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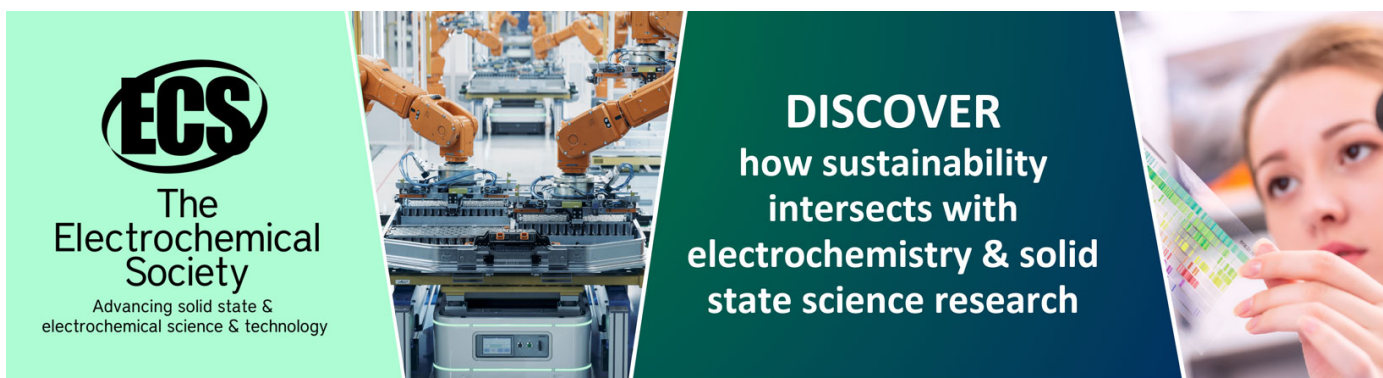
Implementation of Energy Efficiency and Visual Comfort in Malang's Foreign Exchange Office Lighting

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Implementation of Energy Efficiency and Visual Comfort in Malang's Foreign Exchange Office Lighting

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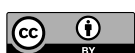
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Abstract. The Victory International Futures office is running on foreign exchange. It is located in East Java, Indonesia, in Malang. The furniture in this office has an HPL finish, which is typically dark and has a brown cotton color. The light source's reflections will be lessened as a result. The southeast-facing Victory International Futures building has good lighting. However, the lighting may be improved due to the limited artificial lighting offered in some areas and the absence of windows, which prevents daytime sunshine from reaching its full potential. Using windows where none are present results in an improper exchange of air coming in and going out. This study intends to ascertain the effects on workers caused by the influence of office air circulation and light intensity. This study's technique, a case study, requires that we visit the office right away. Data gathering methods included surveys, interviews, and using the Light Metre program to gauge light intensity. According to the test results, the typical room has more light than it needs at night. Through smart lighting, this research proposes designs to enhance the quality of conference room interiors, particularly lighting design. A standard light distribution of 73,9 lux is achieved by simulating one type of lamp already present in the space using the Light Metre application.

Keywords : Energy Efficiency, Office, Smart Lighting, Visual Comfort

1. Introduction

Lighting is one of the elements that allows workers to work on or observe the object being worked on clearly, quickly, pleasantly and safely [1]. Moreover, Victory International Futures is a trading office that requires staff to contact customers using communication tools, both cellphones, tabs, and others. In addition, adequate lighting will give the impression of a good view and refreshing environmental conditions [2]. An object will be seen if the object reflects light, either from the object itself or in the form of a reflection from another light source; thus, lighting makes objects visible [3]. Especially with the use of communication tools today, maximum light is prioritized so that vision on the screen is also not disturbed. Some buildings don't give much thought to interior lighting, even though this has a major impact on the health of the occupants [4]. Many people experience eye fatigue due to insufficient or excessive lighting, which can be



detrimental to the occupant's eye health [5].

The condition of the building at the Victory International Futures office is an old building, using HPL and cotton in the interior. The Victory International Futures building faces southeast, and the light is quite good, but in some rooms the lighting is not optimal with a few artificial lights, windows are also not provided so that during the day the light that enters the room is not optimal. Victory International Futures has operating hours until 20:00, so night lighting is essential for this building. The use of TL lamps combined with hidden lights in several parts of the interior is enough to help brighten the room. The layout of the lights is also quite standard, placed in the middle of the room can help place the lights in a balanced way [6].

Different ages of workers make it necessary to have a standard of lighting brightness intensity so that occupants can avoid problems related to eye health as well as psychological and physical aspects [7]. The intensity of the brightness of this lighting also greatly affects the concentration power produced by workers [8]. Besides that, worker comfort can also be at risk of decreasing worker performance if the lighting in the interior does not meet user standards. In the Victory International Futures office, artificial lighting with an average lamp temperature of 3000K with a light intensity of 300lx or the equivalent of 20W power in each room.

Several previous researchers have examined the comfort of indoor lighting, such as Sun et al [9], who examined work performance regarding the lighting environment in office buildings. Katabaro and Yan also examined the effect of lighting quality on worker productivity in office buildings. Mannan also conducted lighting design analysis in industrial workshops using Dialux Evo software to find new lighting design alternatives. Another study using Dialux as simulation software was conducted by Hangga et al, who examined modeling of lighting systems, including natural and artificial lighting. Meanwhile, research that applies system technology on and off lights has been carried out by Jin et al, who applied passive infrared (PIR) sensor technology to control lighting systems in office buildings. Mouri et al investigated PIR for automatic lighting and security systems. Research using Dialux Evo software to simulate lighting designs in offices and IoT technology for automated systems has never been done by researchers before, so this research is something new in this paper.

This study aims to analyze and determine the impact of light brightness on workers in the Victory International Futures office. Apart from that, it is also to measure the intensity of light in the staff area and analyze the compliance with the lighting requirements of the Indonesian National Standard (SNI) to find out what impacts are caused by the existing variables. In this study the authors provide a lamp design solution that is simulated using Dialux Evo to get lighting that fits the needs of the room. In addition, the author also implements a smart lighting system for energy efficiency in its use.

2. Literature Review

2.1. Office Definition

The meant by an office is if etymologically the term office comes from the Dutch language, namely an office which means a room in which to work, place of agency and others. Then if in English it comes from the word "Office" which means a place to provide services, work space or position. The notion of office is divided into two parts, namely dynamic and static meanings. The meaning of office dynamically is the processes in organizing activities such as collecting, recording, processing, storing and distributing data. So if in a narrow sense it is a place to carry out administrative or activities.

According to Drs. Kamisa, the office means: a building used for work related to administrative matters. According to Erns Neufert, in an office building, the main work is in information handling activities and decision-making activities based on that information. So, offices are buildings that are used for administrative and managerial work. According to George Terry, who was also adapted by The Liang Gie, stated: Office layout is the determination of the

needs in detailed use of this space to prepare a practical arrangement of physical factors deemed necessary for the implementation of office work at a reasonable cost.

Office layout is arranged based on the flow of office work so that office space planning can help workers increase productivity. In addition, good office layout arrangements will provide benefits, including: preventing the wastage of employees' energy and time, because they walk back and forth that are actually unnecessary, guarantee the smooth running of the work process concerned, enables efficient use of work space, is a certain floor area can be used for as many needs as possible, prevents employees in other sections from being distracted by the public who will fill a particular section. Office layout is arranged based on the flow of office work so that office space planning can help workers increase productivity. In addition, good office layout arrangements will provide benefits, including: preventing the wastage of employees' energy and time by walking back and forth that is really not necessary, guarantee the smooth running of the work process concerned, enabling efficient use of work space, namely a certain floor area can be used for as many needs as possible. [10].

Office procedures are office systems or sequences of execution steps - execution of office work in which the work is done and relates to what is done, how to do it where and who does it. The importance of the office system because: makes office work smoother, in carrying out work with office forms and administrative work tools which are very important. Principles of office systems, there are: office systems should be simple so as to facilitate supervision, specialization should be used as well as possible, prevent duplicate work, especially on forms, systems should be flexible and adaptable to changing conditions, appropriate division of tasks, the best use of office machines, administrative work must be carried out to the minimum. [11]

2.2. Lighting

There are two types of lighting, artificial lighting and natural lighting. Artificial lighting is designed and implemented to provide illumination in indoor and outdoor spaces using man-made light sources such as incandescent bulbs, fluorescent tubes, LEDs, and HID lamps. The quality of artificial lighting can affect visual performance, mood, alertness, and circadian rhythm regulation. For example, exposure to cool and bright artificial light at night can suppress melatonin production and disrupt sleep quality, leading to increased risk of chronic diseases such as diabetes, obesity, and cancer. Therefore, careful selection of artificial lighting sources, color temperature, intensity, and duration is critical to minimize negative effects on human health and well-being [12].

Measurement of light (photometric quantity) is a measurement of light parameters. covers the psychophysical aspects of radiation energy that can be visible to the human eye. Common photometric quantities include: Luminous flux (ϕ), is the rate of flow of light energy, or energy radiation that has been loaded with the sensitivity response of the human eye per unit time, the luminous flux has units of lumens (lm). Luminous intensity (I) is the luminous flux per unit space angle (ω , in steradian) in a certain direction. Light intensity has units of candela (cd). Illumination or intensity/level/intensity of illumination (E), is the luminous flux incident on a surface per unit area (A, in) of the surface who received the light. Illumination has units of lux or equivalent with lumens. Luminance (L), is defined as the surface of an object that emits or reflects the intensity of visible light on a unit surface area the object, expressed in candela per square meter (Cd/m²) [14].

The illumination range or brightness level required depends on the type of activity being carried out in the room [15]. For example, activities that require high concentration and visual acuity, such as reading or operating a computer, require higher levels of illumination than activities that are relaxing, such as watching television or sitting around a room. As in table 1 which contains the average illumination based on the use of the building [16].

In lighting design, keep in mind that too high or low levels of illumination from artificial lighting or natural lighting can have a negative impact on human health and comfort in the room. Therefore, selecting and setting the right level of illumination for the type of activity carried out

indoors is very important to ensure the health and comfort of the occupants of the room [17].

2.3. SNI as a Standard Reference in Lighting

SNI is a standard that applies nationally throughout Indonesia, compiled and formulated by the Technical Committee and determined by BSN (National Standardization Agency). This regulation requires goods in certain categories to meet SNI standards, and houses that are categorized as livable must have SNI [18]. This goal is carried out to fulfill safety, health, comfort, and convenience. An example is standard lighting and color rendering according to the function of the room in spatial planning. Light must be considered so that it can function as optimally as possible for the staff so they are comfortable when working. How much light is placed must be in accordance with the function of the space. Two things are obtained from the entry of the sun into the room: heat and light. Heat should be controlled as much as possible so as not to cause an uncomfortable atmosphere due to heat affecting room temperature. Light can be used as a substitute for lighting during the day.

The type of lighting that is suitable for work spaces, especially those using communication devices, requires less light so that the heat entering the room does not raise the room temperature. Then for the warehouse and bathroom it is advisable to get the afternoon sun (has a lot of radiation) so it doesn't get damp. Several sources write down the standard of light intensity in the office space. The light intensity for the workplace around the light source is 300 lux. The latter according to the recommended lighting in the office is 200-500 lux.

3. Methodology

The method used in this research is the case study method. System focused Victory International Futures office lighting in staff room. So that research aims to analyzing the lighting at the victory international futures office, by conducting a survey by looking at the conditions of the victory international futures office. Surveys are carried out during the day and at night in analyzing the incoming lighting in the office. By feeling the effects of the workers there, the author try to interview the staff how the situation of the artificial light that the office has during the day and night. So the results of the case study that has been done found a lack of lighting intensity in the room. By using this method the author managed to analyze and get the results of office space. Use of the lightmeter application as a support in measuring lighting in a room. In this study, the authors also cite several refernces from journal sources and the internet.

4. Result and discussion

4.1. Analysis Existing

From the case study, stated that the condition of the office experienced a lack of lighting which resulted in less than optimal productivity of office workers. Causes visual fatigue by an overstimulated eye function. Continuous muscle strain occurs when examining small objects on electronic devices used by workers for long periods of time, and strain on the retina can be caused by continuous light contrast. Visual weakness can irritate the eye, and cause watering and reddening of the conjunctiva of the eye, double vision, headache, decreased power of accommodation, decreased visual acuity, contrast sensitivity, and speed of reception. From the survey we conducted by interviewing Mr. Grenaldi as the office manager, it can be explained that there were complaints about lighting problems in the staff room. Staff often complain about the lack of lighting in the room / area, and feel a bit dim if used for long periods of time. Especially at night, in the morning and during the day when it's cloudy, the room will get darker, thus making it difficult for the staff to do their work and other activities.

Meanwhile, Mr. Grenaldi himself was also confused about how to solve this lighting problem due to a limited budget and lack of knowledge about lights. The data collection was carried out using a light meter measuring device in the form of a supporting application on a smartphone. The VIF office which is used as an object has 1 floor with several rooms lined up with the staff room

in the middle [20]. Activities carried out especially in the staff room have a longer term and are often used by workers or staff in the VIF office. Because of that, the purpose of choosing the room object is because the workers are more active in the staff room.



Figure 1. Down light of staff area (left) and natural light during the day of receptionist (right)

The SNI standard for light intensity in a workspace or office during activities is minimum of 100 lux [21]. While the office as a whole has an SNI standard of 200-500 lux [22]. So that at the Victory international Office a survey and measurement of light illumination was carried out in the staff room where this room is more often used for all office workers. By using the supporting light meter application on the smartphone. The light intensity results in the staff room are 73.9 lux, with 6 downlights in the middle of the room. And has a room size of 6x29 m² so that the need for lights is not sufficient for entire room.

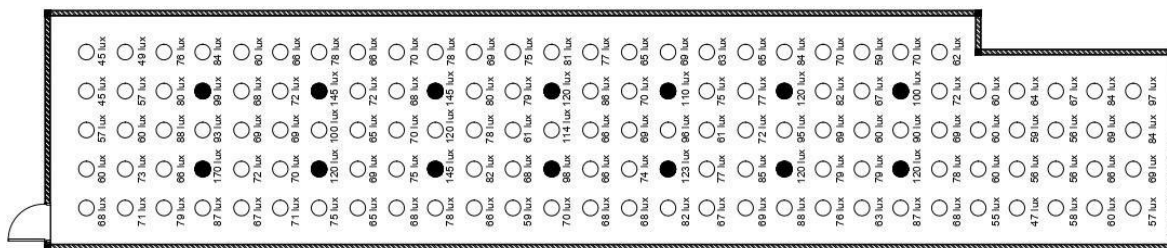


Figure 2. Measure the light intensity in a room using the lux meter application.

According to the results of measurements in the room, as seen in Figure 2, the authors took 135-point samples, and the authors did this every 1 meter. From the measurement results, it was found that the lowest light intensity was 45 lux. This number is at the farthest point from the light source. The area adjacent to the lamp will produce a brighter light intensity; the highest amount is 170 lux. For the area around the lamp, the value is less than 100 lux. The authors got an average value of 73.9 lux from the sample points the authors took. The authors add up all the values in the sample and divide it by the number of samples, and we get the average number, namely 9972 lux: 135 samples = 73.9 lux. This value is far from the standards set by SNI.

4.2. Impact of non-standard light

Based on surveys and calculations using a light meter that was carried out directly at the Victory

International Futures Office, it can be said that some of these offices lack light, especially in the staff room/area. In this room / area, because it is in the middle of the building, there are also no adequate doors and windows, which makes the office feel dark when the weather is not supportive, such as overcast. So that the Victory International Futures office has several problems with the lighting used in the office, such as natural lighting which is less than optimal due to lack of windows and ventilation in the room. Then for the placement of artificial lights that are not quite right to illuminate the entire room. Another problem is also because the wrong type or brand of lamp used makes the intensity of artificial light less and makes the light look dim even though it's on and cannot help workers in carrying out their activities, especially in looking at electronic screens in the staff room.

4.3. Proposed Improvement

From the problems that have been mentioned, there are problems in the placement of the lamp points used and the lamp brand that is not suitable. So that the following is a suggestion for the design of the placement of the required light points in the staff room using Dialux Evo software with the appropriate lumen.

The first solution to solve this problem is to provide windows or open ventilation so that besides being able to help natural lighting during the day it can also help circulate cooler air, as represented in Figure 3. With window openings, we will include natural lighting during the day with the sun. However, there is no excessive sunlight coming in because of the wall behind the staff room. The light distribution map will look like in Figure 4 when using natural lighting. Meanwhile, Figure 5 will depict how the room will appear.

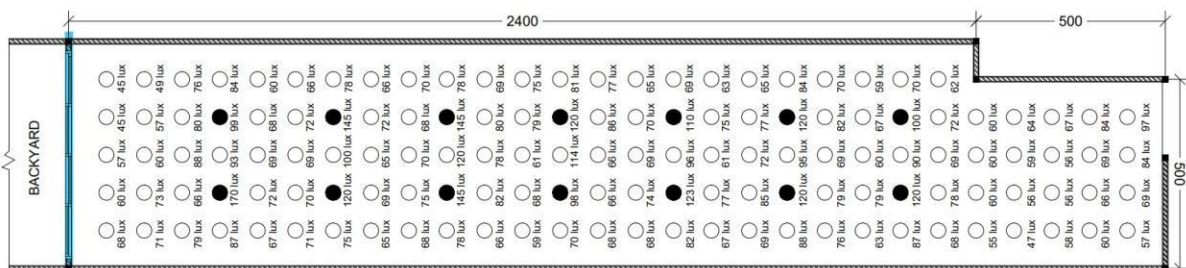


Figure 3. Layout plan, embedding large glass sliding door (blue highlighted) in the rear side of the building

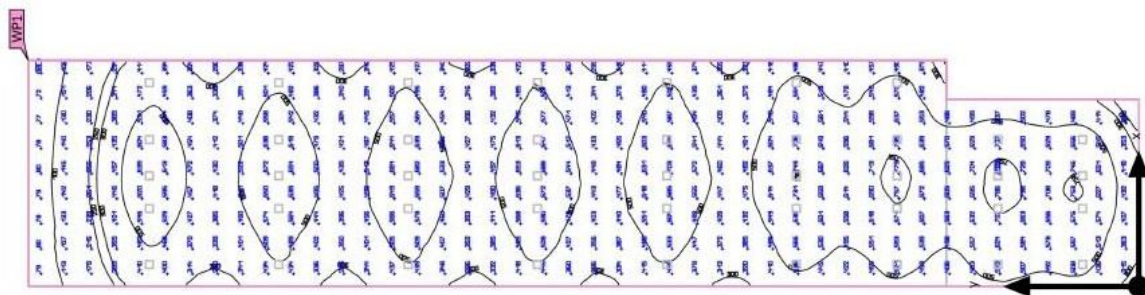


Figure 4. Simulation of light distribution using Dialux Evo software



Figure 5. Visualization of a space that employs natural light

4.4. Smart Lighting system

The authors also suggested replacing the existing type of lamp with a Philips smart wifi led downlight lamp. This lamp has a smart lamp feature with motion sensors and a remote control, so it can be controlled remotely with the WIZ app that integrates with Siri, Amazon Alexa, and Google Assistant [23]. The warm white and cool daylight color settings of this lamp can be changed to meet office workers' demands while at work. In order to best illuminate the entire space, downlight placement on the ceiling is also extended.



Figure 6. The appearance of the office at night utilizing downlights equipped with a smart lighting system

Additional artificial lighting will be placed in the staff room equipped with a passive infrared (PIR) sensor. This artificial lighting is in the form of floor lamps placed on each table in the

room. This floor lamp takes advantage of the created design and integrates a smart lighting system with a feature that turns on when something moves. The light will remain on if there is movement under the table. This function aims to increase the utility and effectiveness of lighting. The visualization in Figure 6 will represent how artificial light will appear in the space.

4.5. Sustainable Development Goals (SDGs)

Proper lighting that meets SNI standards will benefit the health of its users. As previously stated, a lack of lighting causes eye tiredness, which harms the occupant's eye health. Excessive light, conversely, is not beneficial for the user because it can induce glare, headaches, and tension. As a result, good illumination will favour enriching productivity, enhancing efficiency, and reducing labour errors. It adheres to the aims of SDGs 3, which is concerned with Good Health and Well-being.

The solution that the author conveys by providing windows for natural lighting from morning to evening will be able to reduce energy use in the building. Apart from that, the application of automation technology to the room lighting system can make energy efficient. This is one way to save energy consumption in buildings. Both play a role in the success of the government's campaign for SDGs number 11, sustainable cities and communities.

5. Conclusion

The office needed more lighting, which harmed office workers' productivity. The placement of the lamp points employed and the brand that needs to be more appropriate both have issues resulting from the issues mentioned. The following is a recommendation for using the Dialux Evo software to install the necessary light spots in the staff room at the correct luminosity.

The answer to this issue is to install windows or allow for open ventilation, which will assist in circulating cooler air while also allowing for natural lighting during the day. We will incorporate natural daytime lighting from the sun through window openings. However, the wall behind the staff room prevents excessive sunlight from entering. In order to turn on and off smart lights in boardrooms and boardrooms with IoT utilizing the Smart Lighting System, an app must be installed on the tablet. Users can adjust the smart lighting system using this technology following their activity requirements. An adequate lighting system will have a healthy impact on residents following SDGs number 3, Good Health and Well-being. Additionally, applying energy efficiency in buildings supports SDGs number 11, sustainable cities and communities.

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