

DAYLIGHT PERFORMANCE IN SPORT RESEARCH LABORATORY UNDER
TROPICAL SKY CONDITIONS

LIM SIAW YEN

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To my beloved parents and siblings.

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ABSTRACT

ASEAN users are different with European, American or either typical Asian. ASEAN live under tropical climate with different behaviours, sensory capabilities, and physical attributes. Adidas Sport Research Laboratory is set up mainly for performance footwear engineers to undergo the shoe testing involved with all performance footwear, mainly focus on ASEAN's popular sport, such as: basketball, jogging, running, cycling, and hiking. The aim of this research is to maximize the use of natural daylighting where architectural aspects of atrium is explored. Active space is created through daylighting conditions that may positively stimulate activities. Physical methods and virtual methods are assessed by computer simulations with integration of modelling tools and data manipulation. The simulation result is synthesized into architectural design strategies for future references. From the simulations it can established that by allowing light reaches further down into an atrium, the reflective component of the atrium wall becomes the aiding component to increase the illuminance of work plane adjacent to the atrium. It is therefore crucial to use high reflective, light coloured surfaces within the atrium. While going up nearer to the fenestration system, the control of the diffuse daylight through the roof become crucial element to control the illuminance of the work plane at the upper floor. The research outcome helped in the design thesis where the sawtooth roof and external light shelf is used to induce optimum natural daylight from the fenestration system until the floor of the atrium.

ABSTRAK

Pengguna ASEAN adalah berbeza dengan pengguna di Europah. Pengguna ASEAN hidup dalam keadaan cuaca tropikal yang pelbagai tingkah laku, keupayaan deria, dan sifat-sifat fizikal. Makmal sukan Penyelidikan Adidas ditubuhkan untuk jurutera menjalani ujian yang terlibat dengan semua prestasi kasut, terutamanya memberi tumpuan kepada sukan popular ASEAN, seperti: bola keranjang, berjoging, berlari, berbasikal, mendaki dan lain-lain. Tujuan dari penelitian ini adalah untuk memaksimumkan penggunaan pencahayaan semula jadi dan aspek atrium dikaji untuk menciptakan ruang yang aktif melalui keadaan pencahayaan yang mampu merangsang kegiatan. Cara fizikal dan cara virtual akan dinilai dengan simulasi komputer dengan integrasi alat pemodelan dan manipulasi data. Hasil simulasi akan dianalisis ke dalam strategi seni bina untuk rujukan masa depan. Keputusan simulasi juga mengesahkan bahawa komponen reflektif dinding atrium menjadi komponen untuk membantu cahaya semula jadi mencapai tempat berdekatan dengan atrium yang lebih dalam. Demi meningkatkan reflektif, permukaan berwarna terang digunakan dalam atrium. Sementara naik lebih dekat ke sistem bumbung, tempat kerja di tingkat lebih atas menggunakan cahaya semula jadi dari atrium yang dikawal oleh sistem bumbung. Hasil kajian yang diperoleh membantu dalam reka bentuk tesis dengan menggunakan bumbung atap gigi gergaji dan rak cahaya luaran digunakan untuk mengundang cahaya semula jadi yang optimal dari sistem bumbung sampai ke lantai atrium.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Daylighting in office buildings is commonly known as an essential energy-saving design alternatives which needs proper architectural design in order to optimize the benefits (Johnson et al.,1985). The amount of natural lighting allowed in the building is majority decided by the window openings that admitting daylight to the interior for a pleasant and attractive atmosphere, and keep a constant visual contact with the exterior environment (Li & Tsang, 2008). Introduction of daylighting in the building is widely recognized as an strategy to reduce the electric consumptions and there is an increasing trend to design daylight-efficient buildings.

Other than the energy savings, natural daylight also helps to improve indoor environmental quality where indirectly increase the productivity of the occupants. A recent survey by Dogrusoy & Tureyen (2007) proven the advantages that daylight is more preferable among most building occupants than artificial light and the three most important factors which are natural light, sunlight and natural ventilation that make the building environment more comfortable and interesting. Another study showed that a group of individuals can resolved about 10% more tasks correctly, faster and less tired under daylit environment compared to a group of occupants that had to complete the same tasks under artificial lighting (WAREMA, 2003).

Therefore, building design needs to consider not only the quantity of daylight, but quality of daylight which contributes to the occupants' well-being and health.

1.2 Sport Research Laboratory

The sport research lab mainly focus research on ASEAN users' movement and motion with respect to the biomachanic element under tropical country. The research should be more sensible intervention which respects the natural daylighting to simulate tropical sky.

In contrast with the increasing consumers and suppliers chain in South East Asia, a research and development centre is essential to the development of new product concepts, processes, digital applications to strengthening market position in South East Asia. The research and development is an integral part of the product and user experience creation process allowing producers to connect and collaborate with the consumers.

ASEAN users are different with European, American or either typical Asian. ASEAN live under tropical climate with different behaviours, sensory capabilities, and physical attributes. Sport Research Laboratory is set up mainly for performance engineers to undergo the products testing involved with all product performance, mainly focus on ASEAN's popular sport, such as: basketball, jogging, running, cycling and hiking. The engineers carry out sport and exercise biomechanics research approach based on a mixture of theoretical modeling and experimentation with the machinery aid such as portable metabolic measurement system, motion capture system, computer simulation and modeling of human movement and etc. The controlled indoor environment is essential for reducing sport injuries and bad weather or climate.

The researches and experiments is carried out with qualitative research technique among the local ASEAN consumers to provide an intensive, holistic and in-depth understanding of a single event, activity, program, process, or individual. The research and development also help to identifies recurrent patterns in the form of

different categories of sports and provide a descriptive understanding and exploratory interpretation to improve the sport products.

In contrast to conventional office typologies, the sport research laboratory need a direct relationship to the communicative outer surroundings with a controlled tropical climate and weather in order to simulate the tropical sky conditions. In order to positively invites the surrounding to find a continuation within the interior, atrium architectural aspects is further explored to create active atrium space through daylighting conditions. Natural daylight is also introduced as the primary source of daytime illumination to create a more suitable working environment by employing different suitable means. Introduction of daylighting in the sport research laboratory can provide adequate daylighting aesthetically and functionally in terms of energy efficiency to facilitate safe play to an appropriate standard.

The main objective of this chapter is to identify the fundamental problems that lead to the author's research topic, generate research aims and objectives, to organize the outline of this dissertation. At the same time, it establishes a brief understanding of the selected research methodology. It is envisioned that the research findings will contribute to articulate the building concepts for the Design Thesis and enhance the author's understanding on certain considerations that are necessary to be made in the future while designing a multi-storey office building.

1.2.1 Adidas

Adidas is a global brand with German roots mainly focus on Sport wear performance to help athletes to make a difference in their games. The main focus is on key categories such as football, running, basketball, and training (Adidas, 2016).

According to Adidas Group Annual Reports 2015, the Global Operations worked with 320 independent manufacturing partner worldwide where 79% were located in Asia, 12% in Europe and 9% in America. Among the 79% of the suppliers in Asia, Vietnam represents the largest sourcing country with 41% of the total volume, followed by Indonesia with 24% and China with 23%. Profitability in South

East Asia increase from 18% of net sales in 2009 to 29% by 2013 and in Pacific increase from 12% in 2009 to 20% by 2013.

There are 5 Adidas design studio in the world, which is located at Herzogenaurach (Germany), Canton (China), Portland (U.S.), Shanghai (China), and Tokyo (Japan). Currently, there is no design studio in South East Asia (Adidas, 2016).

In contrast with the increasing consumers and suppliers chain in South East Asia, a research and development centre is essential to the development of new product concepts, processes, digital applications to strengthening Adidas market position in South East Asia. The research and development is an integral part of the product and user experience creation process allowing Adidas to connect and collaborate with the consumers.

1.3 Statement of the Problem

In contrast to conventional office typologies, the building need a direct relationship to the communicative outer surroundings with a controlled tropical climate and weather in order to simulate the tropical sky conditions. Hence, atrium is introduced for efficient tropical daylighting. There is abundant indoor daylight quantity due to the high external natural lighting availability in the tropic. However, the building occupants prone to 'reject' the inefficient daylighting if the daylight quality is improperly controlled and totally depend on the electric lighting instead. Therefore, the balance between daylight quantitative and qualitative performances is essential to achieve efficient tropical daylighting (Lim et al, 2012).

The purpose of this study is to tackle the problems of direct sun light patches from atrium. The findings need to explain that the integration of daylight is the effective design for contemporary high-rise office or research centre. There are a lot of efforts needed to further develop the knowledge of tropical daylighting.

1.4 Research Aims

The research aim is to establish a fundamental atrium configuration to maximize daylighting as well as side daylighting in contemporary multi-storey office or research centre.

1.5 Research Objectives

There are three main objectives that are targeted to be accomplished in this research which are:-

- i. To provide adequate natural daylighting as the primary source of daytime illumination conditions that may positively stimulate activities and create a more suitable working environment.
- ii. To explore architectural aspects under tropical sky conditions that may positively optimize daylighting.
- iii. To research on the illuminance level and daylight factor for office environment and produce simulation results in visual graphics.

1.6 Research Questions

The goal of this dissertation is achievable by responding to the research questions below:

- i. How to simulate optimum tropical outdoor environment conditions in the interior of Sport Research Laboratory that conducive for sport performance?
- ii. How to optimize natural lighting in Malaysia contemporary multi-storey open plan office and laboratory?
- iii. How to avoiding glare and direct sun light patches in open plan office?

1.7 Significance of the Research

This research is important to understand the alternatives for introducing quality daylight into buildings, in its spectral composition and variability to give a better illuminated environment than artificial lighting. More daylighting technologies and effective lighting controls is explored for possibilities of energy savings via the use of daylighting which is considerable to be adapted to the design of other building types and other industries in the future. The research also provide significant help in design thesis (refer to Appendix B).

1.8 Research Methodology

Generally, the basic research structure will be categorized into four different stages: to identify the research problem, data collection, data analysis and last but not least the conclusion. Primary data is gathered through existing literature reviews, journal articles, books or reading materials, internet-based articles and the primary data collected will be supported by thesis done by alumni as the secondary data.

The research will be aided with computer simulation programs which can be modified to be simulated with different climatic conditions, dimensions and fenestrations. A proper software is vital to prepare the required performance and design variables. The simulation software that aiding in this research is Ecotect Radiance which is developed by Greg Ward in the year 1985, an advanced lighting simulation and backward ray-tracing rendering package which simulates indoor illuminance and luminance distributions due to daylight for complex building geometries and a wide range of material surface properties for one sky condition at a time.

1.9 Expected Findings

The research presented the efficient introducing of tropical daylighting in Malaysia contemporary multi-storey open plan buildings especially office and laboratory. There is plenty of indoor daylight quantity in the tropic due to the high external daylight availability. However, the users tend to 'reject' the inefficient daylight if there is no proper control of good daylight quality, and totally depend on the electric lighting. Hence, it is essential to find a balance between daylight quantitative and qualitative performances to achieve efficient tropical daylighting.

The findings will explain that the integration of daylight is the effective design for contemporary high-rise office or research centre. Daylight can be introduced into the building by avoiding direct sun light patches. There are a lot of efforts needed to further develop the knowledge of tropical daylighting.

1.10 Structure of Research

This dissertation included five main chapters. An brief introduction and overview of this research will be delivered in Chapter 1, including the background of study, research aim and objectives, research questions, research methodology and the expected findings. Meanwhile, Chapter 2 will be covering the literature reviews with the topics related to integrating tropical daylight in high rise building to induce daylighting. Case studies and examples are included to support the research. A section explaining about the sport research laboratory is included, where the researchers or scientists unlock athlete insights in the laboratory to help designers create advanced footwear, apparel and equipment for athletes as well as to reducing sports injuries and improve human performance and potential. Chapter 3 mainly covered on the methodology of the research used for this dissertation where data is assembled majority from existing literature reviews, journal articles, reading materials or books, internet-based articles. The analyzed data will be deliberated in

order to create a potential architectural solution to encounter the research aim and objectives at the end of Chapter 3. Last but not least, Chapter 5 will wrap up the discussions and proposals from Chapter 4 by responding to the research questions and further highlights the significance and importance of the overall research. Chapter 5 will also includes the limitations, challenges and future recommendations for the research for daylight building design.

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