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A COMPARATIVE STUDY ON THE PERFORMANCE OF SIDE-LIT ATRIA AND TOP-LIT ATRIA IN LOW LATITUDE TROPICS KUALA LUMPUR, MALAYSIA

MOHD. HAMDAN AHMAD, Ph.D
MD. NAJIB IBRAHIM, Ph.D
Department of Architecture
Faculty of Built Environment
Universiti Teknologi Malaysia
Skudai, Johor

Abstract

Top-lit atria are more popular than side-lit atria because they are believed to have a better distribution and higher daylighting level. However, in low latitude humid tropics they may cause over lighting and thus overheating. Using computer simulation, this study attempts to compare the distribution and level of daylighting in top-lit atria with those in the side-lit atria.

1.0 Introduction

The atrium form, which is imported from the West, is believed to be not suitable for the low latitude tropics Malaysia. The large area of exposed horizontal glazed roof of the atrium in most cases may cause a very bright and warm atrium spaces even when the spaces are air-conditioned. As the atrium spaces are used merely for circulation and temporary occasional functions, the high level of daylighting is unnecessary. These circumstances may cause unnecessary glare with associated severe cooling energy penalty. The absence of natural planting in most of the atrium spaces, for which reason such lighting level is normally required, reinforces the inappropriateness of such daylighting design solutions. In this situation, there is a need for alternative design solutions for atrium buildings in Malaysia, in which an appropriate quantity and suitable quality of daylight can be attained. The final result may lead to the reduction of the unnecessary cooling requirement, while maintaining visual and thermal confort. Many research have been done on daylighting distribution of atrium for temperate climates (see for example Liu et al., 1991; Cole 1990; Usha, 1990; Willbold-Lohr, 1989). Only a limited number of studies are available on atrium in low latitude tropics Malaysia (see for example Quek, 1989: Hamdan, 1997).

2.0 Methodology

This study consists of two parts; descriptive and quantitative analysis. The descriptive analysis identified the typical characteristics of atrium in Malaysia through case study on eight buildings in Kuala Lumpur City (Latitude 3°10' N and Longitude 101°40' E). The qualitative analysis examined numerically the light distribution and daylight factor (DF) in typical atria.

Descriptive Analysis

The descriptive analysis consists of personal visit to the case study buildings, an interview with building managers or design architects, collecting architectural drawing and observation/field measurement to determine geometrical configurations and physical dimensions, and reflectance of the atrium enclosure surfaces.

Quantitative Analysis

In the quantitative analysis, the level and distribution of daylighting in the mathematical model of a typical atrium is calculated using SUPERLITE (in ADELINE 1.0)

3.0 Result and Discussion

Based on the descriptive analysis, the characteristics of typical atrium in Malaysia may be summarised as the following :

1. Geometrical configurations and physical dimensions of typical atria.

1.1 The Plan-Aspect-Ratio (PAR) of rectangular atrium form is about 1:3 and for linear atrium form is about 1:9.

1.2 The Section-Aspect-Ratio (SAR) for both atrium forms is about 1:1.

1.3 The atrium walls are normally glazed with the Glass-to-Wall Ratio of between 80 to 100% on all floors.

1.4 The atria are normally top-lit

1.5 The number of floors is normally 4 stories with floor-to-floor height of 12 feet (approximately 4m).

(Table 1 shows details of the length, width, height, PAR, SAR, and Well Index Value of the eight buildings. In this table all dimensions used are measured in feet)

2. The reflectance of the atrium floor is about 25%.

Table 1 : Geometrical Configurations and Physical Dimensions

Building Identification	Length	Width	Height	PAR	SAR	Well Index Value
A	84	56	90	1:15	1:1.61	1.34
B	142	52	80	1:2.73	1:1.54	1.05
C	234	24	48	1:9.75	1:2	1.1
D	56	56	60	1:1	1:1.07	1.07
E	1092	50	50	1:218	1:1	0.52
F	400	20	30	1:20	1:15	0.79
G	126	52	60	1:2.42	1:1.15	0.82
H	196	84	60	1:2.33	1:0.71	0.51

The results of quantitative analysis are summarised in Table 2, Table 3, and Figures 1 through 4. The DF in Table 2 and 3 are calculated for overcast conditions on December 22nd. Figures 1, 2, 3 and 4 are based on the data calculated in Table 2 and 3.

Table 2 : Calculated DF for top-lit and side-lit atria (Linear Form ; PAR 1:3).

Type of Models	Maintenance Factor (%)	Max DF	Mean DF	Min DF	DF at centre of atriums floor
TOP-LIT	100	52.2	42.5	28.6	52.2
	50	26.1	21.2	14.3	26.1
SIDE-LIT	100	11.5	8.6	5.3	11.5
	50	5.7	4.3	2.7	5.7

Table 3 : Calculated DF for top-lit and side-lit atria (Linear Form ; PAR 1:9).

Type of Models	Maintenance Factor (%)	Max DF	Mean DF	Min DF	DF at centre of atriums floor
TOP-LIT	100	50.1	43.3	24.2	50.1
	50	25.0	21.7	12.1	25.0
SIDE-LIT	100	12.8	10.5	5.5	12.8
	50	6.4	5.2	2.8	6.4

Figure 1 shows that in Top-Lit Atria the range of DF in both rectanggular and linear atrium is well above the target DF as suggested by Hamdan (1997). The suggested minimum DF in Malaysian atria for casual activities was 2% and for plants was 10%. In low latitude tropics the excessive daylighting is undesirable since it causes a higher air-conditioning load.

In comparison, Figure 2 shows that in Side-Lit Atria the range of DF in both rectangular and linear atrium is around the target DF. This means by using Side-Lit technique, both rectangular and linear atrium may achieve optimum daylighting without a heavy penalty to its air-conditioning load.

Figure 3 shows the distribution of daylighting in an atrium across its width/length is more uniform in the side-lit as compared to the top-lit. This means glare problem will not occur in the side-lit atrium.

Similarly, the uniformity of distribution as described above can be seen in Figure 4. Figure 4 shows the distribution of DF across longitudinal and sectional sections on the floor of Linear Atria.

Figure 1 : Maximum and Minimum Ranges of DF During Overcast Conditions for Top-Lit Atria.

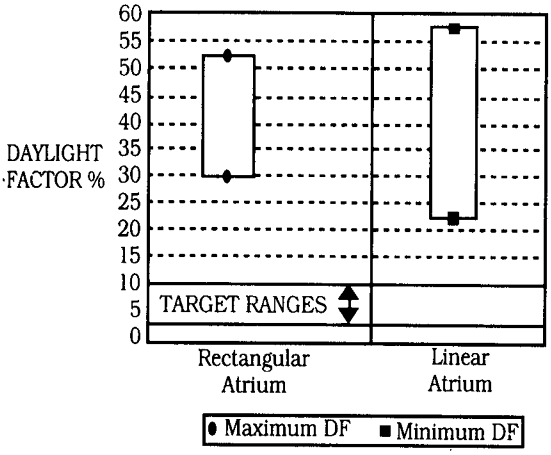


Figure 2 : Maximum and Minimum Ranges of DF During Overcast Conditions for Side-Lit Atria.

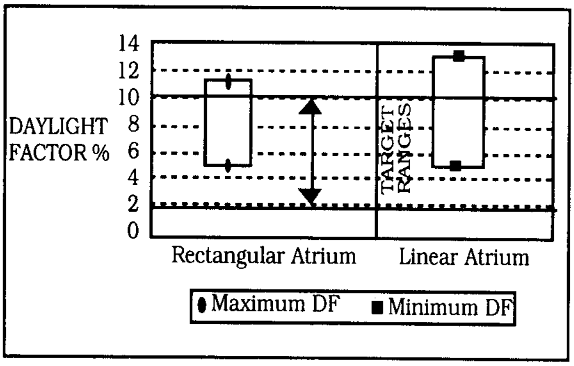


Figure 3 : Distribution of DF Across Longitudinal and Cross Sections of Rectangular Atria on Overcast Day.

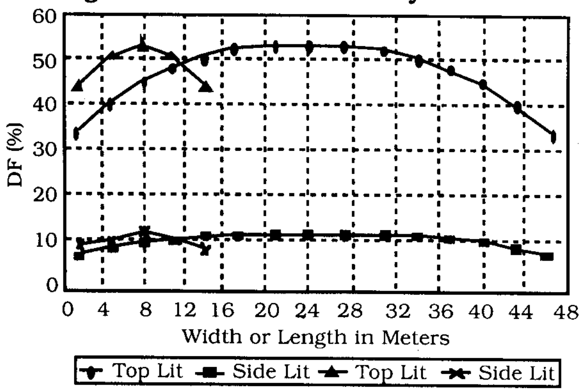
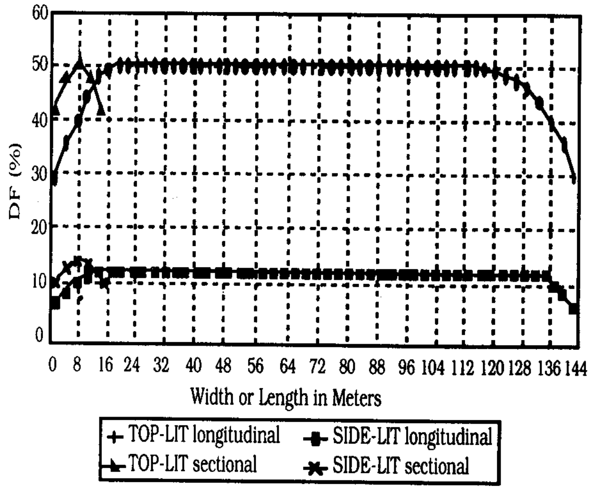


Figure 4 : Distribution of DF Across Longitudinal and Sectional Sections on Atrium Floor of Linear Atria.



4.0 Conclusion and Recommendation

This study shows that the use of Side-Lit Atria should be encouraged in low-latitude tropics Malaysia. Further study should be conducted to improve daylighting in side-lit atria such as modification to roof form, glazing position and glazing material.

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