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# Lighting for the Elderly in the Interior of Santa Maria Fatima Church, Magelang

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## Abstract

*The church is a place for religious communities to worship. Architecture within the church can be used to create spiritual experiences and strengthen religious identity. One of the elements capable of facilitating spiritual experiences for the congregation is the element of enlightenment. In addition to serving to arouse a spiritual atmosphere in the church, lighting also serves as a symbol of religion and illumination in the space. In the case study of the Church of St. Mary Fatima Magelang, the church is undergoing a reconstruction process in which the old church will be established and rebuilt using a new design. One of the special conditions of the church of Santa Maria Fatima Magelang is that the majority of the congregation in the church is elderly. The aim of this research is to find natural and artificial lighting designs that can provide visual comfort to the elderly during worship and maintain the spiritual atmosphere in the church of St. Mary Fatima Magelang. This research uses quantitative descriptive methods. The result of this study is the addition of vertical shading to the east side opening to regulate the intensity of light entering the worship room. In the case of artificial lighting, a number of applications of lighting colors, lighting types, angles, and lighting arrangements correspond to the Model 3 study, which has proven to provide visual comfort to the elders as well as a spiritual atmosphere at Mass.*

Keywords: natural lighting; artificial lighting; catholic church; elderly

## 1. Introduction

Church architecture plays an important role in creating a spiritual experience and strengthening religious identity. Lighting plays a key role in providing this experience by creating a dramatic atmosphere that enhances the congregation's connection to the Divine. Byzantine churches, for instance, employed light to evoke mystical and spiritual experiences, directing the congregation's focus towards the altar, where they experienced a profound sense of God's presence. Lighting also functions as a religious symbol and is important in facilitating worship rituals and helping the congregation follow the worship procession.

In the case of the Santa Maria Fatima Church in Magelang, which is being reconstructed, accommodating the needs of the congregation, the majority of whom are elderly, is a challenge in itself. The decline in vision experienced by elderly congregants requires special attention to lighting design to ensure a spiritual atmosphere and practical visual comfort. Understanding seniors' preferences, such as a tendency toward soft, warm colors due to visual sensitivity, is important in creating a welcoming environment for all.

Challenges in current church design, such as excessively high ceilings and potential glare from openings on the east side, also had to be addressed. Harmonizing the needs of the elderly with the spiritual atmosphere in the church becomes a complex design dilemma.

This study aims to explore lighting design in the Church of Santa Maria Fatima with the aim of balancing the needs of the elderly congregation with the spiritual atmosphere during mass services.

## 2. Literature Study

Natural lighting in Catholic churches relies on light from the sun entering through openings in the church. Natural lighting can be used during morning mass hours, so more attention is needed to avoid glare due to excessive light

entering through church openings. There are several factors that need to be considered for visual comfort related to natural lighting, namely the level of bright light intensity, even distribution of light illuminance, and light glare limits that do not exceed standards [1].

Regarding artificial lighting, church architecture certainly cannot be separated from its theological aspect, namely the church liturgy. Based on the liturgical function, zones or sacred spaces are created in Catholic church architecture, where these zone divisions will reflect the sacredness of the Catholic church. First, the most sacred area in the layout of a Catholic church is the sanctuary or altar, which is where the Holy Eucharist meal is held. Second is the chancel area or choir section. Finally, the nave is the middle part of the church where people attend worship [2]. As it is known that lighting has an effect on creating an atmosphere in a space, it has also been proven that increasing the level of lighting illuminance in three areas of the church from the lowest level (narthex area) to the highest level (altar area) helps increase the focus of the congregation towards the altar or the priest who leads the way of worship [3].

Based on SNI 03-6575-2001 concerning Procedures for Designing Artificial Lighting Systems in Buildings, it is stated that the lighting standard for churches is 200 lux. According to [4], an illuminance level of 150 lux from a height of one meter above the floor is a good starting point where lighting can be developed for the congregation area (nave area). At this level, it is possible for people to read the Bible or prayer book well. Meanwhile, the color of light used is a warm color with a color temperature of 2700K to 3000K. The lights used can be general lighting, such as hanging lamps installed on the ceiling or church structure, depending on the condition of the ceiling. If the church ceiling is too high, lights can be installed in vertical columns to support the main lighting. The shape of the church, which has high ceilings, makes placing lights on the ceiling inefficient. Therefore, to meet people's functional needs for reading, the use of task lighting can be a solution to increase visual comfort [5].

Furthermore, the lighting level is increasing in the chancel area, or the place for the choir, music, and reading staff during worship. The illuminance level used is 200 lux so that officers can read the readings for a long time. The important thing to note is that the person speaking must receive attention, so the use of beam lighting or flood lighting with a color temperature of 4000K to 6000K can be used to illuminate the focus object and create color contrast between the subject and the background so that it stands out visually. In addition, lights hanging from the ceiling or building structure can also be used at a lower height than hanging lights in congregation areas.

The final area is the altar, which must be the visual focus object in the church. Therefore, the lighting level must be higher than the previous area, which means more than 300 lux. Lighting of 300 lux makes the environment look bright and clear, where the lighting must be distributed evenly so that no area is too bright or too dark. The lights used in the sanctuary area (the entire altar area) are general lighting in the form of spotlights installed on the side wall of the altar at a height of 8 meters from the floor. The light color used on the altar is warm white with a range of 2700K to 3000K [5]. Important parts of the altar include the altar table, tabernacle, and pulpit, where the priest leads and carries out the eucharistic procession.

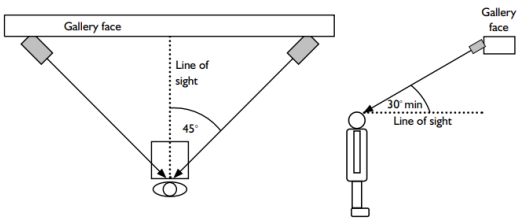


*Figure 2 1 Horizontal and Vertical Lighting Angles*

The type of lighting that can be used is spotlights installed from the direction of the congregation with a lighting angle of 45° horizontally and 30° to 45° vertically to avoid glare (figure 2.1). The color of light used is 4000K for cold temperatures, or you can also use 2700K to 3000K for warmer color temperatures [3]. The difference in lighting levels and color temperature of light between the altar and the central room where the congregation is located creates a contrast that helps the congregation focus towards the altar.

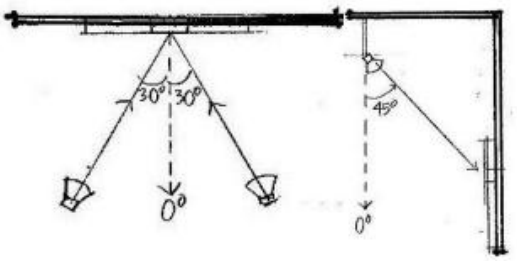


*Figure 2 2 Placing the corner of the spotlight on the Altar Symbol*

Apart from the main lighting in the altar area, there is also special lighting to illuminate the symbols on the altar. This lighting uses an accent lighting technique in the form of up lighting or downlighting with a lighting angle of 30° from the right, left, or center, or it can also be done with a 45° angle highlighting vertically towards the object from bottom to top [6]. Apart from that, the use of a spotlight lamp that is fired towards the cross with a lighting angle of 30° horizontally and 45° vertically can also be used (figure 2.2), with a color temperature of 3000K [7].

## 3. Research Method

This research uses quantitative descriptive methods. In the research process, data will be collected regarding the illuminance of the prayer room according to the latest church

design. Then the measurement results are used as a benchmark to find the appropriate level of illuminance in the prayer room by changing the color of light and type of lamp in the simulation.

Data collection was taken from natural and artificial lighting simulations in the new church design to determine the level of illumination in the worship space of the Santa Maria Fatima Church, Magelang. Meanwhile, data analysis was carried out using quantitative methods with natural and artificial lighting simulation data using dialux. The simulation process is carried out using several appropriate design scenarios based on light color, lamp type, lumens, and lighting angle. After analyzing the simulation results, the best scenario was found, which will later be applied to St. Maria Fatima Magelang.

## 4. Result and Discussion

There are three things that will be discussed, namely:

### *4.1 Natural Lighting*

The problem occurred at the opening of the church, which was oriented to the east, in December at 8.00 a.m.

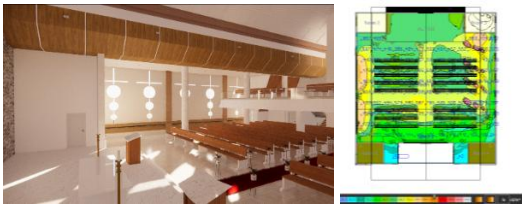

*Figure 4.1 1 Problem in the East Church Opening*

The amount of light entering is too much, causing the illuminance value to be in the range of 5000 lux, marked in red (Figure 4.1 1). This can cause glare in the congregation area, thus contradicting the theory, which states that visual comfort is related to glare standards and even the distribution of light (Risky et al., 2016).

The solution to this problem is done by adding shading to reduce excessive illuminance entering the prayer room.

*Figure 4.1 2 Vertical Shading*

The shading form used is vertical shading (Figure 4.1 2) using Polyvinyl Coated Membranes (PES) material.

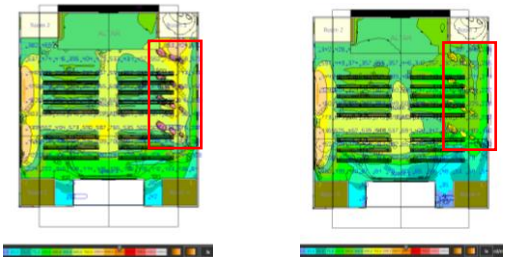

*Figure 4.1 3 Simulation Result of Vertical Shading*

The amount of illuminance entering the prayer room has decreased significantly (Figure 4.1 3). This is in accordance with the theory from the book Architectural Graphic Standards 8th edition, John R. Hoke, ed. Wiley, 1998, which states that shading in the form of rotating vertical fins is good for openings that have a west and east orientation.

### *4.2 Artificial Lighting*

The problem of artificial church lighting is related to the amount of light illuminance in the altar area not meeting standards, and the distribution of light is still not evenly distributed in all areas.

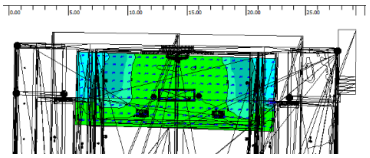

*Figure 4.2 1 Altar Illuminance Level*

The illuminance level in altar area is only 112 lux (figure 4.2 1), so it still does not meet the standard, which is ≥300 lux (Suriyothin, 2016). The distribution of light in the altar area is also not evenly distributed, as can be seen from the distribution of green color (200 lux) only in the middle of the altar. Meanwhile, the edge of the altar has a blue color (50-100 lux) (figure 4.2 1).

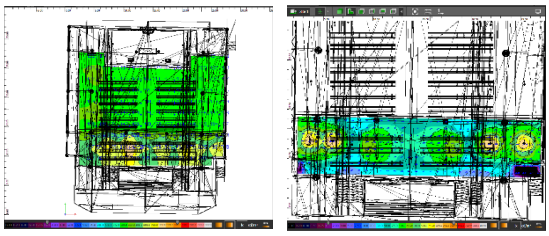


*Figure 4.2 2 Congregation and Balcony Area Illuminance Level*

The distribution of light in the people's area is still uneven, both up and down. As shown in Figure 4.2 2, the lower population has an uneven yellow (500 lux) indicator in the lower area of the balcony, whereas the upper population also

Before After

has a green (200 lux) and a circle-shaped yellow (500 lux), which is uneven between the blue indicators (50-100 lux).

*Figure 4.2 3 Dialux Render for Altar and Congregation Area*

The solution to this problem is to design a model study using the color of the warm white lamp (3000K) on the altar and the neutral white lamp color (4000K), on the public area, and the cool white color (6000K, on the chancel area). The type of lighting used is a combination of general lighting, spotlight, and downlight in all areas. The entire lamp is placed at angles of 45° and 90°. The lamps are placed in the ceiling area as general lighting, in the column structure and in the symbol area as spotlight. (figure 4.2 3).

### *4.3 Validation Test for Study Model 3*

After finding the best model study, a model study test was carried out on ten elderly respondents who were members of the Church of St. Mary Fatima Magelang.

*Figure 4.3 1 3D Visualization on Oculus VR*

The test was carried out using the Oculus Virtual Reality tool to determine the level of comfort of the elderly while reading at Mass (figure 4.3 1).

| NO | R | Kejelasan | | | | Lelah Mata | | | | Tidak Sakit Kepala | | | | Tidak Kaku Leher | | | | Tidak Stress | | | | Fokus | | | | Tidak Silau | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 4 | 5 | 1 | 2 | 4 | 5 | 1 | 2 | 4 | 5 | 1 | 2 | 4 | 5 | 1 | 2 | 4 | 5 | 1 | 2 | 4 | 5 | 1 | 2 | 4 | 5 |
| 1 | L 67 | | | ✓ | | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | ✓ | | | | | | ✓ |
| 2 | L 78 | | ✓ | | | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | ✓ | | | | | | ✓ |
| 3 | L 76 | | | ✓ | | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | ✓ | | | | | ✓ |
| 4 | L 75 | | | ✓ | | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | ✓ | | | | | | ✓ |
| 5 | L 68 | | ✓ | | | | | ✓ | | | | ✓ | | | | | ✓ | | | | ✓ | ✓ | | | | | | ✓ | |
| 6 | P 65 | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | ✓ | | | | | ✓ |
| 7 | P 65 | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ |
| 8 | P 73 | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ |
| 9 | P 75 | | | ✓ | | | | ✓ | | | | ✓ | | | | | ✓ | | | | ✓ | | | ✓ | | | | | ✓ |
| 10 | P 72 | | | ✓ | | | | | ✓ | | | | ✓ | | | | ✓ | | | | ✓ | | | ✓ | | | | | ✓ |

*Figure 4.3 2 Result of Validation Test for Study Model 3*

Test results showed that the Model 3 study can provide visual comfort to the elderly while reading, whileining a spiritual atmosphere during the Mass (figure 4.3 2).

## I. CONCLUSION

The conclusion of this study is design evaluation on natural lighting is on the opening on the east side that has been proven to be potentially causing blur. This can be seen from a simulation showing red indicators in the 5000lux range.

Then, redesign for natural lighting can be done with the addition of vertical shading to covers the front of opening area on the east side. The shading has mechanisms that can be opened and closed as needed. The addition of this shading has been shown to reduce the amount of illumination coming in, as seen from the simulation results that showed the illuminance value of 5000 lux changed to 500 lux.

Meanwhile the problem of artificial lighting in St. Mary Fatima is the average amount of illumination on the altar is 112 lux so it still does not meet the standard. Another problem is the uneven distribution of light in almost the entire worship area, causing a glare of more than 30 UGR.

Redesign on artificial lighting using a Model 3 study that uses the color of the warm white lamp (3000K) on the altar and the neutral white lamp color (4000K), on the public area, and the cool white color (6000K, on the chancel area). The type of lighting used is a combination of general lighting, spotlight, and downlight in all areas. The whole lamp is placed at angles of 45° and 90°. The lamps are placed in the ceiling area as general lighting, in the column structure and in the symbol area as spotlight. The illumination values obtained on the altar were 315 lux, on the chancel area 200 lux, in the upper population area 232 lux, and in the lower population area 169 lux.

## APPENDIX

The analysis is performed using quantitative methods with natural and artificial lighting simulation data using dialux and simulated using several appropriate design scenarios based on light color, type of light, lumens, and lighting angle. The schemes obtained from the simulation results will be subsequently analyzed to choose which scenarios are suitable for the comfort of the elderly and retain a spiritual atmosphere during Mass worship (Table 1 1).

*Table 1 1 Studies Model for Artificial Lighting*

| Design Studies | Location | Location Details | Light Color | Types of Lighting | Angle & Placement | Lighting Standards | Illumination Value | UGR Value |
|---|---|---|---|---|---|---|---|---|
| Studies 1 | Altar | Tabernacle Area, Altar Table, and Pulpit | 3000 K | Spotlights installed from the direction of the faithful | 45° right left church structure | **Illumination**: ≥ 300 lux<br>**UGR limit** : 19<br>**Uniformity** : >0.4<br>**Cylindrical Lighting** : >150 lux | | |
| | | Sanctuary Area | 3000 K | Spotlight mounted on the side wall of the altar at a height of 8m from the floor | 60° spotlight up and down | | | |
| | | Side area of the altar | 4000K | Downlight | 90° spotlight down | | | |
| | | Altar Symbol | 2700 K | Accent lighting by using uplighting techniques | 90° from bottom to top | | | |
| | | | 3000K | Striplighting to emphasize the shape of the altar where the cross symbol is placed | | | | |
| | Chancel Area | Choir Area | 4000 K | Beam lighting | 25° installed from the church structure | **Illumination** : 300 lux<br>**UGR limit** : 22 | | |
| | Congregation Area | Congregation Upper Area (balcony) | 3000 K | General lighting (pendant lights) installed on church structures and ceilings | | **Illuminansi** : 150 lux<br>**UGR limit** : 25 | | |

| Design Studies | Location | Location Details | Light Color | Types of Lighting | Angle & Placement | Lighting Standards | Illumination Value | UGR Value |
|---|---|---|---|---|---|---|---|---|
| | | Lower Congregation Area | 3000 K | The fluorescent lights installed in the church structure are equipped with tasklighting to assist the faithful in reading. | | | | |
| | | Ceiling | 3000K | Using floodlights installed in the church structure, then shining them on the ceiling | 45° upwards | | | |
| Studi 2 | Altar | Tabernacle Area, Altar Table, and Pulpit | 4000 K | Spotlights installed from the direction of the faithful | 45° right and left church structure | **Illumination** : ≥ 300 lux<br>**UGR limit** : 19<br>**Uniformity** : >0.4<br>**Cylindrical Lighting** : >150 lux | | |
| | | Sanctuary Area | 3000 K | Spotlights mounted on the side walls of the altar | | | | |
| | | Side area of the altar | 3000K | Downlight | 90° downside | | | |
| | | Altar Symbol | 3000 K | Spotlights fired at the cross and other symbols | 30° right left highlighting from above | | | |
| | Chancel Area | Choir Area | 6000 K | Flood lighting | | **Illumination** : 300 lux<br>**UGR limit** : 22 | | |
| | Congregation Area | Congregation Upper Area (balcony) | 2700 K | Fluorescent lights installed on church structures and ceilings | | **Illumination** : 150 lux<br>**UGR limit** : 25 | | |
| | | Lower Congregation Area | 3000 K | The fluorescent lights installed in the church structure are equipped with *tasklighting* to assist the faithful in reading. | | | | |
| | | Ceiling | 3000K | Spotlights directed to the ceiling of the church structure | 45° upwards | | | |
| Studi 3 | Altar | Tabernacle Area, Altar Table, and Pulpit | 2700 K | Spotlight leading to the altar | 45° right and left church structure | **Illumination** : ≥ 300 lux<br>**UGR limit** : 19<br>**Uniformity** : >0.4<br>**Cylindrical Lighting** : >150 lux | | |
| | | Area Sanctuary | 3000 K | Spotlights mounted on the side walls of the altar | | | | |
| | | Altar Symbol Area | 3000 K | Accent lighting untuk penekanan simbol di altar | 45° horizontally | | | |
| | | Side area of the altar | 3000K | Downlight | 90° highlight down | | | |
| | Area chancel | Choir Area | 6000 K | Beam lighting | | **Illumination** : 300 lux<br>**UGR limit** : 22 | | |
| | Area Umat | Congregation Upper Area (balcony) | 3000 K | Fluorescent lights installed in church structures | | **Illumination** : 150 lux<br>**UGR limit** : 25 | | |
| | | Lower Congregation Area | 4000 K | The fluorescent lights installed in the church structure are equipped with *tasklighting* to assist the faithful in reading. | | | | |
| | | Plafond | 4000K | Using spotlights installed in the church structure, then shining them on the ceiling | 45° upwards | | | |


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