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# Optimizing Smart Shading System in the Unit Residential Housing in Surabaya

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**Abstract**

In sustainable architectural practice, the climate aspect greatly determines the requirements for the comfort conditions of the building resulting from the design on the building facade. The potential that comes from sunlight to influence lighting performance depends on the performance of the facade. The linear relationship between light intensity and window opening is often expressed, this lighting approach is needed to optimize the facade performance configuration of the four building areas. Excessively sunlight entering space can be controlled by a shading system to block the angle of sunlight that varies from time to year. The lighting performance that comes from direct sunlight is greatly influenced by the composition of the window openings installed. This paper presents a lighting model using an automatic shading panel that is able to move opening and closing depending on the intensity of light entering the room. Field measurements are carried out every hour in one day between 6:00 until 16:00 in the south, north, east, and west fields then the results are simulated quantitatively. The results showed that the imaging panel device was able to work open and close according to the movement of sunlight, and the orientation of the openings also affected the amount of light intensity that entered the space. The optimal performance of the opening generated by this automatic shading panel occurs in the south orientation is 65-85 degrees with an opening of 12,81-14,42% of the window area.

***Keywords:*** *Optimizing, opening window, light intensity, automatic shading panel.*

## 1. Introduction

Natural lighting that enters the space comes from sunlight, either directly or indirectly. In the Big Indonesian Dictionary, the sun is the center point of the solar system in the form of a ball filled with gas that brings light and heat to the earth during the day. Indonesia, which is at 6°N - 11°S, gets sunshine throughout the year, because several cities in Indonesia are traversed by the equator. This year round sunlight must be avoided in order to create thermal comfort in the building. The need for a minimum standard of sunlight that meets the requirements for comfort in space and can be used for various purposes, such as the family room and bedroom in the house, has an intense need for light in the range of 60-120 Lux (Rissa Damayanti, 2018).

The use of permanent shading systems is often unable to block the entry of sunlight, which changes from time to time during a year's rotation of the sun. So that the entry of sunlight into the room sometimes exceeds the expected light intensity requirements so that the comfort of the room is disturbed, or even because there is no barrier system that blocks the entry of sunlight into the room it will cause glare. The existence of a barrier that is located above the opening and is still located such as a sosoran or curtain is not able to provide sufficient filter and is able to block the entry of sunlight in the morning or evening (Zulhendri K. and Ridho P. 2017)

Why did this happen. Because the concept of conventional shade does not consider the parameter of the angle of direct light fall and cannot actively adapt to changes in sunlight intensity that occur outside the room. So we need a shading system that can adjust to these changes automatically, especially to avoid excessive light intensity in space (Prowler, 2008). Considering this, the shading device in this study is designed to work automatically based on the light parameters in the room, so it is hoped that this system will support the realization of a smart device that makes it easier for buildings to increase visual comfort when doing activities in it.

The sun barrier system or shading device is a system of preventing or blocking the entry of sunlight from entering the space as needed (M. Nurul Imam, 2019; SNI, 2001). Placement of the sun barrier system in front of the opening will control the entry of sunlight into the space, especially direct sunlight so that there is no glare or excessive light intensity in the space. Because this will have an impact on decreasing the quality of comfort in the room due to increased heat in the room so that the room becomes hotter or the temperature in the room increases.

From the results of previous research (Zuhri, 2010) it is said that space openings greatly affect the entry of sunlight into the room, but openings that do not have a shading system will cause the intensity of light entering the room to also not determine the size or difficulty. controlled. In this study, a sun barrier system was applied with a simple folding technique to understand the behavior of the geometric pattern opening and closing it on the building façade (Snyder, 1979).

The application of this shadowing system uses a control system that detects the entry of sunlight so that the lighting needs inside are still constant. This system has the ability to optimize the use of the shading system so that it is responsive to changes in the intensity of sunlight outside the room. And the lighting control system has a function to control a device that can move the image panel to open and close. These solar shading systems known as active or adaptive shading systems, also called dynamic or kinetic imaging systems, are often designed to respond to one or several environmental situations, including control over daylight. The adoption of an active shading system is an important step towards increasing energy efficiency in the built environment.

## 2. Methodology

The analysis used in this research used two methods, namely is qualitative and quantitative research. The qualitative method is used to visually see the movement of the imaging device installed in the test room which is able to move according to changes in the intensity of sunlight detected by the sensor. Quantitative measurements are used to measure the changes that occur in the imaging device and how much ability to open the device to allow incoming sunlight as needed.

The data collection technique in this study was carried out by direct observation, namely through automatic recording on the data base using a lux meter installed on the sensor. Direct observations in the field of the results of the application of the shading system applied to openings in order to find out how the system adapts to direct sunlight in the morning to evening.

## 3. Result and Discussion

Research simulation using a shading device (sun shading) which is placed in an opening whose function is to enter sunlight into the space inside. The use of this shading device is to control the sunlight entering the room to remain in a constant condition according to the required light intensity. In this measurement, a limit with a value of 100 lux to 200 lux is used as the upper and lower limits so that the device can open or close.

### 3.1 Sun Shading Device

In this sun shading device, folding shading systems are used in architecture, the use of folding forms is still new in the development of architecture technology materials, especially as a façade building. When installed, they usually have different motion typologies such as translation, rotation and scaling, where external forces are required. Recent trends in shading device design have tried to replace traditional mechanical systems with integrated intelligent and multifunctional actuators responsible for moving or controlling the mechanism.

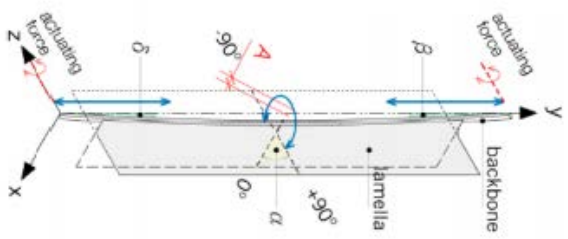


Fig. 1. Folding Shading Systems

This sun shade device is a hydraulic double panel shading device or panel. The hydraulic dual panel system is equipped with a hydraulic system that regulates the opening and closing mechanism when the hydraulic drive motor works. These hydraulic shading panels are installed in front of openings or windows in spaces where natural lighting is required.

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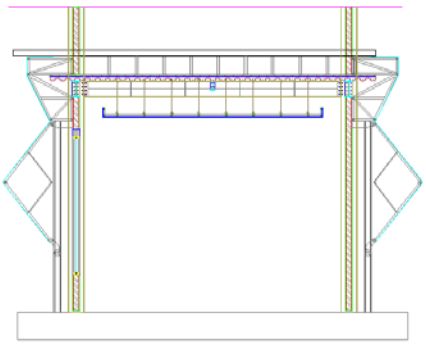


Fig. 2. Positioning of Shading Devices

The application of a mobile sun shade system to respond to changes in sun intensity so that the panel can move actively in the opening plane. This shading unit is placed in front of the opening (window) of the space according to the movement of the sun's direction, either the position of the building area to the East or West so that sunlight reception can function optimally.

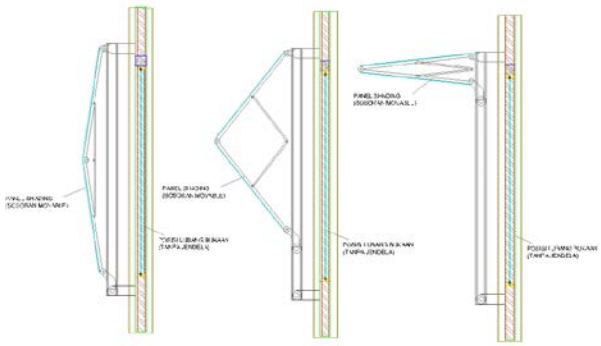


Fig. 3. Closing and Opening Panel Positions

This panel consists of two leaf blades that can move up and down on rails attached to either side. This panel is made of a hollow frame with a cover made of single-layer plywood with wheels attached to the lower right and left of the panel that can move freely up and down.

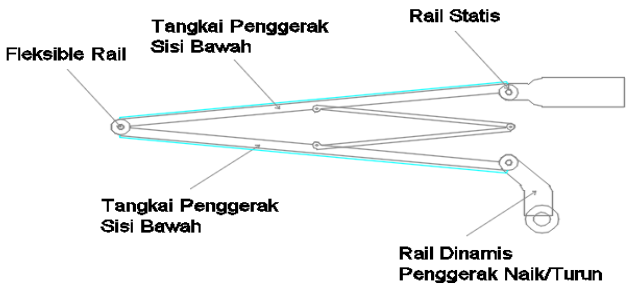



Fig. 4. Details of Shading Device

## 3.2 Automatic Device Mechanism

The shading panel drive system is based on the reception of sunlight received by a light sensor that is placed on the shading panel. In this study, a linear actuator electric drive system with a single axis type that moves on a one-sided vertical axis with control using an Arduino microcontroller. This control will regulate the light intensity change data that enters through the LDR sensor.

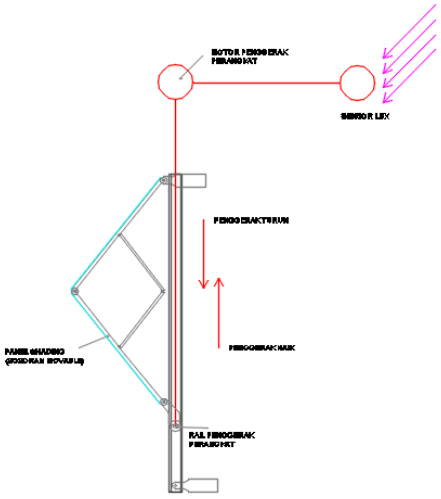


Fig. 5. Diagram Shading Device Automation System

The operation of the system is controlled by Rasberry tools which functions as a single board computer that can be used for the operation of the program to run commands for the operation of a system, namely moving the motor so that the shading panels can move up or down according to the intensity of sunlight received by the lux sensor.

Next, to move the shading panel so that it can move up or down, a gear box is used in the top of panels, which is a rotating motor engine connected to a rope connected to the bottom of the panel so that the panel can be lifted or lowered by the gear box according to the command given by Raspberry.

## 3.3 Ability of Sun Shading

From the test results to see the ability to open and close the shade device according to the movement of the sun which is in the morning 6:00 to 18:00 in the afternoon. Next, testing the opening and closing of the shading device, followed by measuring the size of the area of the opening (m2) that occurs due to the movement of the shading device each period (per hour), while the angle of incidence of sunlight is measured using an arc of 360 degrees to the work plane.

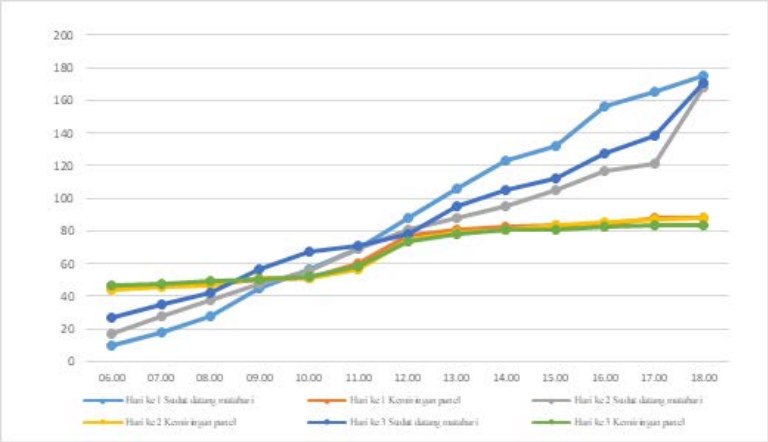



Fig. 6. Graph of measurement of the angle of incidence of sunlight as it enters the opening

From the results of the study, it was explained that the shade panel was in a slightly open position due to the high intensity of sunlight when sampling at 06.00 to 11.00 and gradually increasing the width of the opening until 16.00 because gradually the intensity of the sunlight was getting dimmer.

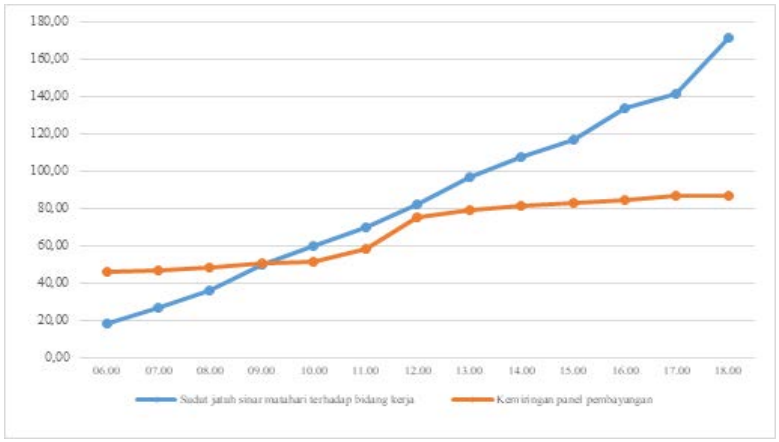



Fig. 7. Graph of the measurement of the average angle of incidence of the sun against the slope of the shading device

The movement of the shading device towards the parameters tested in the example of a flat residential unit, where the direction towards the window is located in the west and east side of the building. This example is used because the position of the sun that moves from East to West will directly hit the area of the building where the opening is from 06.00 to 18.00 the time of circulating sunlight from morning to evening with the position of the shading device installed on the unit opening occupancy.

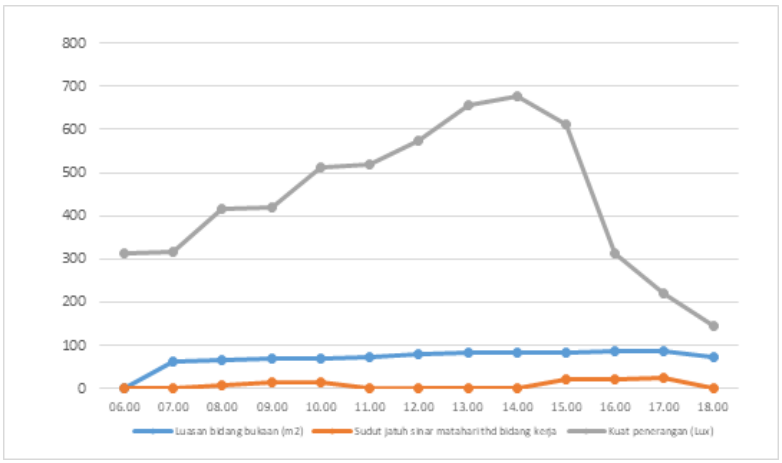



Fig. 8. Graph of the measurement of the average angle of incidence of the sun against the slope of the shading device

The ability of shading devices to open or close is capable of reaching an average area of 8.94% of the opening area. So it can be said that the intensity of sunlight outside is very high, because by opening a little the need for sunlight intensity in the room can be fulfilled properly.

## 4. Conclusion

The use of sun visors attached to room openings that function to enter sunlight into the space can function properly. The control panel is able to respond to open and close the panel according to the intensity of natural lighting that can be captured by sensors placed in the room. With an intensity range mounted on an intensity ranging from 100 lux to 200 lux, the sensor is able to respond to move the panel to open or close.

The ability of shading devices to open or close is capable of reaching an average area of 13.38% of the opening area. So it can be said that the intensity of the sunlight outside is very high, because by opening a little the need for sunlight intensity in the room has been able to be fulfilled properly and has shown that this device has a positive response to sunlight and the device works adaptively to changes in sun intensity.

With the use of materials and technology within a certain set of constraints and conditions, contemporary architectural surfaces are classified into "dynamic" and "static". The building envelope acts like the skin, the intermediary

between the interior and the exterior. This skin has evolved over time, with the help of engineered solutions; the purpose of dynamic facades is to help advance sustainable and responsive architecture.

**Appendix**

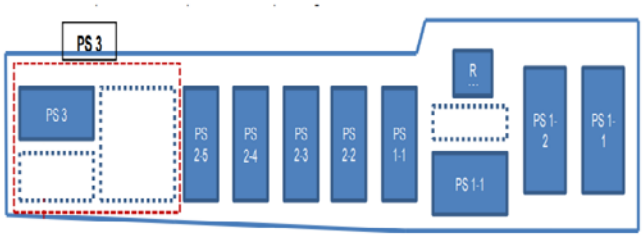



Fig. 9. Case Study Location

Table 1. Windows Types

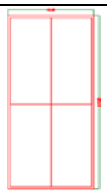
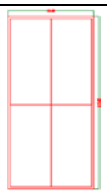
| Nu | Type | Area (M2) | Types |
|---|---|---|---|
| 1 | PS 1 | 18 |  |
| 2 | PS 2 | 21 |  |
| 3 | PS 3 | 36 |  |

Table 2. Areas

| Nu | Types | Areas (M2) | Materials |
|---|---|---|---|
| 1 | PS 1 | 1.44 | Kaca Polos |
| 2 | PS 2 | 1.44 | Kaca Polos |
| 3 | PS 3 | 2.88 | Kaca Polos |

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