirah et al. (2020) aimed to assess the performance of natural lighting in the Amirul Mukminin Mosque and to determine the quality of light at various points mapped by dividing the area based on the light levels in the room.

Natural lighting in buildings is not only influenced by light-responsive design shapes but can also be related to other elements surrounding or outside the building. The context of natural physical features around the building can be a sustainable factor in a design (Syam et al, 2023; Syam et al, 2023b). This sustainability is necessary not only in terms of design accommodating shapes but also in relation to the elements around the building. This will certainly support energy savings in the future (Syam et al, 2023c). The analysis of natural lighting in this study differs from previous research conducted on the subject. This is mainly related to the primary object, the Al-Raudhah Mosque in Medan, which was studied using direct field observation techniques. The character of the Al-Raudhah Mosque also differs from other research cases, particularly in its use of transparent materials. Therefore, it is interesting to examine the natural lighting concept in the Al-Raudhah Mosque, Medan. This study aims to analyze the natural lighting in the Al-Raudhah Mosque, Medan, using the existing theoretical framework.

THEORETICAL REVIEW

Natural Lighting and Its Influencing Factors

Light is a part of the electromagnetic spectrum that is sensitive to human vision. Visible light has a wavelength range of 380-750 nm. Sunlight entering a building is categorized into three types (Szokolay et al., 2001): 1) Direct sunlight, 2) Diffuse light from a clear sky, and 3) Diffuse light from reflections off the ground or buildings. The daylight factor is the ratio of the illumination level at a specific point on a surface inside a room to the illumination level on a flat surface in an open field, serving as a measure of the performance of the room's lighting openings. According to SNI 03-2396-2001 (2021), the components of the natural lighting factor include: 1) Sky component (sky factor - fl), which is the direct lighting component from the sky; 2) External reflection component (external reflection factor - frl), which is the component originating from the reflection of objects around the building; and 3) Internal reflection component (internal reflection factor - frd), which is the lighting component originating from the reflection of interior surfaces (SNI 03-2396-2001).

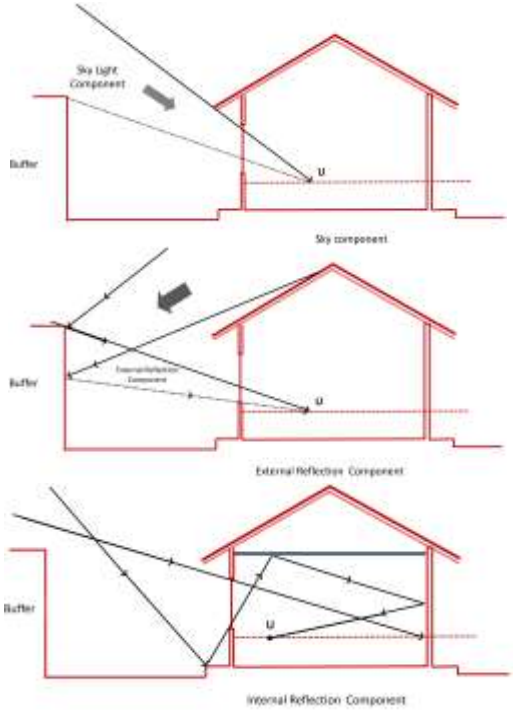


Figure 1. Components of Natural Daylighting Factors
(Source : SNI 03-2396-2001)

Natural Day Lighting System in Buildings

According to Lechner (2015), the implementation of natural lighting systems in buildings is influenced by several aspects of basic natural lighting strategies, including:

1. Orientation. Orienting the building towards the south is optimal for natural lighting as this side receives the most consistent sunlight throughout the day and year. The second-best orientation is towards the north because the light on this side is also constant. The worst orientations are towards the west and east because these sides only receive sunlight for half of the day and the sun is low in the sky, causing glare and shadow issues.
2. Roof Lighting. Openings in the roof can be either horizontal or vertical. Horizontal openings receive more light than vertical ones, but they are difficult to control for shadows. Therefore, buildings are often advised to use vertical openings in the roof in the form of clerestory windows, monitors, or configurations such as sawtooth.
3. Building Shape. Based on the same area, square and rectangular buildings have different lighting characteristics. A square layout has 16% of the area not receiving natural light, 33% receiving partial light, and 51% receiving maximum light. A rectangular layout eliminates the dark central area but still has a large area receiving partial light. A square layout with an atrium in the center can receive full light by using top lighting above the atrium.

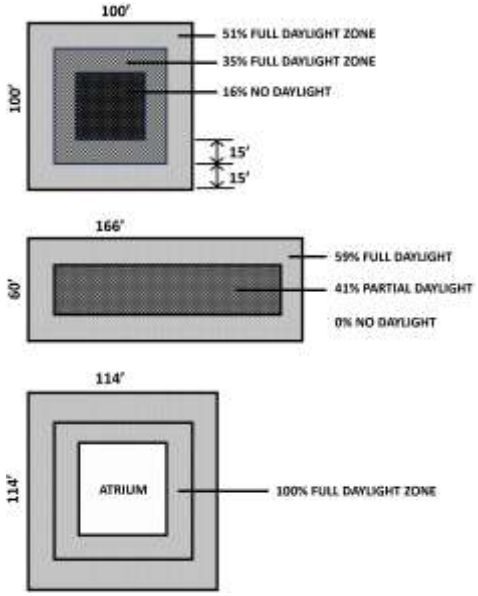


Figure 2. The Basic Shape of Building
(Sumber : Lechner, 2015)

4. Space Planning. This aspect relates to interior spaces, such as the use of glass partitions to bring light into the room (borrowed lighting), taking light from openings directly bordering the exterior space.
5. Color. The use of bright or light colors is preferred because they reflect more light, both on the exterior and interior of the building.

The light entering the building at certain months is also influenced by the position of the sun, such as on June 21st and December 21st when the sun is at its farthest position from the equator. The analysis of natural lighting in this research utilizes a theoretical framework as discussed in the theoretical review above, namely: 1) Building Orientation; 2) Roof Lighting; 3) Building Shape; 4) Space Planning; and 5) Color.

METHODOLOGY

This study is a qualitative research that utilizes a descriptive-exploratory method based on Muhajir (2000, as cited in Nuraini et al., 2023a) and Howel (2013, as cited in Nuraini et al., 2023b). Data collection was conducted through direct field surveys (Groat and Wang, as cited in Nuraini, 2024) and documenting the research object into matrix diagrams of plans, elevations, and sections. The results of the field survey were then analyzed using the theory of natural lighting systems in buildings based on Lechner's theory (2015) to demonstrate the lighting analysis of the case study object, the Al-Raudhah Mosque in Medan.

RESULTS

Description of Al-Raudhah Mosque in Medan

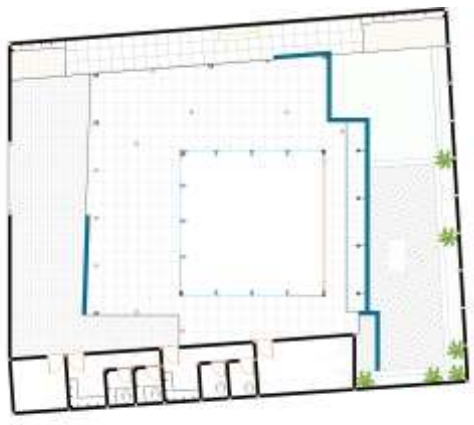
The Al-Raudhah Mosque in Medan is located on Kemuning Street, in the Tanjung Rejo village, Medan Sunggal district, Medan City, North Sumatra. The mosque is situated near the complex of the Shafiyyatul Amaliyyah Educational Foundation (YPSA) and was built by the extended family of YPSA. This mosque has a Ka'bah-shaped concept with its main hall surrounded by glass. This provides a bright effect throughout the mosque's interior through natural lighting. The mosque's concept also gives an open impression with the use of transparent glass, complemented by architectural details. The location of the mosque can be seen in figure 3. The front view of the Al-Raudhah Mosque can be seen in figure 4.

Figure 3. The location of Al-Raudhah Mosque
(Source : a. Lamudi, 2023; b/c. Googlemaps, 2024)

Figure 4. Front view of Al-Raudhah Mosque in Medan
(Source : Studio Entitas, 2014)

The design of Al-Raudhah Mosque in Medan

The Al-Raudhah Mosque is built on a site that is not too large and has several natural physical advantages, namely lush vegetation in the form of trees. The mosque is designed to be open so that the square-shaped prayer area provides uniform lighting effects that are received and enter the building. The location of the mosque within its site, in the form of a ground plan and site plan, can be seen in figure 5. The floor plan of this mosque is basically square or rectangular. When viewed from the choice of shape, a square is a shape that is flexible. The square shape of the floor plan of the Al-Raudhah Mosque also accommodates the imaginary lines of people forming the prayer shaft and forming a square. The prayer area of this mosque is only one-eighth of the total site area. The site is mainly allocated for open spaces in the form of terraces and courtyards. The view of the Al-Raudhah Mosque building with a site-appropriate view can be seen in figure 6.



a

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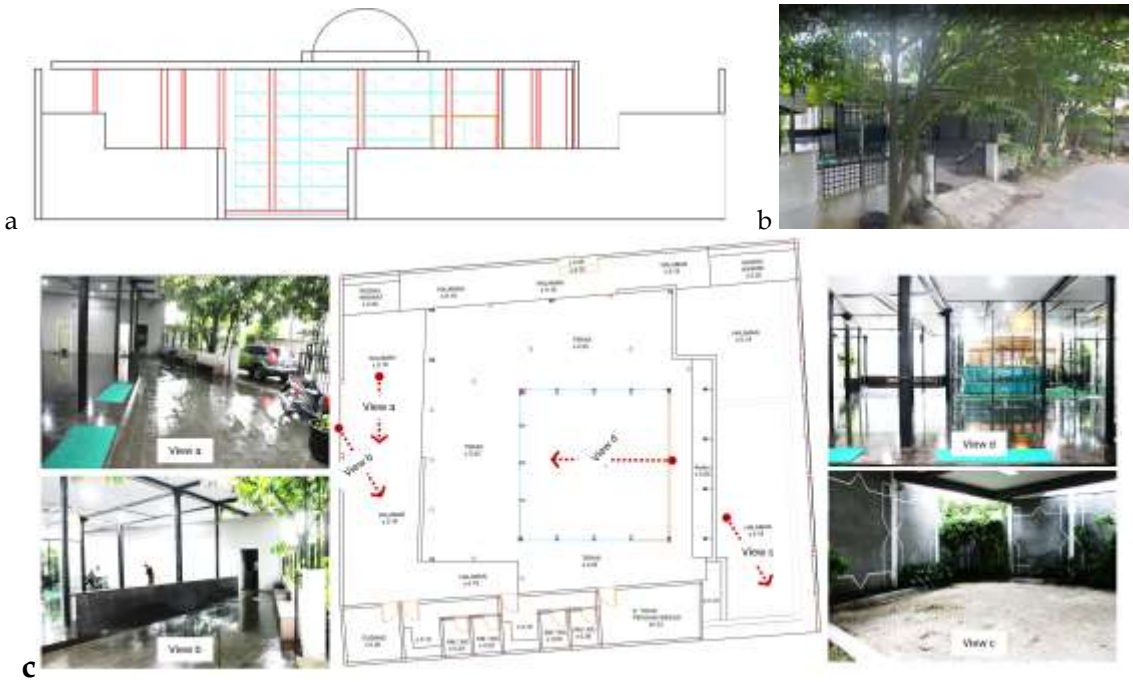
Figure 5. a. Groundplan; and b. Siteplan
(Source : Authors, 2024)



a b c

Figure 6. a. Front View of Al-Raudhah Mosque; b. Entrance Gate of Al-Raudhah Mosque; and c. View from Several Observation Spots
(Source : Authors, 2024)

DISCUSSION

Based on the theoretical framework outlined earlier, the discussion of the analysis of natural lighting in the Al-Raudhah Mosque in Medan follows the sequence: 1) Building Orientation; 2) Lighting; 3) Building Shape; 4) Space Planning; and 5) Color. The explanation of each analysis substance can be elaborated as follows:

Building Orientation

In terms of building orientation, the Al-Raudhah Mosque is positioned in a north-south direction. The eastern and western areas are provided with facade protection so that the light effects passing through the north and south sides can maximally enter the building. Glare effects from the west and east sides are mitigated by planting shading trees and concrete overhangs, thus obscuring glare and shadows. Illustrations of building orientation regarding glare and shadow effects can be seen in figure 7.

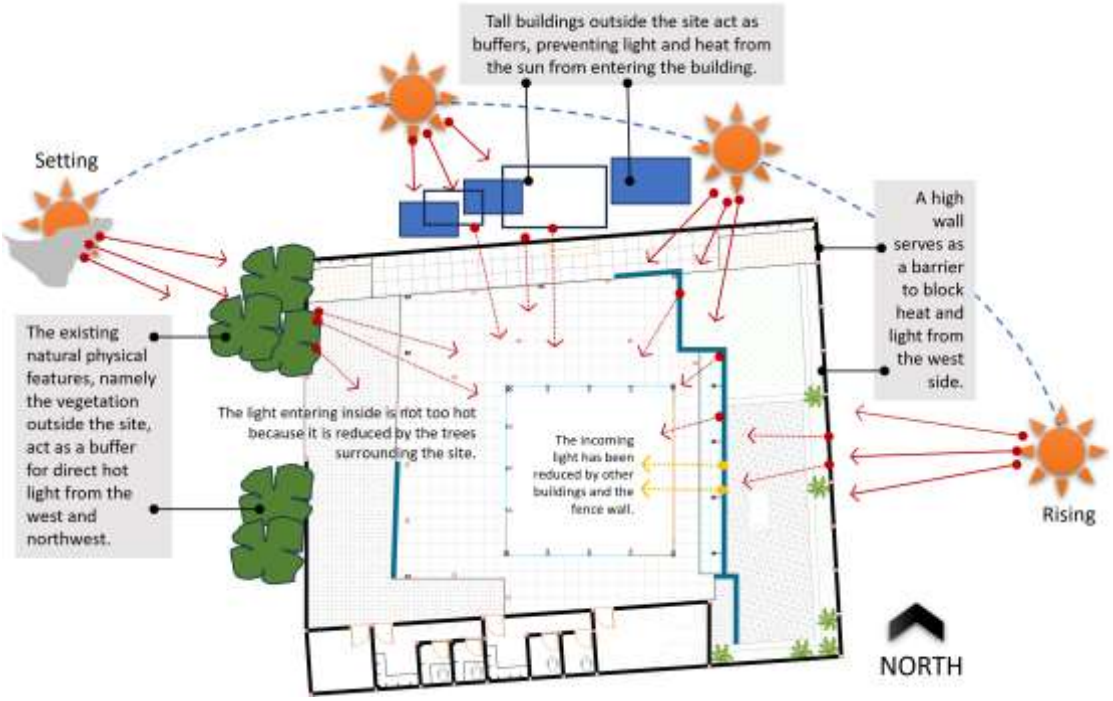


Figure 7. Analysis of Building Orientation
(Source : Authors, 2024)

Roof Lighting

Natural lighting in the Al-Raudhah Mosque in Medan is maximized through the use of glass surrounding the prayer hall. The use of transparent glass material also reduces the use of lights inside the mosque and maximizes the use of sunlight as its illuminator. The light entering the mosque makes the space inside the mosque appear more spacious due to the use of glass material. In addition to the vegetation outside the site, which greatly helps create a cool and lush atmosphere, several vegetation are also planted inside the site to minimize the sunlight entering, making the mosque feel cooler and greener. The analysis of lighting and roof lighting in this mosque can be seen in figure 8.

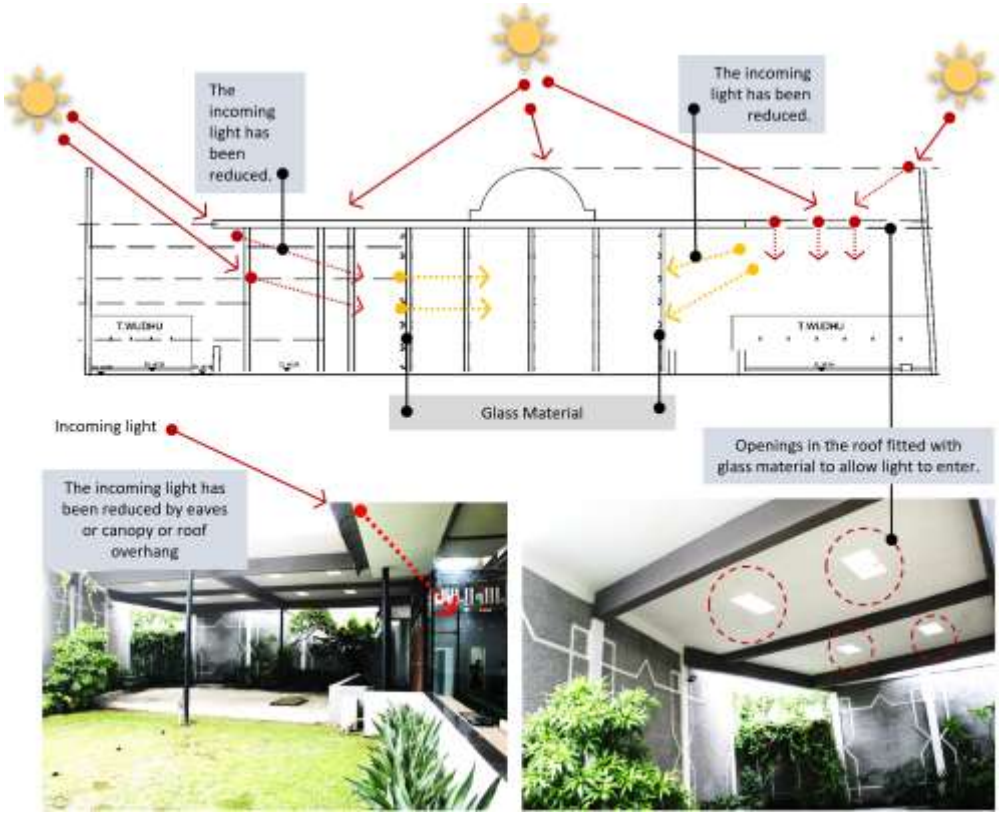


Figure 8. Analysis of Lighting
(Source : Authors, 2024)

Building Shape

In terms of its basic shape, this mosque uses a square layout. This indicates that, in terms of the floor plan, the prayer area of the mosque has 100% of the area receiving maximum light. This is because of the use of glass material surrounding the main hall (prayer area), so automatically the prayer area receives maximum natural lighting during the daytime. The existing lights are used during the evening and night. Analysis of the shape regarding lighting can be seen in figure 9.

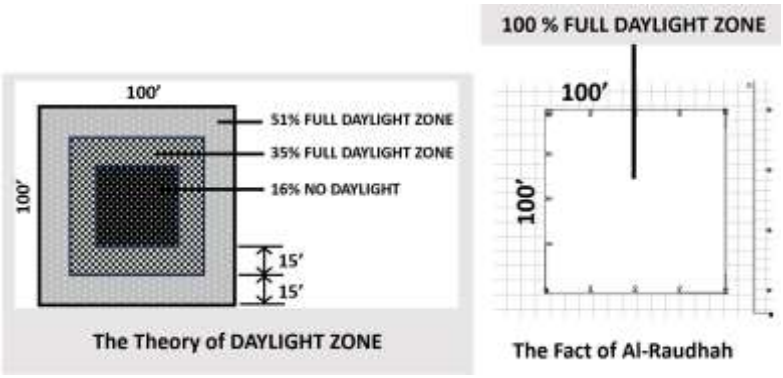


Figure 9. Lighting Analysis of Building Shape
(Source : Authors, 2024)

Space Planning

Space planning involves the use of materials that can bring maximum light into the building. The core space of this mosque uses transparent glass materials, allowing maximum light to enter the prayer area during the daytime. If the use of glass is not maximized, the potential light entering may be only around 35%. Analysis of space planning that selects the use of glass materials in the design of this mosque can be seen in figure 10.

Figure 10. Space Planning with the use of Glass as Walls
(Source : Authors, 2024)

Color

The use of bright colors in this mosque is also one of the factors that maximize natural lighting in the building. The dominance of white color and a hint of orange on the room divider in the mihrab area leads to maximum lighting with a play of natural colors. Several appearances of the use of bright colors in the mosque area and its interior can be seen in figure 11.

Figure 11. The use of Bright Colors on the Walls, Ceilings, and Partitions (Source : Authors, 2024)

CONCLUSIONS AND RECOMMENDATIONS

Based on the survey results and simple analysis conducted at Al-Raudhah Mosque, several conclusions can be drawn:

1. Natural lighting in this mosque applies five basic principles: orientation, roof lighting, building shape, space planning, and color usage.
2. The aspect of building orientation considers the position of the building in relation to other elements surrounding it, such as taller buildings, trees outside the site, and surrounding building walls.
3. Roof lighting aspect is maximized in several parts of the building where the walls do not use glass, such as the ablution area and corridor.
4. The building aspect is differentiated into the main prayer area which maximizes natural light through a square shape and supporting areas that maximize natural light from the roof.
5. Space planning aspect maximizes the use of transparent glass elements in the main area (prayer area) to obtain 100% natural light.
6. The aspect of color usage reflects maximum natural lighting because of the use of bright and natural colors, such as white.

As for recommendations, one should consider that the implementation of the five aspects of natural lighting in buildings, especially places of worship such as mosques, should take into account the surrounding conditions. The potential of the environment that supports natural lighting design should be maximized, such as the presence of vegetation outside the site and taller buildings can be used as a building setting strength so that natural lighting can enter maximally without causing excessive heat. To maximize lighting while ensuring comfort from glare and heat, it is advisable to choose environmentally friendly and low-emission glass materials such as Low-E (Low-Emissivity) Glass, Tinted Glass, Reflective Glass, Insulated Glass (Double or Triple Glazed), or Laminated Glass with UV Protection.

FURTHER STUDY

This study is a basic research on natural lighting in the case study of a mosque that utilizes glass elements in its walls. It is interesting to further investigate the use of other materials, especially constructions that support the use of glass elements as the main material for its walls. Construction and structures that can support the use of glass elements in building design are also interesting to study, especially in cases of buildings other than mosques.

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