WALL DESIGN FOR BORROWED DAYLIGHT IN ENCLOSED CORRIDORS

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Abstract

Previous studies by same authors, % DF values were calibrated comparing field work data to Radiance simulations and scaled model study for an enclosed corridor in tropical climate. Corridor walls are usually opaque resulting in very dark situations relying solely on artificial lighting. The objectives of this study in Paper 2 are to further investigate the extent of daylight which can be borrowed to light the internal enclosed corridors. This is carried out by experimenting on the various types of corridor wall designs with added transparent or glazed areas for daylight to be borrowed to the enclosed corridors. The designs experimented with various horizontal and vertical alternatives. The effects of these new corridor wall designs to daylight distribution in corridors are investigated by Radiance simulations. Results are compared to base case which is a situation of all opaque walls for the corridors as the worst situation. The findings show that the newer designs of corridor walls can provide daylight to corridors with significant improvements. Even though the %DF found were very low, outdoor illuminance in tropics are high therefore it is still sufficient for corridor lighting. Corridors with 50% glazed areas in a 4 strips horizontal design was found to perform the best for allowing borrowed daylight to occur.

Keywords : %DF, % Daylight Factor, Corridor Wall, Illuminance, Borrowed Daylight.

Introduction

There are several ways in which natural lighting can play an important role in sustainable design. An innovative approach is the introduction of advanced daylighting strategies and systems, which can considerably reduce a building's electricity consumption and also significantly improve the quality of light in an indoor environment. Providing a building with natural light is more than just the solution of a problem of energy consumption; more, even, than an aesthetic resource easily incorporated into the architecture. Natural light in architecture must be part of a more general philosophy that reflects a more respectful, sensitive attitude in human beings towards the environment in which they live (Serra, 1998).

Borrowed Light

1. Internal windows or clerestories which connect a daylit room to a space inside the core of the building are referred to as borrowed light. It provides a means of getting daylight into places

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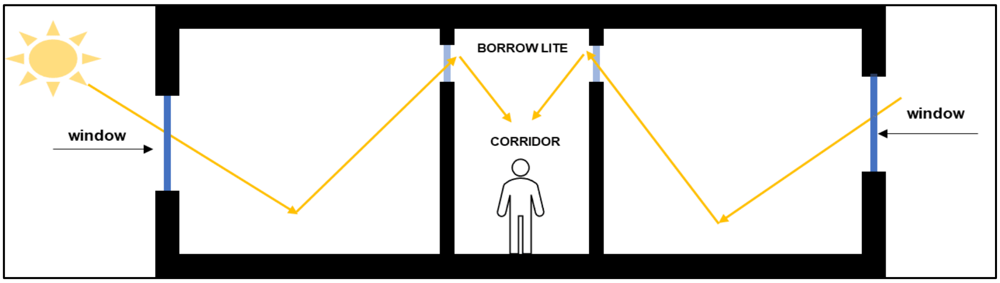
that would not normally be daylight, because they have no access to the periphery of the building (Comfortable Low Energy Architecture, 2012).

2. Borrowed light is not normally intense enough to replace task lighting in offices. However, for corridors, storage areas or restrooms, it can provide adequate illumination and make the use of artificial light unnecessary during daylight hours (Comfortable Low Energy Architecture, 2012).

Figure1: Example of Borrowed Light in Corridors.



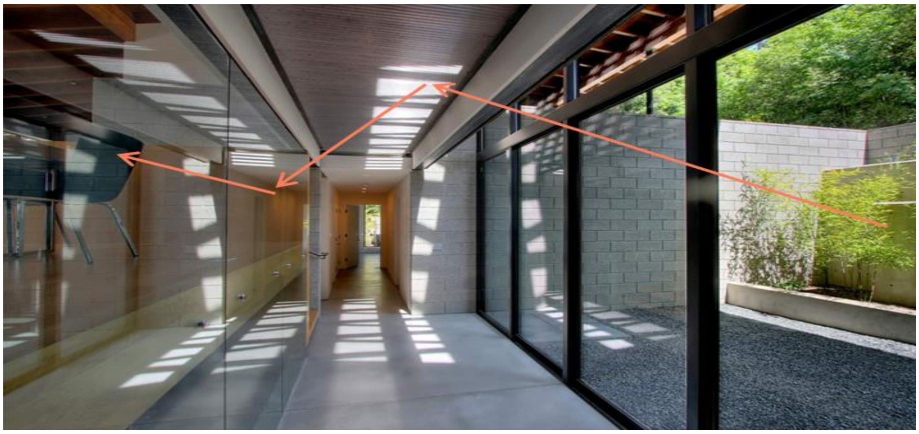
Source: Author, (2020).

Corridor Walls

Interior spaces without access to an exterior wall or spaces oriented in a way that restricts access to adequate daylight are common problems, each with a unique solution.This section will review some of the solutions used by borrowed light.

One solution to practice borrowed daylight is to have a particular design of interior walls. Interior walls can be built to collect and disperse light rather than restrict it.Transparent and translucent materials reflect, absorb and scatter light, and they make great walls for borrowing light.(Wittkopf, 2007). The degree of translucency will affect just how much light is scattered.The effect is similar to obscuring direct sight but preserving the passage of daylight. Diffused light is comfortable and limits eyestrain.According to Haldimann et al. (2014), Glass is a transparent material allowing light, heat, and also a view of the outside world into interior rooms. It is durable, fire and water resistant, and recyclable. Moreover, glass gives aesthetic value and luxury to the design.

Figure 2: Example of Use of Natural Daylight and Glazed Materials in Interiors.



Source: Author, (2020).

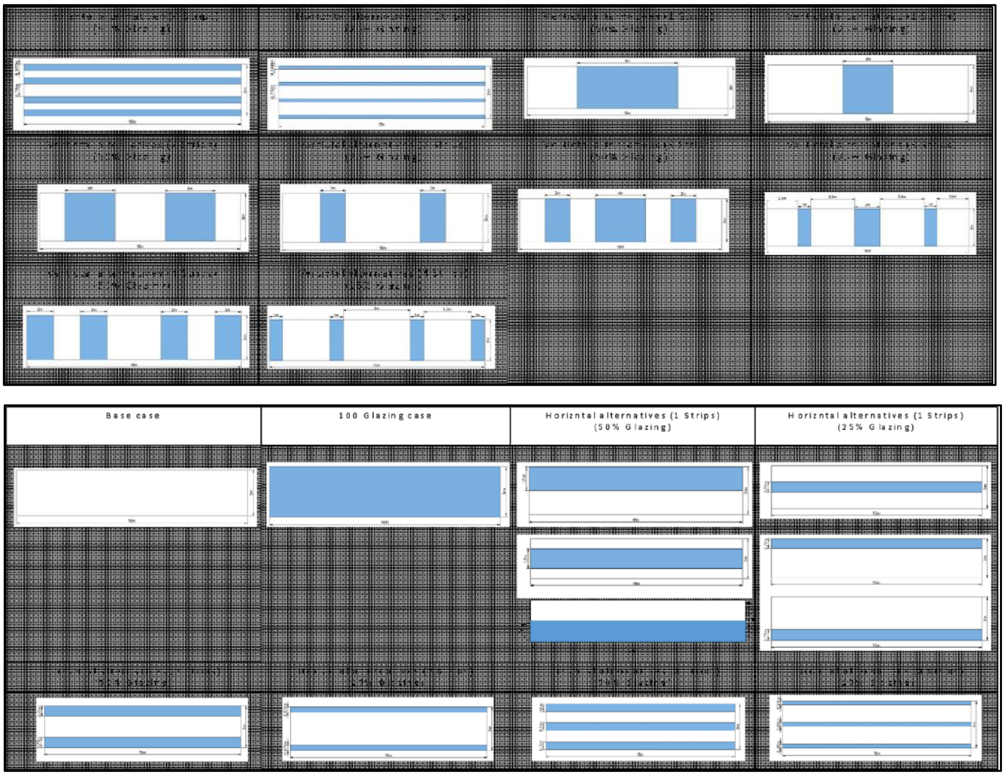
Methodology

The methodology of research used is the method is the experimental using computer simulation method, this is because data inputted into the program can be easily accessed and changed whenever required. This approach challenges the research to further advance and excels in researching because it allows testing under various conditions. In addition, allowing more room for trial and error to occur. The model was designed in the Radiance software to performing daylighting simulation experiments.

In previous studies by similar authors, a detailed calibration method was carried out to ascertain the reliability of using Radiance to simulate the daylighting performance of enclosed corridors under tropical skies. The use of this %DF is further investigated in Paper 2 where simulations of daylight distribution in corridors is examined via base case (original design with opaque corridor walls) and varied transparent horizontal alternatives and varied vertical alternatives. These designs are carefully considered to see the extent of improvements in daylight distribution in the enclosed corridors. The alternatives of the corridor design is given in Figure 3.

Simulated results are then analyzed in terms of min, max and average %DF comparing it to the base case.

Figure 3 : Different Design of Interior Walls for Corridor



Source: Author, (2020).

Radiance Simulation Study

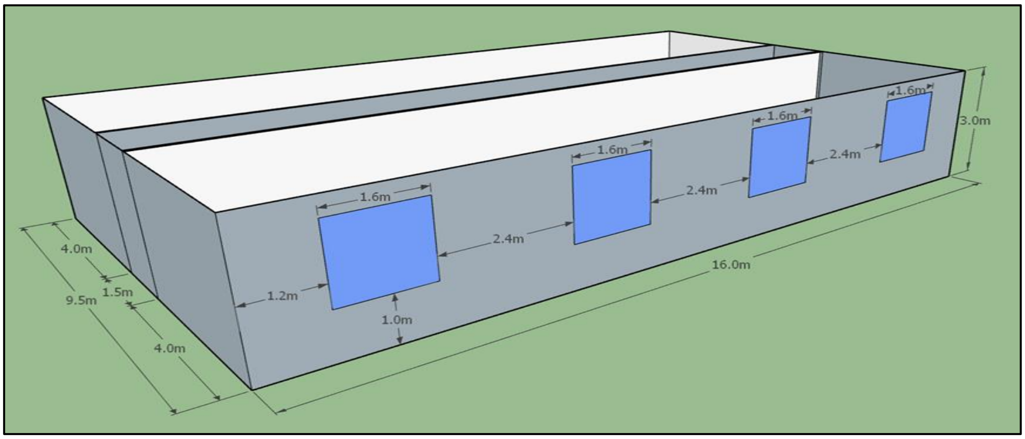
Computer simulation and modelling method is considered to be the most efficient, when measuring energy consumption and light density of buildings. Over the past 50 years, hundreds of building energy programs have been developed, enhanced, and is at use throughout the building industry (Crawley *et.al*. 2008).

The Desktop Radiance software automatically prepares the Radiance input file and activates the Radiance algorithms for the computation of the desired output, which is also controlled through a graphical user interface. Through a "simulation manager," it supports easy management of multiple simulations, storing all input specifications and results into a project database. (Reinhart *et. al.* 2001; Mardaljevic, 1995).

Model Description

The corridor is 1.50 meter width x 16 meter length as shown in figure5. The corridor is 1.50 meter width x 16 meter lenght as shown in figure4. The simulated model is similar to the one in Paper 1 but simplified to be only 16m long with 2 openings at the ends of the corridor. The Radiance simulated results show a very dark environment at the middle of the corridor which cannot be visualize or stipulated if the 16m long corridor was used. Therefore for the purpose of this research, a 7 m long corridor at the middle was extracted out for more detailed daylighting pattern analysis.

Figure 4 : Simulation Model with Dimensions.



Source: Author, (2020).
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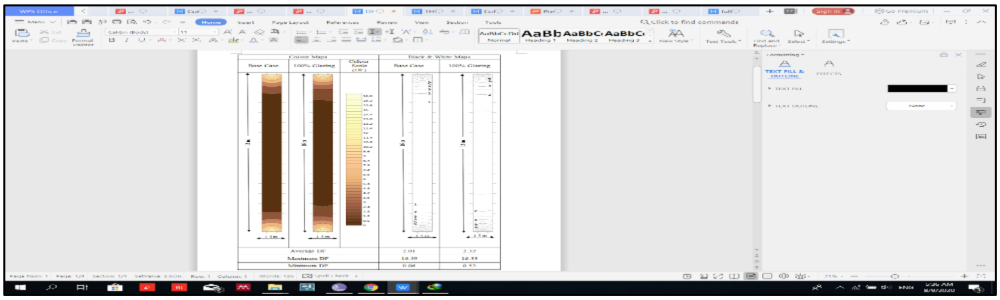
Results and Discussion

Figure 5: The Results of Simulation for of Base Case



Source: Author, (2020).

The simulation of this case was done according to average, maximum and minimum of DF. As showing in Table1

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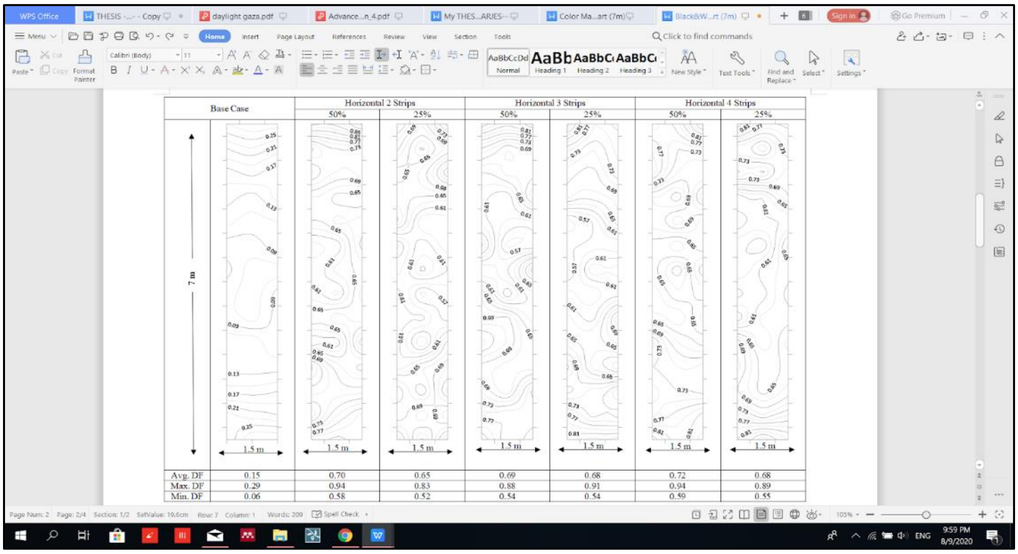
Table 1: Result of Simulation for Base Case.



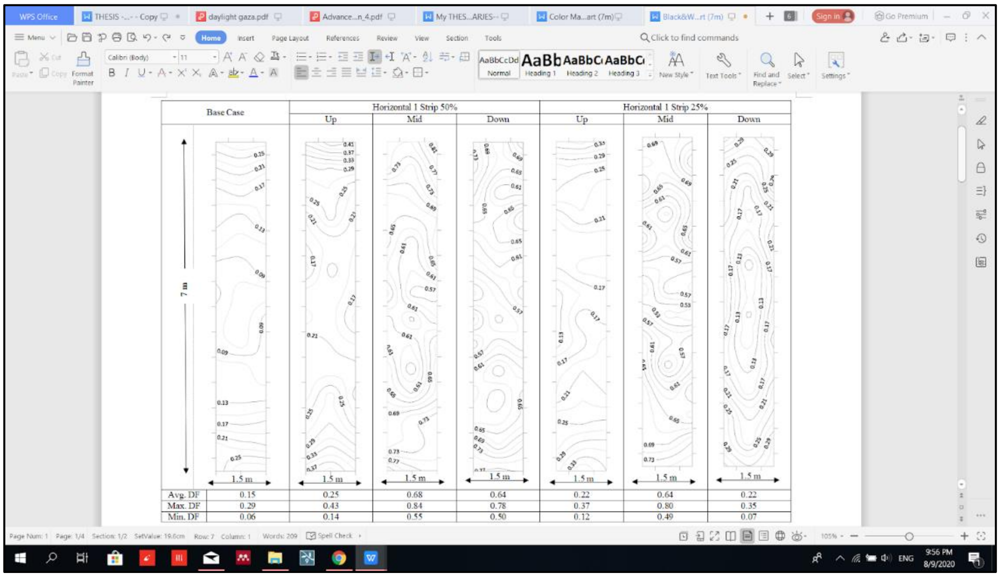
	Base Case	Horizontal 2 Strips 50%	Horizontal 2 Strips 25%	Horizontal 3 Strips 50%	Horizontal 3 Strips 25%	Horizontal 4 Strips 50%	Horizontal 4 Strips 25%
Avg. DF	0.15	0.70	0.65	0.69	0.68	0.72	0.68
Max. DF	0.29	0.94	0.83	0.88	0.91	0.94	0.89
Min. DF	0.06	0.58	0.52	0.54	0.54	0.59	0.55

Source: Analysis Data, (2020).

Result of Simulation for Horizontal Alternatives

The simulation of this case was done to investigate the effect of horizontal alternatives on the illuminance level in the simulated. As showing in Table.2.

Table 2: Result of Simulation for Horizontal Alternatives.



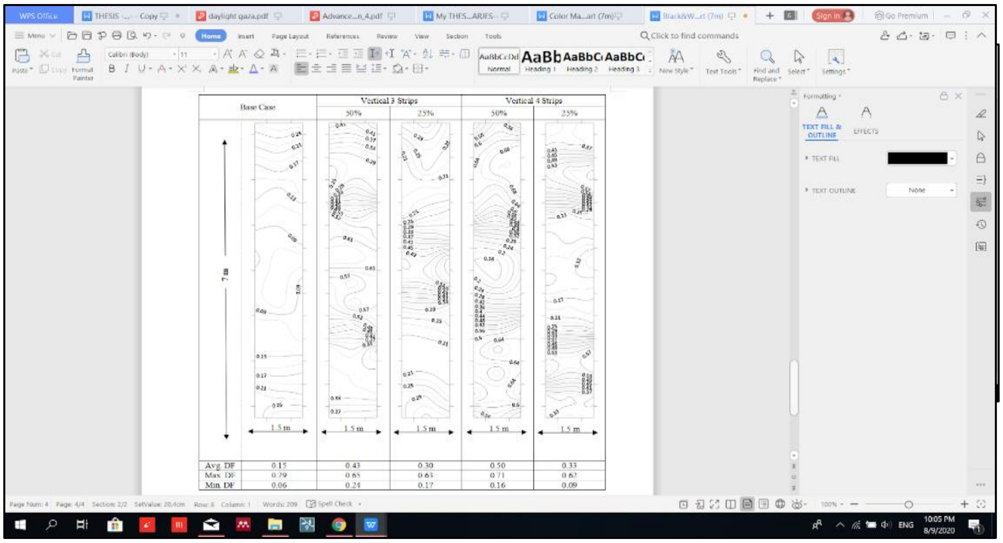
	Base Case	Horizontal 1 Strip 50%			Horizontal 1 Strip 25%		
		Up	Mid	Down	Up	Mid	Down
Avg. DF	0.15	0.25	0.68	0.64	0.22	0.64	0.22
Max. DF	0.29	0.43	0.84	0.78	0.37	0.80	0.35
Min. DF	0.06	0.14	0.55	0.50	0.12	0.49	0.07

Source: Analysis Data, (2020).

Result of Simulation for Vertical Alternatives

The simulation of this case was done to investigate the effect of vertical alternatives on the illuminance level in the simulated. As showing in Table.3.

Table 3 : Result of Simulation for Vertical Alternatives.

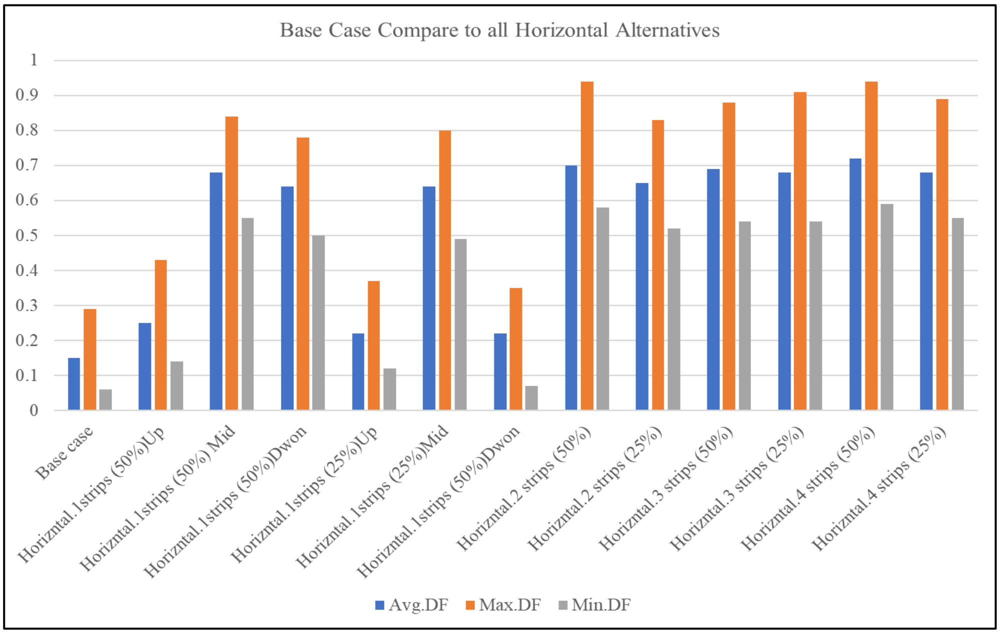


	Base Case	Vertical 3 Strips		Vertical 4 Strips	
		50%	25%	50%	25%
Avg. DF	0.15	0.43	0.30	0.50	0.33
Max. DF	0.29	0.65	0.63	0.71	0.62
Min. DF	0.06	0.24	0.17	0.16	0.09

Source: Analysis Data, (2020).

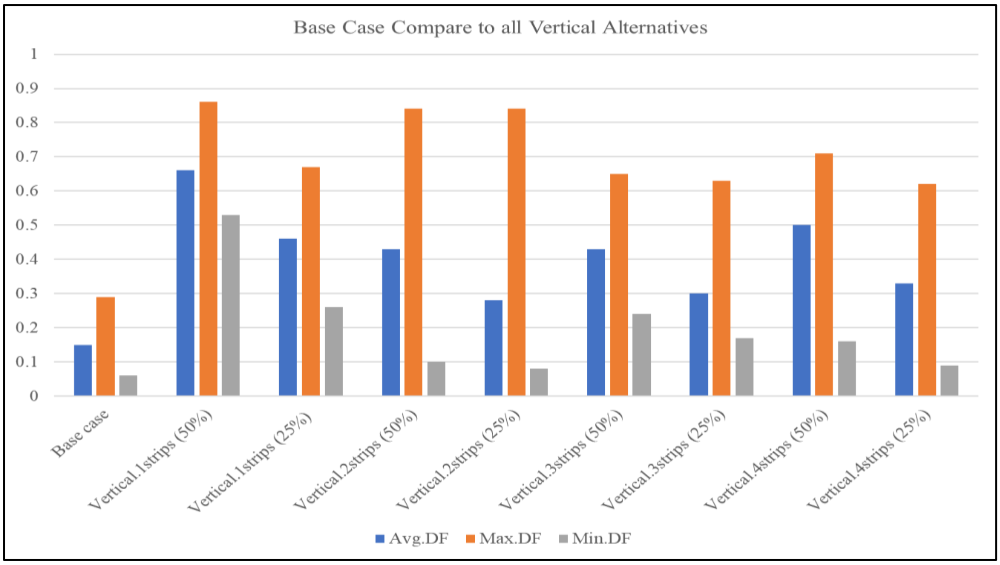
Varied design strategies were studied to Borrow Daylight for use in corridors to investigate the extent of daylight which can be borrowed to light the corridors to compare the varied design alternatives comparing them to the base case. As showing in Figure 5.

Figure 5: Base Case Compare to All Horizontal Alternatives



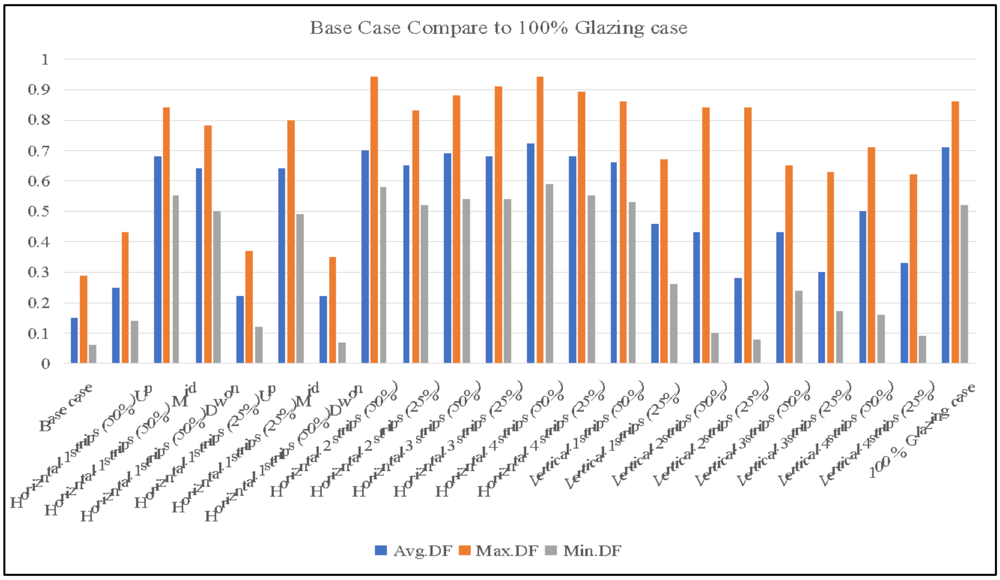
Source: Author, (2020).

Figure 6: Base Case compared to All Vertical Alternatives



Source: Author, (2020).

Figure7: Base Case Compare to All Glazing Case.



Source: Author, (2020).

Conclusions

In the research methodology, 20 alternatives design strategies were studied to determine which are the best for use in corridors. The results showed that case horizontal alternatives is better than case vertical alternatives , where the lighting level increased. The increase in the glazing area in general helped to improve the daylight environment in the enclosed corridor space .It is very essential that daylight be integrated with enclosed corridor so that the reliance on artificial lighting can be minimized. When corridor walls are designed with borrowed daylight opportunities, healthier and cheerful environment is also created due to the benefits of the borrowed daylight. These corridor walls can also allow borrowed artificial light to occur in the night time when the spaces adjacent to the corridors are used at night. Therefore the borrowed lighting potential should be utilized as best possible.

This research also emphasized on the fact that minimal values of %DF lower than 1 % should not be underestimated especially in very bright sky illuminance as in Malaysia. For example, at Eo 60,000 lux of sky illuminance which is a normal occurrence here, 1%DF is already at 600 lux and 0.5%DF is at 300 lux. Even values of 0.05%DF (at 30lux) is invaluable and for corridor usage acceptable. Therefore more research to determine suitable %DF requirements for corridors is needed especially in tropics with high outdoor illuminance. This research is hoped to be in that direction.

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