Analysis Of Anidolic Daylighting System Parameters In Tropical Climate

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Abstract: Producing available daylight in building is a crucial issue for reasons of energy-efficiency as well as improvement of occupant's health and well-being. Anidolic Daylighting System (ADS) is a type of daylighting system that provides daylight in the deep plan area in far from window. It concentrates daylight in collector and transfers it to duct that is situated between collector and distributor and then light is spread to inside of building. The aim of this research is to find out optimum duct shape and width duct that influence on the system's performance. The simulated model was designed in the Integrated Environmental Solution IES<VE> software to performing daylighting simulation experiments. Therefore, three configurations of duct designs with two duct lengths (12m and 20m) were simulated as dust shape variables and also three different sizes in duct width were experimented. Results indicated that the anidolic in a rectangular shape with three meters duct width is better than other cases. For future study, other parameters can be carried out such as the depth of duct, size of the anidolic, collector and distributor of device.

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Keywords: Anidolic Daylighting System, IES<VE> software, Daylight performance

1. Introduction

Reducing the energy especially artificial lighting load is a critical step towards sustainable and energy-efficient buildings. In office buildings are consuming more than 40% of the over electricity with artificial lighting and reduction of that is particularly notable in these places (Jenkins, D. et al. 2007; Li, D. H. et al. 2006; To, D. W. T. et al. 2002). Preparing available daylight in building not only desirable for energy efficiency reasons, but also improves a healthy and comfortable environment for the occupants (Veitch, J. A. 2006). Windows on vertical façades provide the aperture for daylight, but that can only penetrate a limited distance from the windows.

2. Anidolic Daylighting System

Methods are detected to solve above problems include to employing some form of daylight systems to transfer daylight to deep areas of the building. Non-imaging optics that concentrates daylight was used to set-up a new design technology for daylighting systems, aiming at that goal. This novel device is anidolic daylighting systems (ADS) (figure 1). In this system, daylight is collected from the sky vault through the Compound Parabolic Concentrator (CPC) type collector and is transferred by the duct. Distributor is situated in the end of the duct and spread light to indoor of the building (Welford, W. T., et al. 1989). The ADS perform under different sky types in tropical, subtropical and tempered skies have been simulated. These results have shown that the ADS is particularly interesting for tropical area with predominantly overcast skies like Singapore (Wittkopf, S. 2007; Wittkopf, S. et al. 2006).

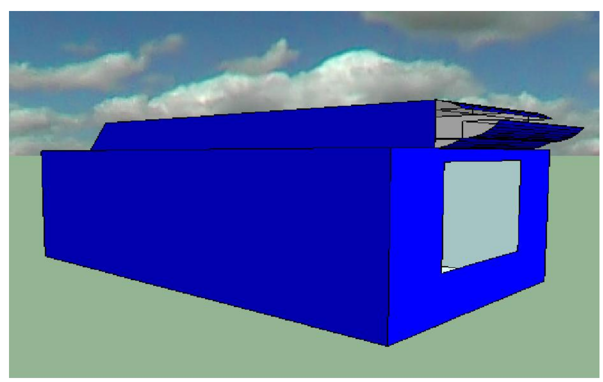


Figure 1 – Simulated anidolic model

2.1. Component of ADS

The anidolic system includes three main components: the collector installed in the façade of building, the rectangular light duct in room interior and the end of the duct is distributing element (distributor) into the internal space. (figure 2)

Duct of ADS is located between the collector and distributor and transfers daylight from collector to distributor. It can change in width, length and height. Moreover, its shape can affect the amount of daylight. This aspect is being evaluated in this research.

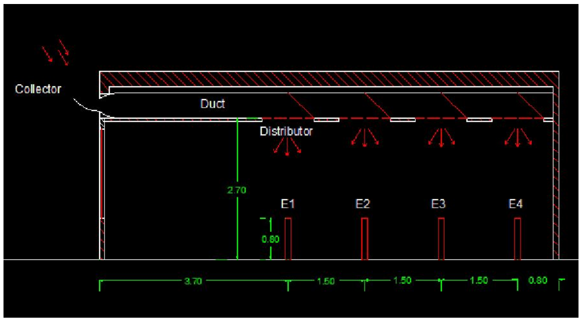


Figure 2 – Components of Anidolic Daylighting System

2.2. Duct Configuration

One of influence criteria to transfer daylight with anidolic is duct configurations, which were tested in during this study such as the shape and width of duct. Summary of the objective to investigate optimum duct configuration is shown in figure 4.20.

3. Methodology

Recently, the use and interest in daylight simulation tools are increased (Ander, 2003; Loutzenhiser et al., 2007). Simulation tools are the best opportunities for improving a building's energy performance before design, and these are feasible for predicting and improve the building daylight design. (Lim et al., 2010)

In this research the simulated model was designed in the IES<VE> software to performing daylighting simulation experiments. All items were measured under intermediate and overcast tropical sky conditions in Malaysia while orientation of them was in south orientation.

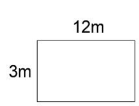
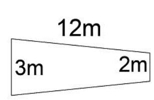
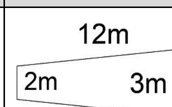
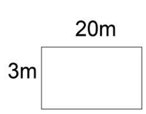
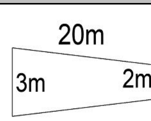
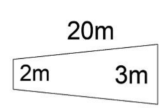
An open plan office was designed with 5m width and ceiling height 2.7m with different depth. Moreover, the ADS has 3×0.5 m width and height respectively with different depth too. The window has glazing, and the window-wall-ratio was 25% (Zain-ahmed et al. (2002b)). The surface properties and material type used in the computer simulation were modeled in according to the table 1. The location of the simulation model was designed in Singapore, with Latitude 1.37 N; Longitude 103.98 E (Lim, 2011).

Table 1: Parameters in the model

Parameters		
Room geometry	Width Length Height	5 m 9 m 3.5 m
Window geometry	Width Height WWR	4m 1.70 m 30% (2.5m*1.7m)
Anidolic	Wall Floor Ceiling	50% 20% 80%

To validate the performance of the IES software Absolute Work Plan Illuminance (WIP) and DF were employed. Summary of the objective to investigate optimum duct configuration is shown in figure 3.

Table 2: Sub-variables plan of duct shape for simulation

Sub-Variables – Duct Shape			
Shape	Rectangular	Trapezoid	Trapezoid
Model	M.1a	M.2a	M.3a
Shape plan			
Model	M.1b	M.2b	M.3b
Shape plan			

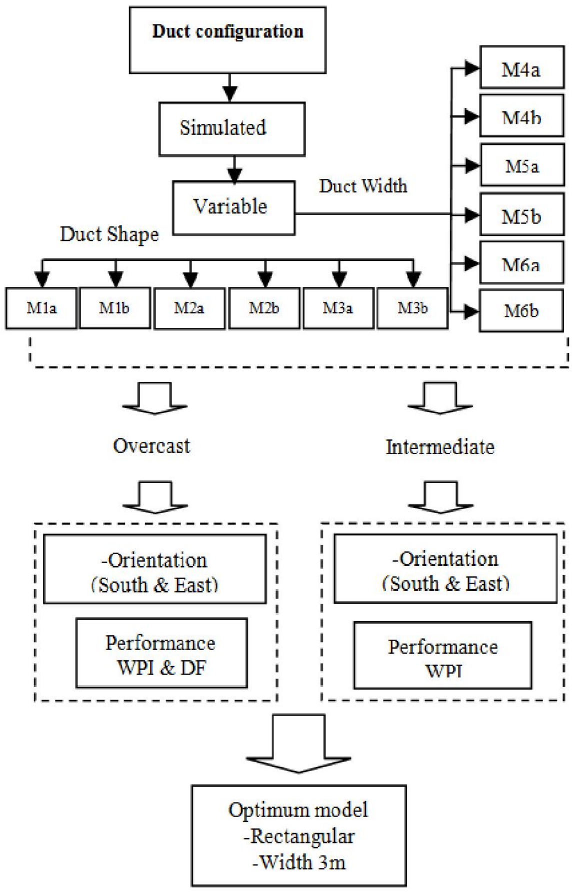


Figure 3 –Summary of the objective to investigate optimum duct configuration

3.1 Duct Shape

The aim of this study is to find out duct shape that can influence on the system's performance. Three configurations of duct designs with two duct length (12m and 20m) were studied in this experiment. The first design was a rectangular and the second design a trapezoid with bigger (3m) duct in front and back (2m). The third design is a reverse of the second design (front duct 2m and back duct 3m). The properties of the shapes are summarized in table 2.

These variables were assessed under overcast and intermediate skies as mentioned in the following. Because overcast sky is the worst condition for daylight availability, and intermediate sky condition, that Malaysian sky is predominant by intermediate sky around 85.6-90% (Zain-ahmed et al. (2002a).

These cases have been designed in two different lengths of 12 and 20 meters, which have been evaluated in two orientations of south and east with the performance of WPI and DF.

3.2 Duct Width

Other factor that can affect the system performance is duct width. To these aim different ducts with the sizes of 1 M, 2 M, and 3 numbers of 1 M, in two different sizes of duct length with the length of 12 and 20 meters have been designed and tested.

As it has been shown in table 4.4, in the M.4 case the anidolic has 2 meters width, in the case M.5 the anidolic has 1 meter width and in M.6 case shows three numbers of anidolic with 1 meter width.

Table 2: Sub-variables plan of duct width for simulation

Sub-variables	Shape plan	Sub-variables	Shape plan
M.4a	12m 2m	M.4b	20m 2m
M.5a	12m 1m	M.5b	20m 1m
M.6a	12m 1m 1m 1m	M.6b	20m 1m 1m 1m

4. Results

4.1. Duct Shape in Overcast Sky

In the first stage, these cases have been tested in the overcast sky. As the daylight in the overcast is the same in different directions, it is not necessary to identify the orientation of the building. According to the figure 4, the illuminance value of the M.1 case in 12 and 20 meters dimension is 72 lx and 9 lx, which has higher illuminance value among other cases.

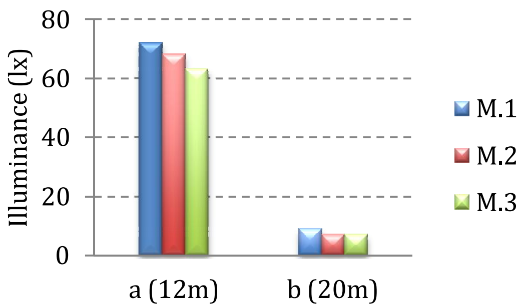


Figure 4 – Illuminance value of variables in points E7 (12m) and E12 (20m) of simulated models

4.2. Duct Shape in Intermediate Sky

In the second stage, these cases have been tested in the intermediate condition, and they have evaluated in the two orientations of south and east in 21st of March (appropriate time for simulation because of the sky condition during equinoxes) in 9 AM, 12 PM and also 3 PM, through WPI performance.

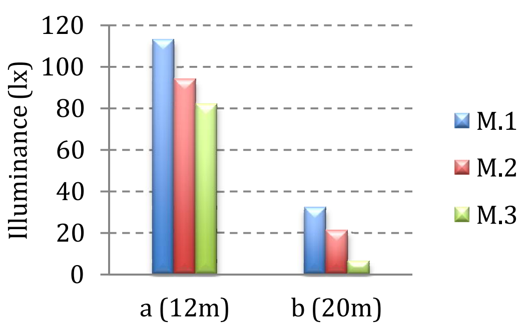


Figure 5 – Mean illuminance value of variables in points E7 (12m) and E12 (20m) in the south orientation on the 21th March

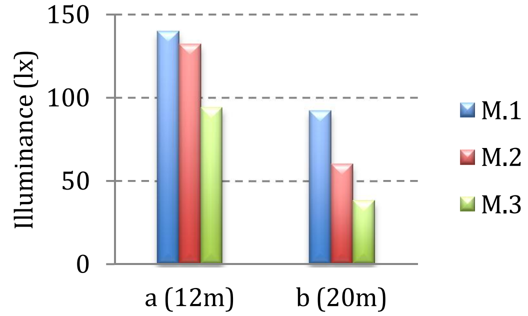


Figure 6 – Mean illuminance value of variables in points E7 (12m) and E12 (20m) in the East orientation on the 21th March

Results of the current study show that the illuminance value in M.1 case in the 12 and 20 meter sizes in the south direction is 113 lx and also 32 lx, that their values are more than the other cases (Figure 5). Additionally figure 6 shows these amounts in the east direction that WPI in M.1 case are 140 and 92, which has the same result with the previous experiment.

4.3. Duct Width in Overcast sky

In the first stage, these cases have been tested in the overcast sky. As the daylight in the overcast is the same in different directions, it is not necessary to identify the orientation of the building. According to the figure 7, the illuminance value of the M.1 case in 12 and 20 meters dimension is 72 lx and 9 lx, which has higher illuminance value among other cases.

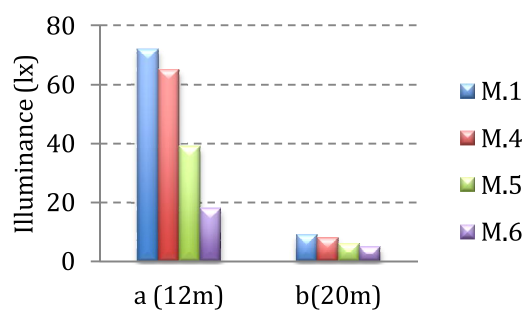


Figure 7 – Illuminance value of variables in points E7 (12m) and E12 (20m)

4.4 Duct Width in Intermediate sky

In the next stage, these cases have been experimented in the intermediate condition sky, and they have evaluated in the two orientations of south and east in 21st of March (appropriate time for simulation because of the sky condition during equinoxes) in 9 AM, 12 PM and also 3 PM, through WPI performance.

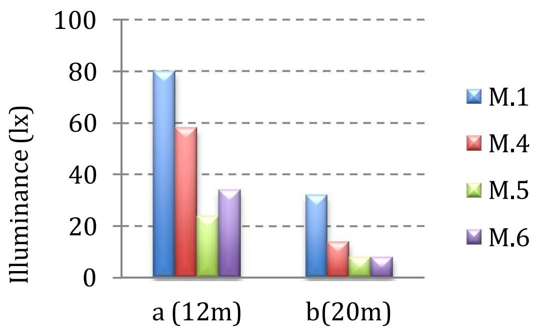


Figure 8 – Mean illuminance value of variables in points E7 (12m) and E12 (20m) in the South orientation on the 21th March

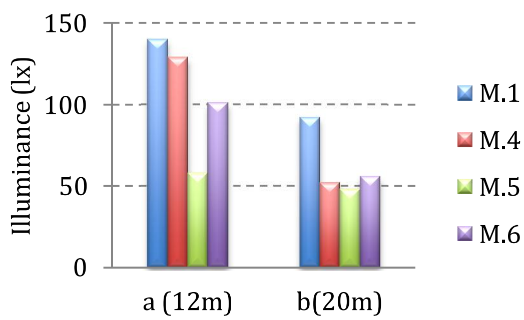


Figure 9 – Mean illuminance value of variables in points E7 (12m) and E12 (20m) in the East orientation on the 21th March

The results of the illustrate that the illuminance value in M.1 case in the 12 and 20 meter sizes in the south direction is 113 lx and also 32 lx, that their values are more than the other cases (Figure 8). Additionally, figure 9 shows these amounts in the east direction that WPI in M.1 case are 140 and 92, which has the same result with the previous experiment.

5. Conclusion

In conclusion, results indicated that the anidolic in a rectangular shape with three meters under overcast and intermediate skies condition in two sizes of 12 and 20 meters are better than other occasions. In addition, in the next step, results showed that M.1 case with three meters width had better illuminance value under overcast and intermediate skies condition in 12 and 20 meters width comparison with other cases.

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