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ANALYSIS OF DAYLIGHT PERFORMANCE OF SKYLIGHT IN TROPICAL CLIMATE USING SIMULATION METHODS

Muhamad Amirul Faiz Bin Fazlee[a], Sharifah Fairuz Syed Fadzil [b*]

[a] *School of Housing Building and Planning, Universiti Sains Malaysia, muhamadamirulfaizfazlee@gmail.com*
[b] *School of Housing Building and Planning, Universiti Sains Malaysia, *sfsf@usm.my*

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Abstract

This paper is to analysed the skylight application performance through comparative simulation of models that apply top lit and side lit skylight with tropical climate conditions which is Malaysia and to test whether which of this types of skylight with various sizes of openings and overhangs works properly and capable to provide comfort to users while distributing uniform amount of average daylight factors throughout the plane. The findings showed that the readings of average daylight factor of both type of sky light were accurate compared towards fieldworks studies and calibrated well. The daylight factor measurement also shows slightly changed of readings when tested in various sizes of openings and overhangs. This is because the variables which is the sky condition plays an important role in providing internal illuminance. The study shows that Top lit with larger openings provide sufficient amount of daylight factors compare to side lit skylight evenhough side lit skylight distribute uniform amount of illuminance.

1 Introduction

1.1. Introduction to Daylighting

Natural daylighting is an important element in designing a building. A sky condition effect the result in determine the placement of opening in a building. An overcast sky result in maximizing the opening of a building. Daylighting is a terms used to described natural sunlight that enters and reflected into indoor spaces of a building through an openings and results in the indoor illuminance quality and its function (M Sharaf, 2014). The use of passive skylight system is an significant effort of design strategy that provides ideal interior condition (M.Karam 2014). This introduced skylight as one of the passive design element in order to harvest natural sunlight towards indoor environment replacing artificial lighting. Electrical lighting
contributes 30% of electricity consumption in building that leads to fossil-fuel emission and contribute to Global Warming (IPCC,2001).

2. Problem Statement

An artificial light transmission has lead to various effect on human body. It is proved that artificial light has caused the changed in dynamism of human body's cell. It can released an important hormone known as melatonin from our pineal gland which can makes human felt sleepy and tired (R.Leah 2014). Artificial lighting such as LED and CFL lamp can contribute to repetitive eye strain. The flickering of it causes human eye to adjust to changes of its intensity. It could results to stress and migraines. In addition to that it is potentially to caused short sightedness (B.Jeff 2017). Skylight as one of the daylighting innovative systems is also still can be questionable in terms of its performance and human comfort. Eventhough in tropical climate that received great amount of sunlight and best to harness natural light while gives good benefit for human health, Researchers from Universiti Teknologi Malaysia, Skudai Johor (A.Hamdan, M.R Tajuddin 2000) stated that due to lack of local researchers and interest in energy studies, building in Malaysia facing major problem in thermal comfort as they prefer top lit skylight more which give uncomfortable heat during sunny day compare to side lit skylight. This studies is to evaluate which type of skylight is sufficient whether top lit or side lit skylight as no studies done to evaluate the performance of skylight comparing top lit and side lit skylight.

3. Research Questions

Based on the problems statement, there are 3 questions were highlighted :

- Which types of skylight is suitable to be use in tropical climate?
- Which types of skylight produce sufficient daylight distribution in overcast sky?
- How the direct sunlight occurs in clear sky condition and how to resolve them?

4. Purpose of the Study

The aim of this research is to compare and analyze the effectiveness of both top lit and side lit Skylight system in tropical climate as an architectural features and daylighting system that can be apply in tropical country's building which is to increase the usage of skylight application in Malaysian climate and to increase user awareness about this application. This paper also aim to identify which is the best position of skylight that can give suitable readings of internal illuminance and which of this system is suitable to be applied in tropical climate.

Objective 1

To analyse and measure varied types of skylight designs (in terms of sizes and top versus side lit) and identify their suitability to be used in tropical climate.

Objective 2

To identify which is the optimum type of skylight application which produces sufficient daylight distribution in overcast sky.

Objective 3

To identify also the direct sunlight occurrences in clear sky and experiment on the possible solution to resolve them (like providing overhangs).

5. Research Methods

This study approaches by conducting a simulation using Revit Software to recreate both top lit and side lit skylights with various size of openings and overhangs which then simulate using VELUX software.

5.1. Experimental Study

Analysed the Sky Descriptive Analysis Image whether it satisfy the expected amount of sunlight that enters and study the light that falls into indoor environment whether it provide too much daylighting that it leads to human discomfort.

5.2. Quantitative Study

Conducting a simulation and measurement for average daylight factors of indoor environment and produces graphs then compare it which type of skylights distribute uniform and sufficient amount of light.

6. Findings

In this chapter, for case study, a fieldwork experiment had been conducted and the results were shown in this chapter to prove that the readings taken on site and the readings in the simulation are accurate and reliable. For VELUX Simulation studies on top lit and side lit, a simulation render were conducted and the result are collected based on various sizes of openings to evaluate the performance of the skylight from top lit to side lit in tropical sky condition. For top lit skylight, an opening various from 1 square metre, 0.75 square metre, 0.5 square metre and 0.25 square metre were tested. For side lit skylight, various numbers of sided is tested with different amount of overhang length. From 1 sided glass to 4 sided fully glass with the length of overhang various at 0.5 metre, 0.25 metre and no overhang. The results shown

below were the outcome from the simulation render in VELUX Visual Daylighting software using the exact coordinate of Penang, Malaysia (100.309N, 5.435E).

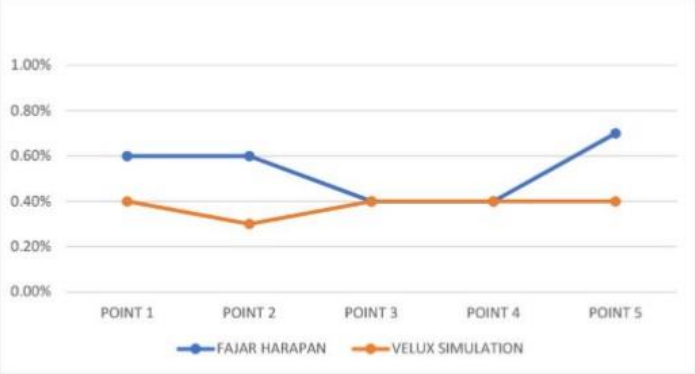
6.1. Case Studies : On-site fieldwork measurement

Location : Fajar Harapan, Universiti Sains Malaysia, Penang

Date : 30 June 2020

Time : 12.00 pm (Overcast sky)

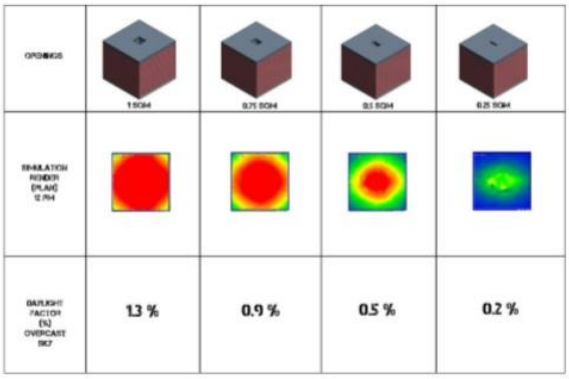
Table 1. Summary chart of both Fieldworks and Simulations data calibrated.



Based on Table 1 above, data found to calibrated well. The next step is to study a series of simulations of a typical top lit skylight with varies sizes of 1 square metre, 0.75 square metre, 0.5 square metre and 0.25 square metre to see the daylight distribution. This is done in both overcast and clear sky conditions to depict the extreme as Malaysian skies is intermediate and difficult to simulate. The dates and times chosen for simulation are 21th June, 12.00 pm. After that, the side lit model was investigated. Various sides is tested from 4 side, 3 side, 2 side and 1 side glass openings with various length of overhang which is 0 metre, 0.25 metre and 0.5 metre with the same dates and times that is on 21th June, 12.00 pm. The coordinates taken are based on the exact location in Malaysia which is Penang (100.309E , 5.435N).

6.2. Top Lit Skylight (Varied Openings)

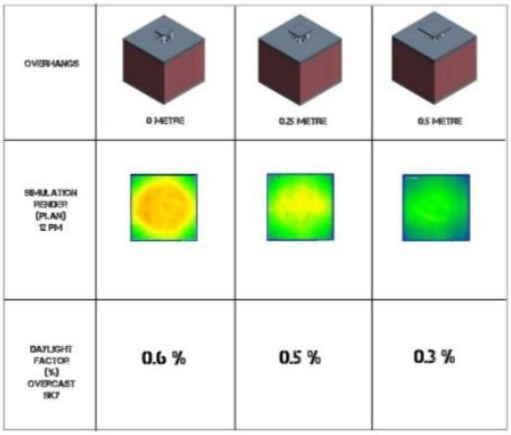
Table 2. Summary shows the difference in reductions of openings under overcast sky condition.



Based on table 2 above, recorded under an overcast sky condition simulations at 12.00 pm in 21th June, the smallest opening with 0.25 square metre shows the amount of daylight factors of 0.2 %. As the opening increase to 0.5 square metre, the numbers of daylight factor increase by 0.3 % in total of 0.5%. By increasing it more to 0.75 square metre, the numbers increase 0.4% to the total of 0.9% daylight factors. The openings is then increases to 1 square metre and the percentages increase 0.4% more to the total number of 1.3% which is the highest percentage of daylight factors to be recorded.

6.3. Side Lit Skylight 4 Sided Glass (Varied Overhangs)

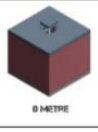
Table 3. Summary shows the difference in increase of overhangs under overcast sky condition.



Based on table 3 above, recorded under an overcast sky condition simulations at 12.00 pm in 21 June, the smallest overhang with 0 metre shows the amount of daylight factors of 0.6 %. As the overhang increase to 0.25 metre, the numbers of daylight factor decrease by 0.1 % in total of 0.5%. By increasing it more to 0.5 metre, the numbers decrease 0.2% more to the total of 0.3% daylight factors. It shows that the longer the overhang, It will decrease slightly about 0.1-0.2% for every metres it is added. For 4 sided skylight it shows that even if the daylight factor is lesser than top lit skylight but it decrease slowly compared to top lit which will decrease even more than 0.1-0.2% each overhang extended. The simulation render also shows that it distribute uniformly without an obvious shape of colour range that demarked the difference of daylight factor compared to top lit which had more obvious of colour ranged changes.

6.4. Side Lit Skylight 3 Sided Glass (Varied Overhangs)

Table 4. Summary shows the difference in increase of overhangs under overcast sky condition.

OVERHANGS	 0 METRE	 0.25 METRE	 0.5 METRE
SIMULATION RENDER (PLAN) 12 PM			
DAYLIGHT FACTOR (%) OVERCAST SKY	0.5 %	0.4 %	0.3 %

Based on table 4 above, recorded under an overcast sky condition simulations at 12.00 pm in 21th June, the smallest overhang with 0 metre shows the amount of daylight factors of 0.5 %. As the overhang increase to 0.25 metre, the numbers of daylight factor decrease by 0.1 % in total of 0.4%. By increasing it more to 0.5 metre, the numbers decrease 0.1% more to the total of 0.3% daylight factors. It shows that the longer the overhang, It will decrease slightly about 0.1% only for every metres it is added. For 3 sided skylight, it shows that even if the daylight factor is lesser than 4 sided glass side lit but it decrease slightly 0.1-0.2% only compared to top lit which will decrease even more than 0.1-0.2% each overhang extended. The simulation render also shows that it

distribute uniformly without an obvious shape of colour range that demarked the difference of daylight factor compared to top lit which had more obvious of colour ranged changes.

6.5. Side Lit Skylight 2 Sided Glass (Varied Overhangs)

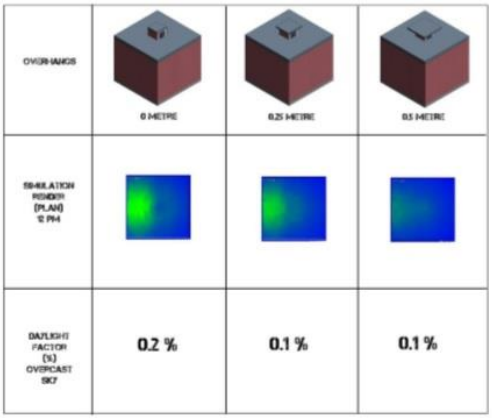
Table 5. Summary shows the difference in increase of overhangs under overcast sky condition.

OVERHANGS	0 METRE	0.25 METRE	0.5 METRE
SIMULATION RENDER (PLAN) 12 PM			
DAYLIGHT FACTOR (%) OVERCAST SKY	0.3 %	0.3 %	0.2 %

Based on table 5 above, recorded under an overcast sky condition simulations at 12.00 pm in 21th June, the smallest overhang with 0 metre shows the amount of daylight factors of 0.3 %. As the overhang increase to 0.25 metre, the numbers of daylight factor maintain at 0.3%. By increasing it more to 0.5 metre, the numbers decrease 0.1% more to the total of 0.2% daylight factors. It shows that the longer the overhang, It will decrease slightly about 0.1% only for every metres it is added. For 2 sided skylight, it shows that even if the daylight factor is lesser than 3 sided and 4 sided glass side lit but it decrease slightly 0.1-0.2% only compared to top lit which will decrease even more than 0.1-0.2% each overhang extended. The simulation render also shows that it distribute uniformly without an obvious shape of colour range that demarked the difference of daylight factor compared to top lit which had more obvious of colour ranged changes.

6.6. Side Lit Skylight 1 Sided Glass (Varied Overhangs)

Table 6. Summary shows the difference in increase of overhangs under overcast sky condition.



Based on table 5 – 14 above, recorded under an overcast sky condition simulations at 12.00 pm in 21th June, the smallest overhang with 0 metre shows the amount of daylight factors of 0.2 %. As the overhang increase to 0.25 metre, the numbers of daylight factor decrease at only 0.1%. By increasing it more to 0.5 metre, the numbers maintain at 0.1% daylight factors. It shows that for 1 sided glass, the longer the overhang, It will decrease slightly about 0.1% only for every metres it is added. For 1 sided skylight, it shows that even if the daylight factor is lesser than 2 sided, 3 sided and 4 sided glass side lit but it decrease slightly 0.1-0.2% only compared to top lit which will decrease even more than 0.1-0.2% each overhang extended. The simulation render also shows that it distributed only at one side of the planes without an obvious shape of colour range that demarked the difference of daylight factor compared to top lit which had more obvious of colour ranged changes.

7. Conclusion

From the results obtain from this researched, it can be conclude that to have a uniform distribution of light, Side lit Skylight is better in performance. Side lit with 4 sided glass and no overhangs shows great potential in distributing uniform illuminance as it is distributed consistently without losing much greater of light until 4 pm compared to top lit skylight that already lose illuminance at greater amount at 4 pm. For daylight factors, it is still poor and not enough of illuminance reflected on planes as for MS 1525 requirements stated that to get an average daylight factor must be 1% and above. For greater amount of light harvested for tropical climate sky condition, 1 square metre top lit skylight since to show more lux readings and great amount of daylight factors which exceed more than 1% compare to side lit skylight but as the sun is low in the evening, the lux

readings drop and show non uniform distribution compare to side lit skylight which distribute uniformly throughout the whole day.

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