

EXTERNAL SHADING DEVICES AS PASSIVE DAYLIGHTING STRATEGY
FOR RESTING CORRIDOR IN TROPICS

MUHAMAD FAIZ BIN ZAKARIA

UNIVERSITI TEKNOLOGI MALAYSIA

EXTERNAL SHADING DEVICES AS PASSIVE DAYLIGHTING STRATEGY
FOR RESTING CORRIDOR IN TROPICS

MUHAMAD FAIZ BIN ZAKARIA

A dissertation submitted in fulfilment of the
requirements for the award of the degree of
Master of Architecture

Programme of Architecture
Faculty of Built Environment and Surveying
Universiti Teknologi Malaysia

JULY 2022

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

First and foremost, I wish to express my sincere appreciation to my main thesis supervisor, Ts. Dr. Leng Pau Chung, for encouragement, guidance, critics and friendship. I am also very thankful to my co-supervisor Ar. Norshahida Binti Azili and Ar for their guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here.

My gratitude extends to the Universiti Teknologi Malaysia (UTM), for funding opportunity to undertake my studies at the Department of Architecture, Faculty of Built Environment and Surveying. I would like to thank my fellow classmates for their support and encouragement along the journey of my master study. My completion of this thesis could not have accomplished without them.

Finally, I am grateful to my parents for their love and support for educating and preparing me for my future. Their encouragement when the times got rough are much appreciate and duly noted. My sincere appreciation also extends to others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family member.

ABSTRACT

The use of external shading devices as a passive daylighting approach aims to enhance the comfortability of the rest and relaxation space of the resting corridor in tropical climates. The purpose of this research is to determine the most convenient types of external shading devices that are intended to improve passive daylighting performance in tropical climate resting corridors. However, the primary challenge in harvesting natural daylight for visual discomfort owing to glare and heat gain concerns from direct daylighting for resting corridors in tropical climates is the lack of shade in resting corridor. For example, in tropical states like Kuala Lumpur and Penang, there is no specific study that can justify the response of external shade devices specifically designed to be installed in resting corridors in tropical climates. Furthermore, a literature study analysis was utilised to gather data, which was then incorporated into the experimental pre-test and post-test data collections using the digital simulation approach conducted by Velux Daylight Visualizer and SketchUp, which was then analysed using a chosen literature research for resting space, elements of corridors, external shading devices, and daylighting performance in a tropical climate. Data from the literature is obtained prior to the research in order to offer independent variables for the experiment. Quantifiable data is created as a result of the computer simulation study. Based on the method, the performance of egg-crates with shaded panels with a pitch angle adds to the improvement in daylighting performance in illuminating the inside of the resting corridor than conventional egg-crate shading devices when used as a passive daylighting approach for resting corridors in the tropics. This study definitely answers the question of whether the use of egg-crate external shading devices is effective to obtain excellent illuminance levels and daylight factors at resting corridors in the tropical climate. As the intention of resting corridors is to provide a sense of rest and relaxation with the mechanism of the corridor.

ABSTRAK

Penggunaan peranti teduhan luaran sebagai pendekatan pencahayaan siang hari yang pasif bertujuan untuk meningkatkan keselesaan ruang rehat dan santai yang terdapat pada ruang koridor rehat pada iklim tropika. Tujuan penyelidikan ini adalah untuk menentukan jenis peranti teduhan luaran yang paling berkesan bertujuan meningkatkan prestasi pencahayaan siang hari yang pasif pada ruang koridor rehat dalam iklim tropika. Walau bagaimanapun, pencahayaan siang semula jadi boleh menyebabkan ketidakselesaan visual disebabkan silau dan panas menjadi kebimbangan dan merupakan cabaran utama kajian ini. Hal ini kerana, pencahayaan siang yang terlalu terdedah di ruangan rehat koridor pada iklim tropika merupakan satu kekurangan. Sebagai contoh, di negara beriklim tropika seperti Malaysia dan Singapura, tiada sebarang kajian khusus yang dapat menjelaskan tindak balas peranti teduhan luaran yang dirancang khusus untuk dipasang di koridor rehat pada iklim tropika. Oleh itu, analisis kajian literatur digunakan untuk mengumpulkan data, yang kemudian dimasukkan ke dalam eksperimen pra-ujian dan pasca-ujian dalam pengumpulan data dari ujian tersebut menggunakan pendekatan simulasi digital dengan menggunakan perisian *Velux Daylight Visualizer* dan *SketchUp*, seterusnya dianalisis menggunakan penelitian literatur terpilih untuk ruang istirehat, elemen koridor, peranti teduhan luaran, dan prestasi siang hari di iklim tropika. Data daripada literatur diperoleh sebelum penyelidikan untuk menyediakan pemboleh ubah bebas untuk eksperimentasi. Data yang dapat diukur dijadikan sebagai hasil kajian simulasi komputer. Berdasarkan kaedah itu, prestasi penggunaan *egg-crate* serta peneduh bersudut condong menambah peningkatan prestasi pencahayaan siang dalam menerangi bahagian dalam koridor rehat. Selain daripada ciri peranti teduhan *egg-crate* yang lebih ke arah konvensional apabila digunakan sebagai pendekatan pencahayaan siang hari yang pasif untuk ruang rehat koridor di kawasan tropika. Kajian ini menjawab persoalan sama ada penggunaan peranti peneduhan luaran *egg-crate* berkesan untuk mendapatkan tahap pencahayaan yang terbaik dan antara faktor pencahayaan siang hari pada koridor rehat pada iklim tropika. Seterusnya, menjawab tujuan utama iaitu berehat di koridor dapat memberikan kesan rehat yang santai dan tenang dengan adanya kepelbagaian mekanisme yang terdapat pada koridor.

TABLE OF CONTENTS

	TITLE	PAGE
	DECLARATION	i
	DEDICATION	ii
	ACKNOWLEDGEMENT	iii
	ABSTRACT	iv
	ABSTRAK	v
	TABLE OF CONTENTS	vi
	LIST OF FIGURES	ix
	LIST OF TABLES	xi
	LIST OF APPENDICES	xii
CHAPTER 1	INTRODUCTION	13
1.1	Introduction	13
1.2	Problem Statement	14
1.3	Research Aim	14
1.4	Research Objectives	15
1.5	Research Question	15
1.6	Scope of Thesis	16
1.7	Significant of the study	16
1.8	Research Methodology	16
CHAPTER 2	LITERATURE REVIEW	18
2.1	Introduction	18
2.2	Proposition of resting corridor	19
2.2.1	Resting space	20
2.2.2	Corridor	22
2.3	Fundamental of daylighting	24
2.3.1	Passive Daylighting	25
2.3.2	Illuminance level and daylight factor	26

2.4	Shading devices as a passive daylighting strategy	29
2.4.1	Egg-crate application in resting corridor	31
2.5	Case study	32
2.5.1	Egg-crate: Anibal Building, Ipanema	32
2.5.2	Egg-crate: Chempenai House, Kuala Lumpur	34
2.5.3	Egg-crate: High Court Building, Chandigarh	36
2.5.4	Rest space: Wooden rest space, Seoul	38
2.5.5	Rest space: Zero space, Musashino Art University Tokyo	39
2.6	Summary	40
CHAPTER 3	RESEARCH METHODOLOGY	41
3.1	Introduction	41
3.2	Research Framework	41
3.3	Literature Review	42
3.4	Digital Simulation Method	42
3.4.1	Simulation Procedure	43
3.4.2	Variable of Simulation	43
3.4.3	Simulation Setting	44
3.4.4	Model setting	44
3.5	Research Workflow	45
3.6	Analysis Guidelines	46
3.7	Summary	46
CHAPTER 4	FINDINGS & DISCUSSION	47
4.1	Introduction	47
4.2	Daylight performance in the resting corridor	47
4.3	Result and Discussion	49
4.3.1	Simulation 1: Illuminance (lux)	49
4.3.2	Simulation 1: Daylight Factor (DF)	57
4.3.3	Simulation 2: Illuminance (lux)	59
4.3.4	Simulation 2: Daylight Factor (DF)	67
4.3.5	Simulation 3: Illuminance (lux)	69

	4.3.6 Simulation 3: Daylight Factor (DF)	77
4.4	Summary	79
CHAPTER 5	CONCLUSION AND RECOMMENDATIONS	81
5.1	Introduction	81
5.2	Conclusion	81
5.3	Limitation and recommendation	82
REFERENCES		83
APPENDIX		87

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
Figure 1.1	Research Methodology Flow Chart	17
Figure 2.1	Resting corridor research flow diagram	18
Figure 2.2	Illuminance value for type of interior, task or activity (Sources: Malaysia guidelines on occupational safety and health for lighting at workplace 2018).	19
Figure 2.3	Corridor (Sources: Aguila, T. <i>In the light of the shadow</i> 2016.)	20
Figure 2.4	Aisle (Sources: The British Pilgrimage Trust, 2022)	21
Figure 2.5	Staircase (Sources: Archdaily 2015)	21
Figure 2.6	Height of rooms in places of public resort (Sources: Uniform Building By-Laws 1984.)	22
Figure 2.7	Corridor Types (Sources: Rem Koolhaas, Stephan Trüby, Hans Werlemann, Kevin Mcleod, 2014)	23
Figure 2.8	The Components of daylighting (velux, 2022)	24
Figure 2.9	Active versus passive daylighting system (Onubogu et al., 2021)	25
Figure 2.10	MS1525:2014 Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings suggested an average illuminance level (Department of Malaysian Standard, 2014)	27
Figure 2.11	the formula is used to obtain daylight factor (DF) by determining the ratio of the internal illuminance (Green Quarter, 2016)	28
Figure 2.12	Table of Daylight Factor and Impact (Department of Malaysian Standard, 2014)	28
Figure 2.13	Type of external shading (Sources: Olgyay, Victor. 1963 cited in Faisal and Aldy, 2016)	30
Figure 2.14	Application of egg-crate shading devices in Pertubuhan Arkitek Malaysia (PAM) headquarters (Sources: Thein, M., 2022)	31
Figure 2.15	Anibal Building (Sources: Archdaily,2016)	32
Figure 2.16	Diagonal Egg-crate (Sources: Archdaily,2016)	33

Figure 2.17 Chempennai House egg-crate shading (Sources: Ng and P'ng, 2021)	34
Figure 2.18 Concrete material as sun-filtering device (Sources: Archdaily,2016)	35
Figure 2.19 High court building Chandigarh (Sources: Kamal and Arabia, 2013)	36
Figure 2.20 Pattern concrete egg-crate shading devices (Sources: Kamal and Arabia, 2013)	37
Figure 2.21 Wooden rest space (Sources: ITSLIQUUID, 2014)	38
Figure 2.22 Layered wooden ribs (Sources: ITSLIQUUID, 2014)	38
Figure 2.23 Zero space: (Sources: Igarashi, 2020)	39
Figure 3.1 Research framework	41
Figure 3.2 Variable of simulation	43
Figure 3.3 Model simulation setting	44
Figure 4.1 Variable of simulation model	48
Figure 4.2 Illuminance simulation result: Type A	50
Figure 4.3 Illuminance simulation result: Type B	52
Figure 4.4 Illuminance simulation result: Type C	54
Figure 4.5 Illuminance simulation result: Type D	56
Figure 4.6 Daylight factor (DF) simulation 1 result	58
Figure 4.7 Illuminance simulation result: Type D1	60
Figure 4.8 Illuminance simulation result: Type D2	62
Figure 4.9 Illuminance simulation result: Type D3	64
Figure 4.10 Illuminance simulation result: Type D4	66
Figure 4.11 Daylight factor (DF) simulation 2 result	68
Figure 4.12 Illuminance simulation result: Type D4A	70
Figure 4.13 Illuminance simulation result: Type D4B	72
Figure 4.14 Illuminance simulation result: Type D4C	74
Figure 4.15 Illuminance simulation result: Type D4D	76
Figure 4.16 Daylight factor (DF) simulation 3 result	78

LIST OF TABLES

TABLE	TITLE	PAGE
Table 1	SIMULATION 1: TYPE A	41
Table 2	SIMULATION 1: TYPE B	43
Table 3	SIMULATION 1: TYPE C	45
Table 4	SIMULATION 1: TYPE D	47
Table 5	SIMULATION 1: DAYLIGHT FACTOR	49
Table 6	SIMULATION 2: TYPE D1	51
Table 7	SIMULATION 2: TYPE D2	53
Table 8	SIMULATION 2: TYPE D3	55
Table 9	SIMULATION 2: TYPE D4	57
Table 10	SIMULATION 2: DAYLIGHT FACTOR	59
Table 11	SIMULATION 3: TYPE D4A	61
Table 12	SIMULATION 3: TYPE D4B	63
Table 13	SIMULATION 3: TYPE D4C	65
Table 14	SIMULATION 3: TYPE D4D	67
Table 15	SIMULATION 2: DAYLIGHT FACTOR	69

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
Appendices 1	Simulation 1: Type A	87
Appendices 2	Simulation 1: Type B	88
Appendices 3	Simulation 1: Type C	89
Appendices 4	Simulation 1: Type D	90
Appendices 5	Simulation 1: Daylight Factor	91
Appendices 6	Simulation 2: Type D1	92
Appendices 7	Simulation 2: Type D2	93
Appendices 8	Simulation 2: Type D3	94
Appendices 9	Simulation 2: Type D4	95
Appendices 10	Simulation 2: Daylight Factor	96
Appendices 11	Simulation 3: Type D4A	97
Appendices 12	Simulation 3: Type D4B	98
Appendices 13	Simulation 3: Type D4C	99
Appendices 14	Simulation 3: Type D4D	100
Appendices 15	Simulation 2: Daylight Factor	101
Appendices 16	Simulation 1: Illuminance value graph	102
Appendices 17	Simulation 2: Illuminance value graph	103
Appendices 18	Simulation 3: Illuminance value graph	104
Appendices 19	Simulation 1,2,&3: Daylight factor graph	105

CHAPTER 1

INTRODUCTION

1.1 Introduction

Daylighting is seen as a key component of space identity and, as a result, a key component of space quality. It can have a significant impact on resource conservation, occupant productivity, health, and comfort.(Hafiz and Transport, 2020). Daylighting will help lower the amount of CO₂ in the atmosphere while boosting consumer health. (Muhamad *et al.*, 2022). When the body's equilibrium is achieved by natural illumination, symptoms of sleepiness, lethargy, and exhaustion are decreased. (Muhamad *et al.*, 2022) In Addition, The utilization of natural light has proven equally essential in enhancing the environmental quality and energy efficiency of buildings. (Ku Adzman *et al.*, 2020). In response to natural daylighting, a passive daylighting system is an ideal technique for space quality. According to the study conducted by (Nihmiya, 2021) by collecting natural light and reflecting it into darker areas of the building, passive daylighting techniques increase the quantity and equitable distribution of daylight across a building.

In tropical climates, passive daylighting is the ideal companion in resting corridors. The resting corridor is an element that provided space for hybridization with corridic element. For example, according to (ARUP, 2017) natural light flow in corridors or rest areas between galleries allows visitors to relax and rest their eyes before proceeding. As for that, external shading devices are capable to utilize natural light sources as passive daylighting strategies for enhancing environmental and spatial quality. External shading devices are used to block direct sunlight from entering the living space. (Ku Adzman *et al.*, 2020). Moreover, Shading devices in both ventilated and unventilated rooms have a major influence on enhancing interior temperature conditions. However, due to their arrangement (i.e., a combination of overhangs and fins devices), egg-crate devices are the best in reducing interior air temperature and

minimizing the number of discomfort hours.(Al-Tamimi and Fadzil, 2011) In summary, this research will concentrate on the development of external shading devices as a passive daylighting strategy for resting corridors in the tropics.

1.2 Problem Statement

In tropical climates, such as tropical states like Kuala Lumpur and Penang, the fundamental issue in harvesting natural daylighting for the visual discomfort due to glare and heat gain problems from direct daylighting. According to the (. *et al.*, 2018) glare problem is caused by the exceedingly unequal distribution of daylighting in space. As a matter of effect, no study has been conducted specifically on the external shading devices' response to resting corridors in the tropical climate. The role of resting corridor in public buildings as a space with sense of rest and relaxation with the mechanism of the passageway and the 30% of the efficiency of building could be enhanced by optimizing the corridor as functional spaces. In order to enhance and value-adding the resting corridor, the adjustment and improvement of the corridor has to be done, especially via natural daylighting. Nevertheless, several studies showed the impact of external shading devices. According (Al-Tamimi and Fadzil, 2011) External shading devices such as overhangs, louvres, and egg crates should be encouraged as architectural components in Penang, which has the highest radiation level in Malaysia, to shield building envelopes and inhabitants from solar radiation. However, no specific study can be justified the response of external shading devices specifically to be implemented on resting corridors in the tropical climate.

1.3 Research Aim

The proposed research aims to determine to analyze the type of external shading devices designed to enhance passive daylighting performance in rest corridors in Malaysia.

1.4 Research Objectives

The objectives of the research are:

- (a) To study the significance of external shading devices for rest corridors in the tropics
- (b) To explore the best design typologies of external shading devices in achieving the best illuminance daylighting for a resting corridor in the tropics.
- (c) To evaluate the effectiveness to design parameters to optimize the daylighting performance with external shading devices.

1.5 Research Question

The questions of the research are:

- (a) What are the most essential exterior shading devices in Malaysia for resting corridors?
- (b) What are the design configurations of external shading devices to achieve the optimum illuminance daylighting for resting corridors in the tropics?
- (c) What are the effectiveness of design parameters to optimize the daylighting performance with external shading devices?

1.6 Scope of Thesis

This research will focus on the design and performance of external shading devices in passive daylighting in resting corridors as a sense of rest and relaxation space with the mechanism of the passage way. The design features of external shading devices will be established using the passive daylighting system and theory in the tropical environment.

1.7 Significant of the study

Differentiate external shading devices that are possibly implemented in resting corridor design in Malaysia. The various type of external shading devices and each capability to accomplish the significant space quality in the resting corridor as optimum illuminance daylighting for resting corridors in the tropics

1.8 Research Methodology

This study is using the mixing method which is a combination of the quantitative framework, where the research will be analyzed using computer simulation for daylighting performance in indoor space and the qualitative framework analyzed the selected literature review. The research framework is to evaluate the passive daylighting performance of external shading devices in resting corridors in tropical climates. As for the research conducted with the quantitative framework. A literature review is used to gather information and knowledge of the external shading device's response to the passive daylight system used in a tropical environment.

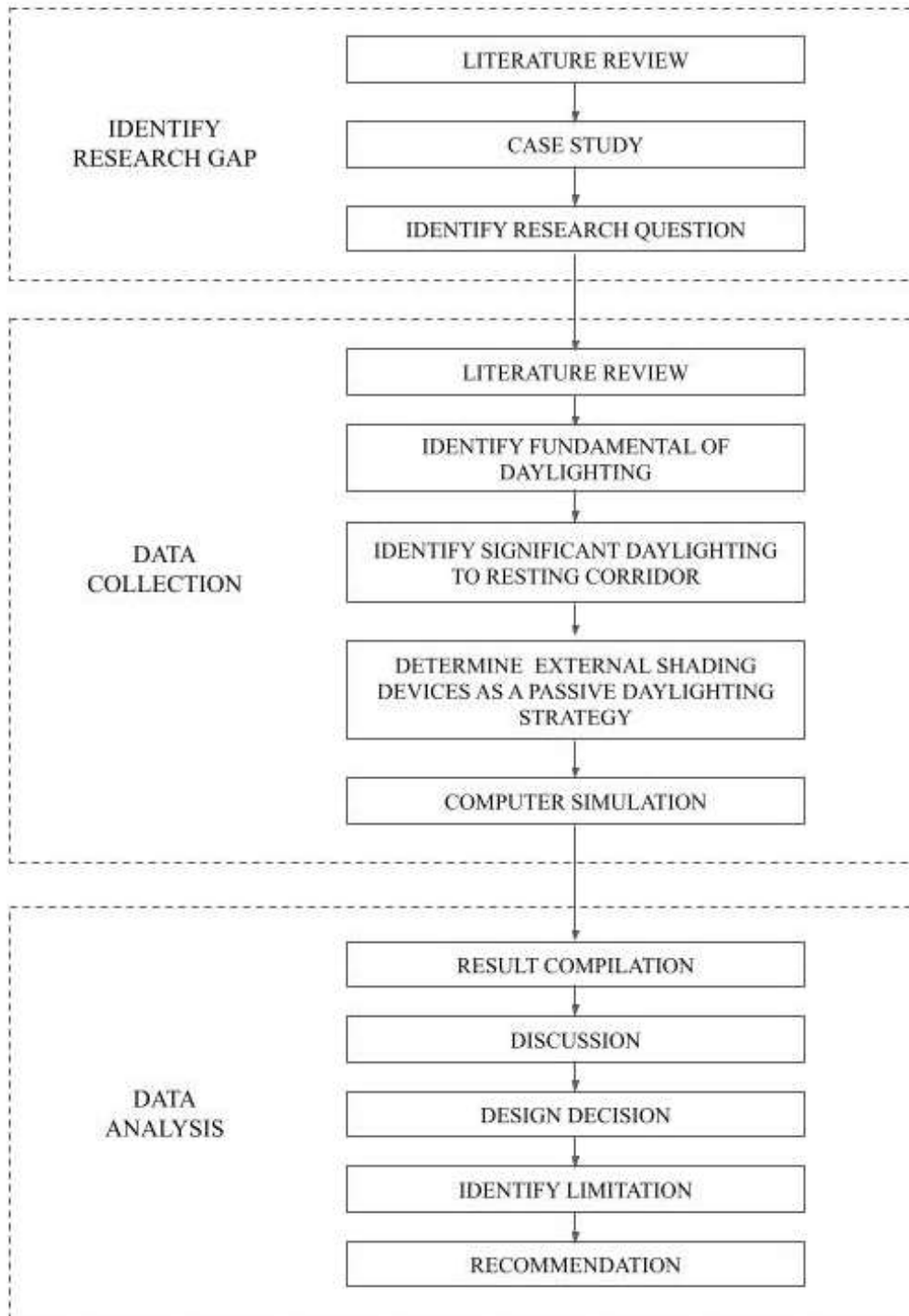


Figure 1.1 Research Methodology Flow Chart

REFERENCES

- . A., . J., Zin Bin Kandar, M. and Yakubu Aminu, D. (2018) 'Light Shelf as a Daylighting System in a Tropical Climate Office Space', *International Journal of Engineering & Technology*, 7(2.29), p. 798.
- Al-Tamimi, N. A. and Fadzil, S. F. S. (2011) 'The potential of shading devices for temperature reduction in high-rise residential buildings in the tropics', *Procedia Engineering*, 21(December 2011), pp. 273–282.
- Al-Yasiri, Q. and Szabó, M. (2021) 'A short review on passive strategies applied to minimise the building cooling loads in hot locations', *Analecta Technica Szegedinensia*, 15(2), pp. 20–30.
- ARUP (2017) 'Rethinking lighting in museums and galleries'.
- Department Of Occupational Safety And Health Malaysia (2018) 'Guidelines occupational safety and health for lighting at workplace 2018'. Malaysia: Ministry Of Human Resources Malaysia.
- Faisal, G. and Aldy, P. (2016) 'Typology of building shading elements on Jalan Sudirman corridor in Pekanbaru', *IOP Conference Series: Materials Science and Engineering*, 128(1).
- Folaranmi, A. O., Ayodele, O. S., Qasim, Y. T. and Abiodun, A. O. (2015) 'User perception of relaxation spaces in hospitals in Abuja', *Journal of Environmental Design and Management*, 7(2), pp. 80–87.
- Hafiz, D. and Transport, M. (2020) 'Daylighting, Space, and Architecture: A Literature Review', (December 2015).
- Kamal, M. A. and Arabia, S. (2013) 'Le Corbusier ' s Solar Shading Strategy for Tropical Environment : A Sustainable Approach', *Jars*, 10(1), pp. 19–26.
- Ku Adzman, K. N. F., Saji, N. and Mohd Arish, N. A. (2020) 'A Study of Daylight Optimization in Building Design in The Student's Residential College of UTHM Pagoh', *Journal of Advanced Industrial Technology and Application*, 01(01), pp. 1–12.
- Li, Z., Wei, Q. and He, H. (2013) 'A brief analysis of spatial constitution and functional organization of museum architecture: A case study on museums in Hefei', *Frontiers of Architectural Research*. Elsevier, 2(3), pp. 354–361.

- Mandalaki, M. and Tsoutsos, T. (2020) *Solar Shading Systems: Design, Performance, and Integrated Photovoltaics*.
- Muhamad, J., Ismail, A. A., Muhammad, S., Sayed, A., Khair, A. and Ahmad, H. (2022) 'A Study of Daylighting Impact at Inpatient Ward , Seri Manjung Hospital', 2, pp. 233–242.
- Ng, V. and P'ng, T. H. (2021) 'Analysing Malaysian Houses with Discursive Idea', *International Transaction Journal of Engineering*, 12(10), pp. 1–7.
- Nihmiya, A. R. (2021) 'Passive Daylighting Systems', *Advances in Technology*, 1(2).
- Onubogu, N. O., Chong, K. K. and Tan, M. H. (2021) 'Review of Active and Passive Daylighting Technologies for Sustainable Building', *International Journal of Photoenergy*, 2021, pp. 6–8.
- Oxford Advanced Learner's Dictionary (2022) *Restroom - UK Dictionary, Oxford Learner dictionary*.
- Oxford Advanced Learner's Dictionary (no date) *Definition of rest noun, Oxford Learner dictionary*.
- Prihatmanti, R. and Susan, M. Y. (2017) 'Adaptive reuse of heritage building and the impact to the visual comfort: Assessed by the lighting quality', *IPTEK Journal of Proceedings Series*, 0(3).
- Rem Koolhaas, Stephan Trüby, Hans Werlemann, Kevin Mcleod, I. B. (2014) *Elements of Architecture: Corridor*. Marsilio.
- Sailer, K. (2018) 'Corridors, classrooms, classification: The impact of school layout on pedagogy and social behaviours', *Designing Buildings for the Future of Schooling: Contemporary Visions for Education*, pp. 87–111.
- Suharjanto, G. (2012) 'Fenomena Perbedaan Tingkat Kebisingan pada 2 Unit Ruang Tidur: Studi Kasus Rumah Tinggal Peneliti di Tepi Jalan Raya', *ComTech: Computer, Mathematics and Engineering Applications*, 3(2), p. 944.
- K. Abdullah, H. (2016). Evaluation of the Optimal Solar Shading Devices for Enhancing Daylight Performance of School Building. (A case study of semi-arid climate – Erbil city). *ZANCO Journal of Pure and Applied Sciences*. doi:10.21271.

- Lau, A.K.K., Salleh, E., Lim, C.H. and Sulaiman, M.Y. (2016). Potential of shading devices and glazing configurations on cooling energy savings for high-rise office buildings in hot-humid climates: The case of Malaysia. *International Journal of Sustainable Built Environment*, 5(2), pp.387–399. doi:10.1016/j.ijbsbe.2016.04.004.
- Thein, M., (2022) *Photoessay: PAM, part I*. [ONLINE]. Available at: <https://blog.mingthein.com/tag/pam/> [Accessed 13 December 2019]
- Ng, V. (2021). Analysing Malaysian Houses with Discursive Idea. doi:DOI: 10.14456/ITJEMAST.2021.198.
- art4d. (2016). *CHEMPENAI HOUSE*. [online] Available at: <https://art4d.com/2016/10/chempenai-house> [Accessed 25 Jul. 2022].
- highcourtchd.gov.in. (n.d.). *Building and Architecture: High Court of Punjab and Haryana*. [online] Available at <https://highcourtchd.gov.in/?trs=building>.
- Kamal, M.A. (2013). Le Corbusier's Solar Shading Strategy for Tropical Environment: A Sustainable Approach.
- ITSLIQUID. (n.d.). *Wooden Rest Space in Seoul*. [online] Available at: <https://www.itслиquid.com/wooden-rest-space-seoul.html> [Accessed 26 Jul. 2022].
- ArchDaily. (2016). *Anibal Building / Bernardes Arquitetura*. [online] Available at: <https://www.archdaily.com/796575/anibal-building-bernardes-arquitetura> [Accessed 26 Jul. 2022].
- Bernardes, T. (2016). *Bernardes Architecture Brings Buttoned-Down Design to Ipanema Office Building*. [online] *Interior Design Magazine*. 30 Mar. Available at: <https://interiordesign.net/projects/bernardes-architecture-brings-buttoned-down-design-to-ipanema-office-building/> [Accessed 26 Jul. 2022].
- Igarashi, H. (2020). *Musashino Art University ZERO SPACE by Igarashi Design Studio*. [online] 6 Mar. Available at: <https://idreit.com/article/zero-space-igarashi-design-studio-tokyo-japan>.
- Uniform Building By-Laws 1984.
- Department of Malaysian Standard, (2014). MS1525:2014 Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings suggested an average illuminance level

Aguila, T. (2016). *In the light of the shadow*. Available at: <https://lightroom.lighting/la-luz-de-la-sombra/>.

The British Pilgrimage Trust (2022). *Peterborough Cathedral Pilgrimage in a Day*. Available at: <https://britishpilgrimage.org/portfolio/peterborough-cathedral-pilgrimage-in-a-day/>.

Archdaily (2015). *Living Staircase / Paul Cocksedge*. Available at: <https://www.archdaily.com/642612/living-staircase-paul-cocksedge>.