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Daylighting Strategy for Enclosed Spaces Office in UTHM Pagoh

Ainul Mardhiah Shaiful Nizam, Nur Hasya Husna Omar Shukir@Shukri, Aslila Abd Kadir*

Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600, Pagoh, Johor, MALAYSIA

*Corresponding Author: aslila@uthm.edu.my
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Abstract

Daylight is the light that is transmitted by sunlight and reflected on a surface to illuminate a space or area. Generally, windows can give appropriate illumination up to 1.5 to 2 times the vertical height of the floor. At UTHM Campus Pagoh, there are some rooms in block A1 that do not get natural light and are completely dependent on electricity. So, the light pipe system is one of the strategies that can be used to reduce the use of electricity. This is because the light pipe system is a linear device that can bring natural light into the interior by capturing, transmitting, and reflecting it. According to the Malaysian Standard (MS) 1525:2014, working spaces like offices and classrooms should have lighting levels between 300 and 500 lux. After identifying the enclosed space through the plan found, the lux and temperature readings in the room are taken for comparison. The simulation was made in DIALux and found that the average illuminance of the room exceeded the MS 1525:2014 lighting level. Light pipe system simulation is made in holigilm and found that light reduction can be done. By using the light pipe system, this can reduce electricity and sunlight can benefit health. These potential reductions would be extremely beneficial in encouraging sustainable solutions in daylighting strategies using a light pipe system, particularly under Malaysian sky conditions.

1. Introduction

Daylight is light that is transmitted by sunlight and reflected on a surface before illuminating a space or area. It is highly necessary for a healthy human life and is readily available. Additionally, daylight-illuminated area will give occupants with high satisfaction of visual and thermal comfort yet consuming low energy for lighting, heating, and cooling [1]. Daylighting strategies can be implemented using either side or top lighting. Side lighting through windows is an essential architectural component in building design. These contribute to the occupant relaxation and inspiration. In general, windows can give appropriate illumination up to 1.5 to 2 times the vertical height of the floor [2][3]. As a result, the areas distant from windows may appear gloomy and require additional artificial illumination. Besides that, there are instances were using windows as daylighting strategies not practical. Due to the building layout, daylight cannot reach spaces located between walls or enclosed spaces, as shown in Fig. 1. Thus, top lighting strategies could be introduced to illuminate the spaces. This method strategy is also more effective than windows at providing adequate illumination [4].

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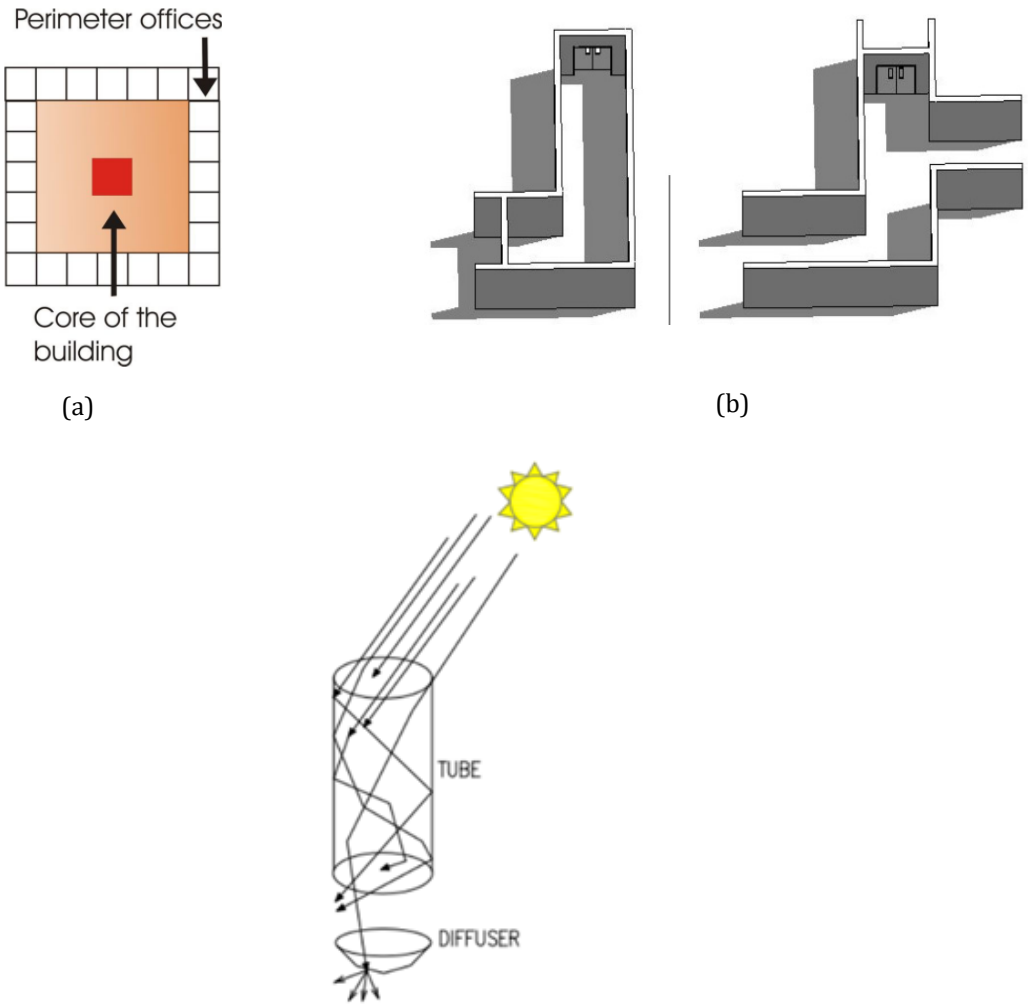

Fig. 1 *Enclosed spaces (a) Perimeter office; (b) Spaces between wall, (c) Light pipe system*

Light pipe system is one of the top lighting strategies. It is a linear device that brings natural light into the interior areas by capturing, transmitting, and reflecting it. The components of the light pipe systems are a diffuser, a light tube, and a collector as illustrated in Fig. 1(c). A collector is usually located at the roof level, and it is made of translucent dome to accept sunlight from the whole sky hemi-sphere. Light tube acts as a light transporter that will guide the light into the rooms through multiple reflections of daylight. It is additionally easier to install. This technology is ideal for both new construction and retrofitting into an existing one. Malaysia is a tropical country and receiving more than 80,000 lux at noon in March indicates that there is a significant potential for using light pipe as a daylighting system [5].

Block A1 is the administrative building for UTHM Campus Pagoh. This five-story building contained administrative offices, meeting rooms, and lecturers' rooms. There are some lecture rooms that cannot be lit by natural light because of constraints in the building layout. As a result, these areas rely on artificial lighting throughout the daytime. According to the Malaysian Standard (MS) 1525:2014, working spaces like offices and classrooms should have lighting levels between 300 and 500 lux [6]. Even though artificial lighting can meet the required lux, but the occupants cannot satisfy the ambience outside the building. Therefore, the aim of this study is to introduce light pipe system (LPS) as a daylighting strategy to illuminate the enclosed office spaces in UTHM Campus Pagoh. This study conducted both case study and simulation using DIALux and HOLIGILM. The objective of this study is to: (1) identify enclosed spaces office in *Blok Pentadbiran Pagoh*; (2) - simulate daylighting strategy that can be integrated into the enclosed office spaces; (3) analyze the illuminance level obtained by proposed daylighting strategy in the enclosed spaces.

2. Materials and Methods

2.1 Case study

A floor plan was obtained at *Pejabat Pentadbiran*. From the floor plan, it will determine every enclosed place in the building. One room was identified to use as case study. The room is located at floor 3, room number 2.A1.3.124 with 3.10 m length, 3.50 m width and 3.65 m height. The data that was collected during the study is temperature, lux and humidity as shown in the Fig. 2.

(a) **(b)** **(c)**

Fig 2 *Data collection (a) Light position, (b) room measurement, (c) data reading*

2.2 Simulation

To save time and to streamline and accelerate numerous design possibilities, computer simulation was used. Computer simulation was created to streamline and accelerate numerous design possibilities while saving time. For the simulation in this investigation, DIALux and Holigilm were used.

2.2.1 DIALux

For calculating interior and exterior illumination, DIALux is a well-liked type of specialized software. DIALux for precise measurement of the amount of light in a confined room. An aluminium reflector and louvre-equipped fluorescent tube ceiling recessed luminaire with a 2 x 18Watt output was chosen for the simulation. The case study room used in this simulation served as the source for the parameters used to create the light fitting, as shown in Fig. 3. In terms of power (Watt) units, the simulation accurately represented the energy required to illuminate the case study.

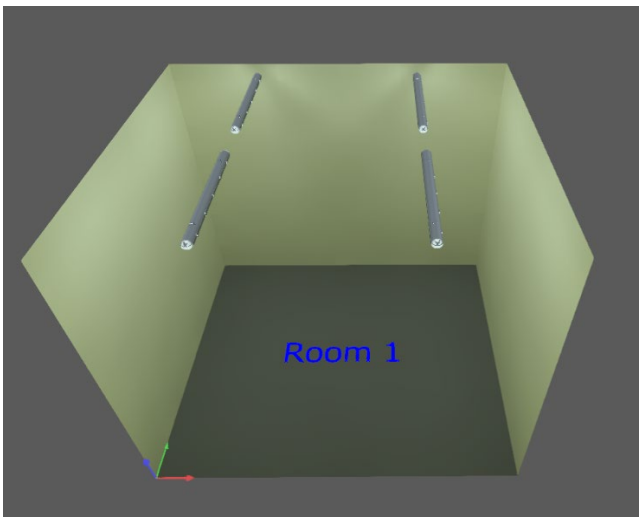

Fig. 3 *Virtual Model Room*

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2.2.2 Holigilm

The daylight performance of a light pipe system was calculated using HOLIGILM. HOLIGILM is the only software developed to forecast the amount of light transmitted by a light pipe system, in addition to being free. Another advantage of HOLIGILM is that past research has shown it to be an effective method.

The simulation method is depicted in Fig. 4 using the HOLIGILM simulation. The simulation began by configuring the room properties, such as its dimensions and orientation, as shown in the figure. The position of the setting sun was tracked using the altitude and azimuth angle determined by the date and time used in the first phase of the measurement. The sky model was performed during periods of clear sky because the simulation aimed to evaluate the illuminance distribution throughout the work plane. As a result, the software's sky model No. 12 (standard sky) was chosen.

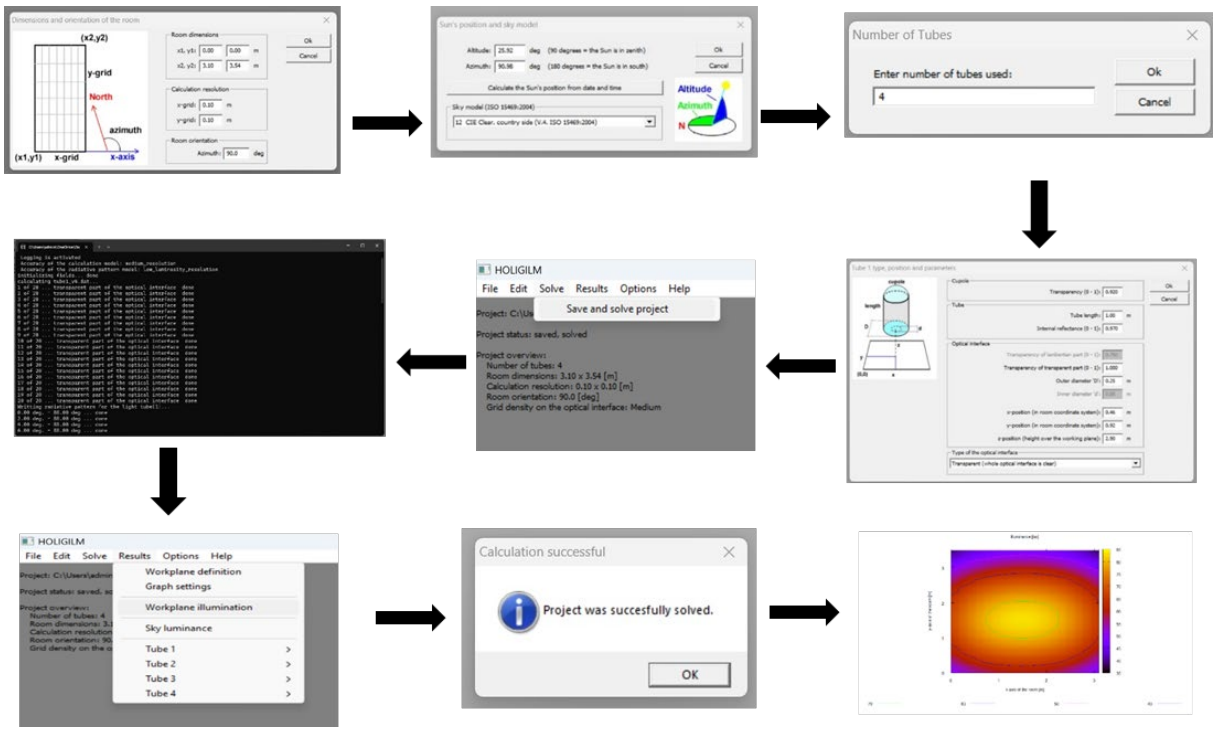


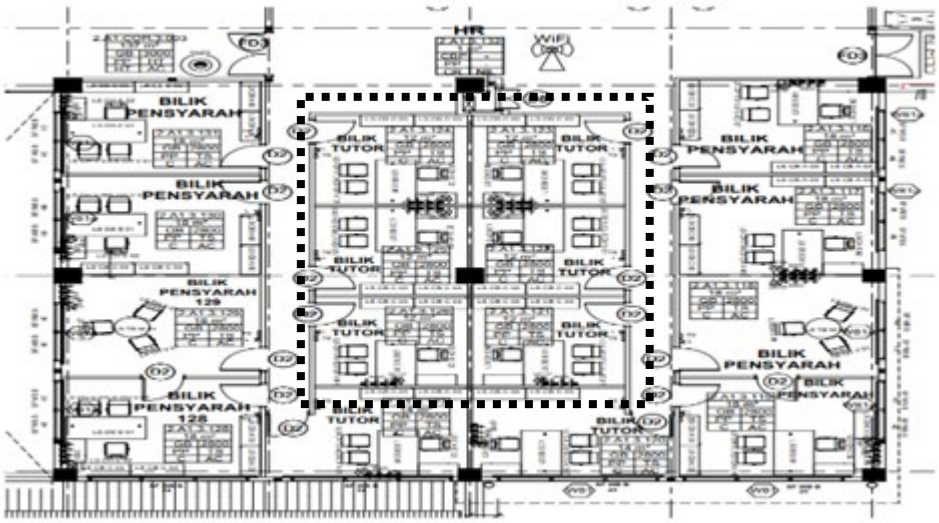
Fig. 4 *Holigilm simulation*

3. Results and Discussion

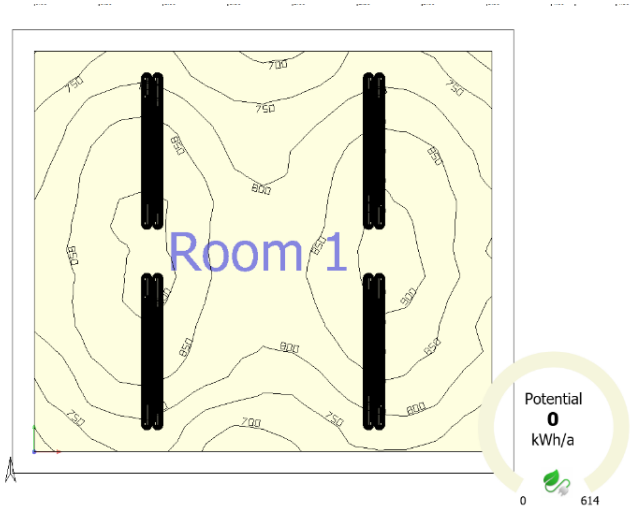
This analysis was made to determine the enclose space in block A1. This is because every enclosed space that exists is completely dependent on electricity. By finding the enclose space, the light pipe system will be done using simulation. The light pipe system can help reduce electricity because it can reflect natural light from sunlight. The data obtained from the simulation will be compared with the lux reading in the room that does not get natural light. As a result, light reduction can be done, and this will save electricity.

3.1 Enclosed Space

At level 2 of block A1, the lecture room that does not get natural light is shown in Fig. 5. This makes them completely dependent on electrical energy. Lux measurements were taken from 8 a.m. to 5 p.m. From the case studies that have been carried out for lux measurements it was found that the average lux throughout the day is 700lux. The temperature for the rooms is 24°C. The finding shows that the lecturer's room showered with illuminance from artificial lighting beyond what is needed. According to MS1525:2014, the average illuminance for an office is 300 to 500 lux.



(a)



(b)

Building 1 · Storey 1 (Light scene 6 (Room 1))

Room list

Room 1

P_{total}	A_{room}	Lighting power density	$\bar{E}_{perpendicular\ (Working\ plane)}$
248.0 W	10.97 m²	22.60 W/m² = 2.76 W/m²/100 lx (Room)	819 lx

pcs.	Manufacturer	Article No.	Article name	P	$\Phi_{Luminaire}$
8	Philips		TCW060 1xTL5-28W HF	31.0 W	2047 lm

(c)

Fig. 5 *(a) Enclosed spaced DIALux simulation (b) Result of average Illuminance, (c) Documentation of simulation.*

3.2 Energy Consumption

In applying the simulation, Fig. 5(b) and Fig. 5(c) shows the lighting arrangement produced an average Illuminance of 819 lux. From the simulation, shows that the total watt is 31.0 W and assumption on how long the lecturer is actually on their room is 5 hours $\pm$ based on their schedule. Energy consumption can be calculated by using formula:

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$$EC = \frac{Watt \times Hr}{1000}$$
$$EC = \frac{31.0\ W \times 5}{1000} \quad (1)$$
$$= 0.155 \text{ kw/hr}$$

3.3 Light Pipe Suggestion

From the holigilm simulation, the most optimal time to use the light pipe system is from 11 am to 3 pm as shown in the Fig. 6. This is because at that time the lighting level has reached from 300 lux to 500 lux. From this simulation, the light pipe system can help reduce electricity.

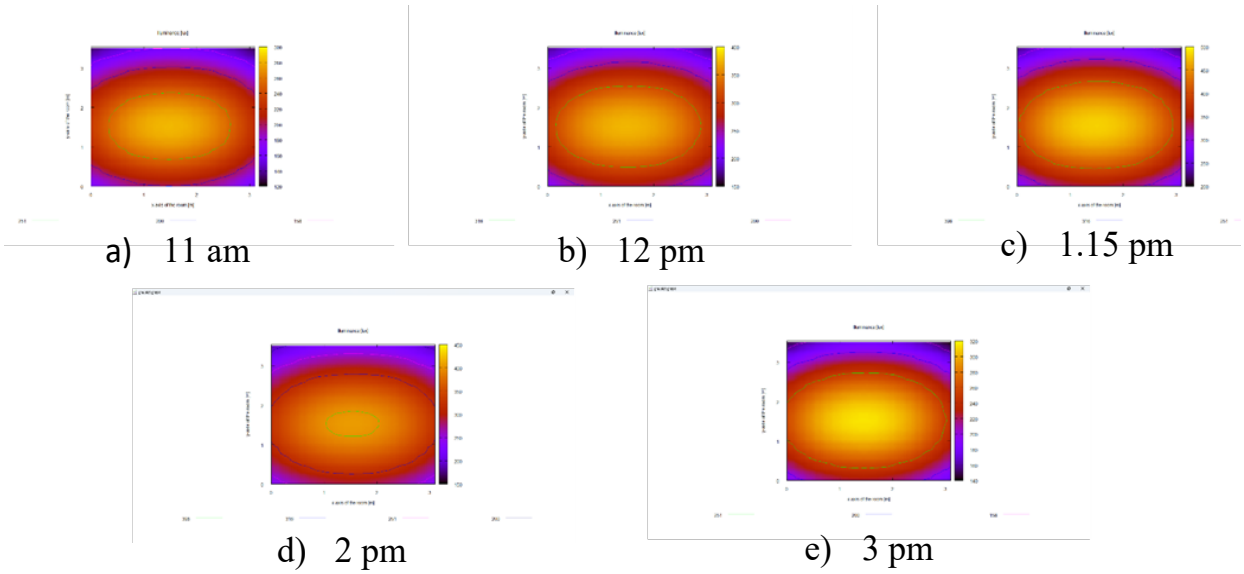

Fig. 6 *Holigilm simulation*

4. Conclusion

The room model was simulated with four light pipes system (LPS). The position of the LPS is according to the position of the artificial lighting. **Table 1** shows, the percentage of the value of backup lighting to achieve the average illuminance by combining natural and artificial lighting. This table shows a reduction of artificial lighting contribution rate from 11:00 am to 12:00 pm. The contribution rate from artificial lighting was decreased to 32.2% from 51.6%. During 1:00 pm, more decrease occurs until 10%. After that, it increased to 24.6% and 42.6% at 2:00 pm and 3:00 pm respectively.

Table 1 *Comparison of LPS and artifial lighting*

Time	Standard illuminance for office (lux)	Illuminance level from light pipe system (lux)	Contribution of the artiial lighting (lux)	Artificial lighting contribution rate (%)
11:00	500	242	258	51.6
12:00	500	339	161	32.2
1:00	500	450	50	10
2:00	500	377	123	24.6
3:00	500	287	213	42.6

In conclusion, integrating a light pipe system and artificial lighting at enclosed spaces will help to minimize the dependence on artificial lighting during the day. When the light pipe system is unable to meet the requirements, this combination would maintain the required illuminance level, especially under gloomy skies. Combining a light pipe system as a natural daylighting source with artificial lighting as a backup has the potential to significantly reduce lighting energy. These potential reductions would be extremely beneficial in encouraging sustainable solutions in daylighting strategies using a light pipe system, particularly under Malaysian sky conditions.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: study conception and design, data collection, draft manuscript: Ainul Mardhiah Shaiful Nizam, Nur Hasya Husna Omar Shukir@Shukri, draft manuscript preparation, Ainul Mardhiah Shaiful Nizam, Nur Hasya Husna Omar Shukir@Shukri, Aslila Abd Kadir. All authors reviewed the results and approved the final version of the manuscript.

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