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e-Proceeding

v-GOGREEN2020

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DAYLIGHT STRATEGIES SIMULATION FOR EDUCATIONAL STUDIO FACILITIES: VELUX SIMULATOR

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Abstract

Malaysian universities face numerous environmental issues in the field of Educational Design Studio (EDS). The occurrence of these issues is due to varied activities and length of occupancy. Owing to unregulated use of artificial lighting, this will cause a raise in the electricity bill, resulting in more energy waste. Daylight Strategy is a method used to increase natural light penetration in EDS. Thus, this paper aims to revitalize daylight strategies in EDS by using the Velux Daylight Visualizer Software. The Interior Design Studio is chosen as the case study. This study was carried out in two phases. Phase one was a field study that took the measurement of the site and transformed it into a generic model. Phase two was model simulation through the use of Velux Daylight Visualizer Software. The Velux Daylight Visualizer Software was used to demonstrate the state of natural lighting in the generic model with respect to the degree of illuminance and daylight factor. This study found that four daylight strategies were essentially used in universities. They were placed at windows, louvres, light-shelf, and overhangs. Based on the simulation analysis, light-shelf achieved the best reading for daylight factor and illuminance, as well as meeting the typical educational lighting level standard. Integrating daylight strategies into the EDS has allowed the studio to have a higher amount of illuminance as well as brightening the studio with daylight strategies being implemented.

Keywords: *daylight; daylighting strategie; educational design studio; velux daylight visualizer software; simulation*

1.0 INTRODUCTION

The key concepts required in the creation of green buildings are energy efficiency and environmentally friendly design. However, the use of energy consumption and sustainability have been of main concerns especially in the educational building. This is because next to the use of air conditioners, lighting consumes the second-highest electricity and it never ceases to increase every year (Zakaria et al., 2013). The reason for this is in the weakness of passive daylighting techniques used where most windows are tinted or furniture obscured (Abdelatia et al., 2010). Husain et al., (2015) argued that the excessive use of lighting would lead to higher electricity consumption, especially in the field of Educational Design Studio (EDS). This paper aims to use the Velux Daylight Visualizer Program to revitalize daylight strategies in EDS. The main strategy is to build an area of green space that eliminates the use of artificial lighting in space and maximizes the use of natural lighting.

2.0 LITERATURE REVIEW

The passive design of an EDS needs to be efficiently structured specifically on the aspect of daylight which is relevant for learning as well as the excellent quality environment for EDS. An adequate amount of daylight penetrated into EDS can have a positive effect on students' wellbeing (Hassanain and Mohammed, 2014). EDS is a space for design-based students gathered for the project's implementation of the design phase process (Bakhshi et al., 2015). In this space, several learning process activities take place, such as, drawing projection, grammar design exercises, model making, and visual composition. The element of lighting is crucially important here. The high-frequency use of EDS will lead to a high electricity energy usage, which will then increase the cost of maintenance and operation to lighten the space (Husain et al., 2015). To allow energy to be used efficiently and ultimately to achieve greener EDS, there is a need to empower daylight strategies for EDS.

Effective daylighting strategies will reduce the energy operating and maintenance costs by extending the lamps and luminaries life. Daylighting techniques are effective solutions for building greener spaces and enabling a university to achieve energy efficiency. Therefore, daylight techniques need to be implemented to ensure that daylight is completely used in EDS. It is found that the most common daylight techniques are (i) windows, (ii) louvres, (iii) light shelf, and (iv) overhangs, based on previous studies

Windows are considered to be one of the essential components of architectural design (Mangkuto et al., 2016). Providing windows in EDS is necessary because windows act as one of the methods for daylight penetration into EDS (Supansomboon and Sharples, 2014). Dahlan and Eissa (2015) noted that windows often play a significant role in diffusing daylight, directing daylight access, and giving external views.

One of the daylight techniques that acts as a shading system is known as Louvers. Li et al. (2016) agree that the proper use of louvers in EDS space as a shading system can enhance thermal comfort, minimise cooling energy consumption, protect the envelope of the building and provide nice daylight and EDS views.

A light shelf is recognised as one of the internationally used natural daylighting techniques. The Light Shelf has shown the best light-redirecting system installed on the outside and one of the methods of daylight exploitation, especially in studios in educational institutions (Meresi, 2016). It is used to make blocked direct daylight when redistributing it by reflection or bouncing it to the ceiling and from there to the room's deepest point (Costanzo et al., 2017).

The overhang is part of a roof framework which is projected on the building's vertical wall. The overhang is functional as it offers direct daylight shade and shield penetration into the studio (Department of Education, 2010). It is also sufficient for reducing, mitigating and modifying the amount of direct daylight and heat gain hitting indoor spaces (Costanzo et al., 2017; Lee et al., 2018).

3.0 THE RESEARCH METHODOLOGY

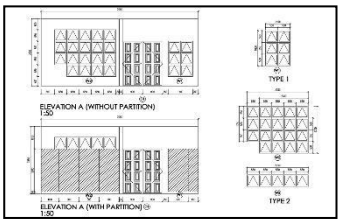
This research was carried out in two stages. Step one was the field research that took the measurement of the site and converted it into a generic model. The measuring was performed using the measuring tape and manual drawings. There were three components measured, which are, (i) the layout plan (size and area), (ii) the EDS's ceiling height, and (iii) the EDS's opening area. All dimensions of the components were composed, and technical drawings were created in the AutoCAD programme. The technical drawings are (i) floor plan drawings, (ii) elevation drawing and (iii) window openings drawings.

The second phase was the simulation of the model by using Velux Daylight Visualizer Software. By building up the standard generic modelling for the model, the modelling stage was carried out. The model was built on the basis of the technical drawing created in previous field study measurements (floor plan drawing and elevation drawing) in Sketch-Up software.

The model was tested and replicated for simulation purposes using Velux Daylight Visualizer software. The generic model simulation was simulated by the Velux Daylight Visualizer programme. The Velux Daylight Visualizer Software was used to show the state of natural lighting with respect to the degree of illuminance and the daylight factor in the generic

model. Velux Daylight Visualizer software has been recommended by many scholars (Mardaljevic and Christoffersen, 2017; Mohelnikova and Hirs, 2016). Four daylight strategies, such as, (i) Window Base Case (WBC), (ii) Light Shelf (LS), (iii) Louvers device / Egg- crate device (LO) and (iv) Overhang (OV) were simulated to the generic model.

Interior Design Studio was selected as a case study. This is due to the report of having the highest consumption of electricity for that premise.



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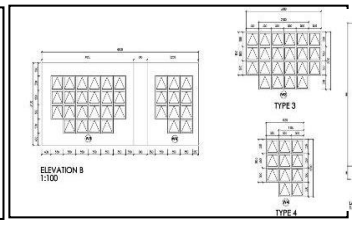
(a) East-direction



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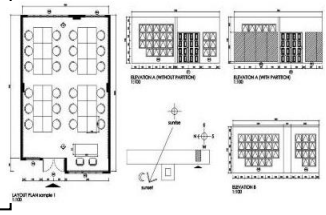

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(b) West-direction

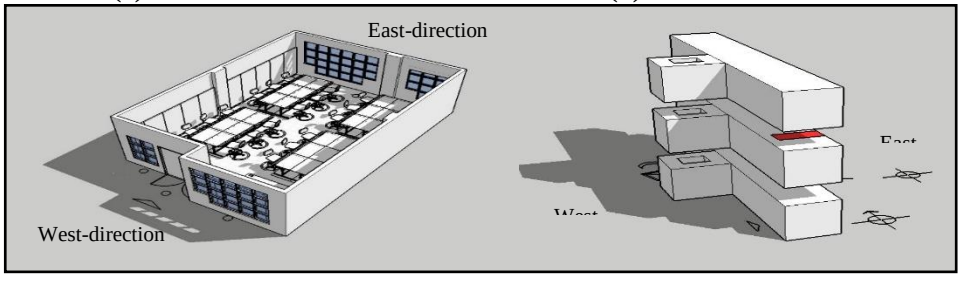

Figure 1: Elevation drawing and opening types drawing for model

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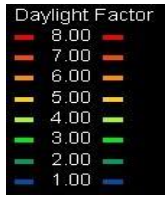
The simulation process took place for 7 days. The outcomes of the simulation were shown on: (i) aspect of the daylight factor (DF); and (ii) aspect of illuminance. This simulation method has shown types of daylighting strategies that can achieve optimal daylighting and as well as having the least potential to penetrate illumination.

There are three types of indicators used in the simulation process to aid the effects of the illuminance and daylight factor (DF): 1) blue is perceptible, 2) green is acceptable, 3) yellow is tolerable, and 4) red is intolerable. As for the DF simulation, 1) blue is acceptable; 2) green is acceptable; 3) yellow is tolerable and 4) red is intolerable. The overview of the simulation is shown in the table below.



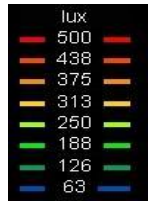
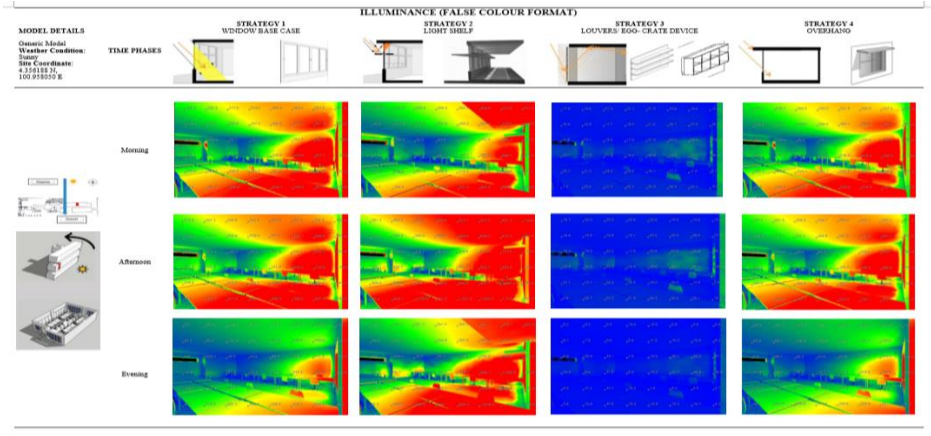


Table 1: Simulation analysis illuminance (false colour format)



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Based on Table 1 and Table 2, it was found that LS strategy obtains the highest illuminance in the model among four daylighting strategies. This can be seen based on the amount of red colour indicated during the simulation. Furthermore, the afternoon time phase received the highest amount of illuminance from the three-time phase analysed. The WBC strategy was the second strategy which received the highest illuminance. In the afternoon time phase, WBC strategy also reported the highest illuminance. The third was the OV strategy. During the afternoon hour, it also achieved the highest illuminance. And the last strategy was the LO strategy. It obtained the least amount of illuminance reported during all studied three-time processes. This can be seen in Table 1 and Table 3 where the simulation model provides only blue colour indicators.

As for the DF simulation, on the other hand, it also showed that the LS strategy received the highest DF value in the three-time process. However, the DF value was low in the morning time-phase instead of the readings reported in the afternoon and evening time-phase. The second highest DF value was the strategy of the WBC, followed by OV and LO.

Table 2: Simulation Analysis Illuminance (iso contour format)

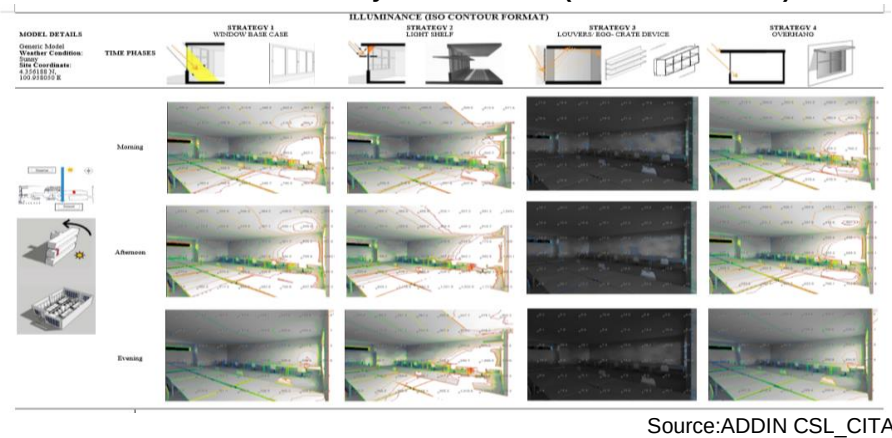

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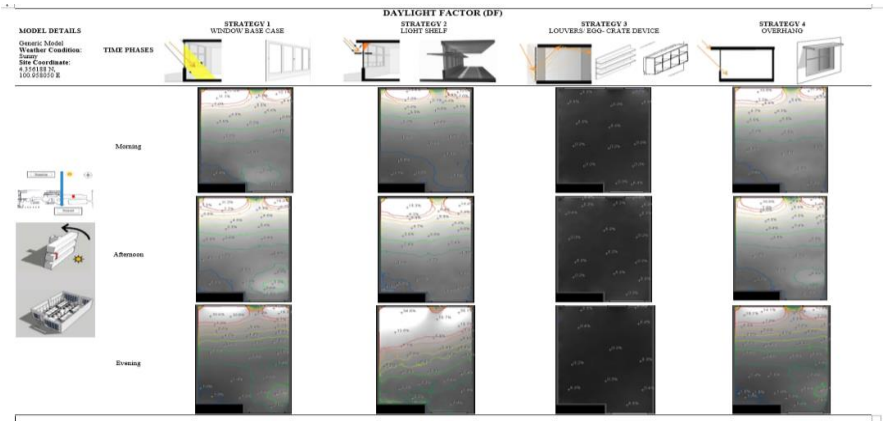
Table 3: Simulation analysis DF (ISO contour format)



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4.0 CONCLUSION

Light-shelf obtained the best reading for daylight factor and illuminance based on the simulation study, as well as achieving the traditional norm of the educational lighting stage. The daylighting strategy was able to provide a larger amount of illuminance and brighten the EDS by incorporating daylight strategy. This would later reduce the carbon footprint of the EDS and ease the energy-intensive issues. Hence, this study has successfully highlighted the use of passive natural daylighting for EDS by using different types of strategies in achieving a sustainable university.

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