SAWTOOTH ROOF SYSTEM IN IMPROVING DAYLIGHTING PERFORMANCE IN AERIAL SPORTS HALL

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UNIVERSITI TEKNOLOGI MALAYSIA

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DEDICATION

This thesis is dedicated to my family, 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 supervisor and university friends for their encouragement and assistance in completing this thesis.

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ABSTRACT

Daylight is the most commonly used type of lighting, and people always welcome it. Even though people have sought to avoid direct sunlight, daylight is always appreciated in public spaces. The importance of natural daylighting for energy efficiency in building has been acknowledged. Additionally, natural daylighting is good for users' psychological and physical health, particularly in terms of their mood, performance, and productivity. Black box architecture typically depends heavily on artificial lighting to fill the room with enough brightness because these spaces lack natural sunshine. The lighting in an aerial sports venue must be carefully considered since both excessive and inadequate illumination might have negative effects. Both circumstances had an impact on the participants' eyesight, which in turn influenced how well they played the game. In an aerial sports hall, natural lighting is advised to save energy use and improve player performance. The athlete's relationship to the light, the activity, and the space is crucial, and ideal sporting circumstances depend on proper spatial geometry and enough illumination. A top-lighting system is a daylighting technique that uses roof openings to evenly distribute daylight across the top floor design. Sawtooth roofs are used in various skylight strategies because they provide gentle, diffuse light rather than harsh light, which is why they are used in aerial sports halls. In this study, several settings and configurations are being tested to determine the best layout for the selected sports hall. Results from the VELUX Daylight Visualizer are assessed and discussed in order to get a reading of the Daylight Factor (DF) and illuminance value (lux), which will help researchers establish whether they are appropriate for the design.

ABSTRAK

Bentuk pencahayaan yang utama ialah cahaya siang yang selalu dihargai oleh orang. Cahaya siang selalu disambut oleh orang di dalam bangunan manakala ada juga orang berusaha menghindari cahaya matahari, yang dikenali sebagai sinar matahari. Pencahayaan siang semula jadi boleh dikatakan sangat penting untuk penjimatan tenaga dalam seni bina. Selain itu, pencahayaan siang hari bermanfaat untuk kesihatan dan psikologi pengguna, terutama dalam suasana hati, prestasi dan produktiviti mereka. Ruang seni bina dengan reka bentuk kotak hitam tanpa cahaya matahari semula jadi biasanya banyak bergantung pada cahaya elektrik untuk mendapatkan cahaya yang mencukupi ke dalam ruang tersebut. Dewan sukan adalah ruang yang sensitif terhadap pencahayaan, kerana kesan pencahayaan yang berlebihan akan menyebabkan silau sementara pencahayaan yang tidak mencukupi menyebabkan kesan redup. Kedua-dua keadaan mempengaruhi penglihatan pemain yang seterusnya mempengaruhi prestasi mereka semasa permainan. Untuk mengurangkan tenaga elektrik yang digunakan dan meningkatkan prestasi pemain, pencahayaan semula jadi disarankan di dewan sukan. Hubungan atlet dengan cahaya, aktiviti dan bilik adalah penting dan bahawa keadaan sukan yang baik adalah soal geometri ruang dan pencahayaan yang mencukupi. Sistem pencahayaan dari atas merupakan strategi siang hari untuk memberikan pengagihan cahaya siang yang seragam ke seluruh denah tingkat atas melalui pembukaan bumbung. Terdapat pelbagai jenis bentuk strategi cahaya langit di mana atap gigi gergaji diperkenalkan untuk dewan sukan kerana memberikan cahaya meresap lembut dan bukannya cahaya keras. Beberapa tetapan dan konfigurasi sedang dieksperimen dalam penyelidikan ini untuk mengetahui reka bentuk yang sesuai untuk dewan sukan yang ditentukan. Hasil yang diperoleh daripada VELUX Daylight Visualizer telah dinilai dan dibincangkan agar pembacaan Daylight Factor (DF) dan illuminasi (lux) dapat ditentukan untuk kesesuaian reka bentuk.

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

In a permanently occupied room, daylight is always valued and welcomed as the primary type of lighting. However, sports halls are frequently built as dark, enclosed spaces without natural daylighting since they are locations where people would continually spend at least an hour each day. When there is no daylight, sports halls often rely on artificial lighting or large windows on the sides to bring direct sunshine inside. In particular for aerial sports like badminton and basketball, some sports halls that combine artificial and natural illumination should be avoided.

Natural daylighting has recently gained attention as a crucial component of energy-efficient building in the last 10 years. As a result, since the 1980s, natural daylighting has also begun to be used in sporting facilities. Implementing daylight benefits the environment by decreasing cooling loads on interior equipment as well as lighting use, which may produce billions of tonnes of carbon annually. Leslie, R. P. (2003) asserts that in order to minimise artificial lighting's energy consumption, artificial lighting must be lowered based on the amount of inside daylight. Additionally, daylight has a significant effect on the building's occupants. According to Edwards and Torcellini's research from 2002, users operate more effectively and do more work in a facility with natural daylighting. In addition, research by Morrell, P. (2005) also revealed a study by the British Council for Offices (BCO) that shown how effectively daylit spaces and smart daylight design increased users' productivity. It implies that having natural daylighting in a sports facility will have a good impact on the players' psychological and physical well-being.

Since the players in a aerial sports hall move around while doing the activities instead of remaining in a single position, the visual environment differs from that of a

normal stationary workspace. In the aerial sports hall, direct sunlight generates glare that is detrimental to the athletes' ability to prepare and compete. Small amounts of light are ineffective, and large amounts of light might make players dizzy.

1.2 Problem Statement

In general, daylight provides illumination for a space that enhances user performance and increases energy efficiency, but too much or direct sunlight can cause users to feel uncomfortable because of the manner the light is distributed, which results in glare and casts harsh shadows. Additionally, due of the glare problem, natural lighting has been omitted from the typical sports hall design. Aerial sports halls are planned without consideration for daylighting considerations due to a lack of explicit regulations in this area, which results in "black-box" buildings that use more electricity to illuminate themselves.

1.3 Research Aim

The aim of this research is to generate a design variation of sawtooth roof with effective daylighting performance in aerial sports hall in tropics.

1.4 Research Questions

The research questions are:

(a) How does daylighting respond to the visual comfort level of users in aerial sports hall?

(b) What is the design parameter of sawtooth roof system in aerial sports hall in tropic climate?

(c) What is the design configuration of sawtooth roof system in aerial sports hall to maximize the performance of daylighting?

1.4.1 Research Objectives

The objectives of the research are:

(a) To identify the use of daylight in aerial sports hall by introducing sawtooth roof system.

(b) To assess the design of sawtooth roof system for optimizing the daylight performance in aerial sports hall in tropic climate.

(c) To improve the daylight performance in aerial sports hall with sawtooth roof system for visual comfort of users.

1.5 Research Scope

The research focuses on the sawtooth roof system's performance and design parameters in tropical climates. The sawtooth roof system's design features will be assessed in context of the theory and design principle of daylight harvesting in tropical climates. To further enhance the effectiveness of daylight in the aerial sports hall, the sawtooth roof system will connect with a kinetic diffuser. Understanding tropical sky conditions and sun angles, particularly in Malaysia, will be part of the research as well. Illuminance (lux) and daylight factor (percent) of the interior of the aerial sports hall

will be utilised as the simulation parameters to assess the daylighting performance of various types of design components of the sawtooth roof system.

1.6 Significance of Research

Aerial sports halls are regarded to be huge spaces that serve both athletes and spectators. It is necessary to research the difficulty of constructing a place with enough natural light and to offer aesthetic comfort. With a basic understanding of daylight performance and visual comfort, it is crucial for an expert to build an aerial sports hall in a way that not only accommodates the size of the windows but also provides enough daylight to improve the visual comfort of the occupants.

1.7 Research Methodology

The research will make use of qualitative methods for gathering data. The initial step in qualitative techniques is to gather data and knowledge about the chosen daylighting design strategy on the basis of a literature research. A few case studies will be investigated in order to comprehend and examine how daylight is used in the aerial sports hall in accordance with the users' degree of visual comfort. In order to assess the effectiveness of daylighting in the aerial sport venues, software will also be utilised to calculate the Daylighting Factor (DF) and illuminance level (lux).

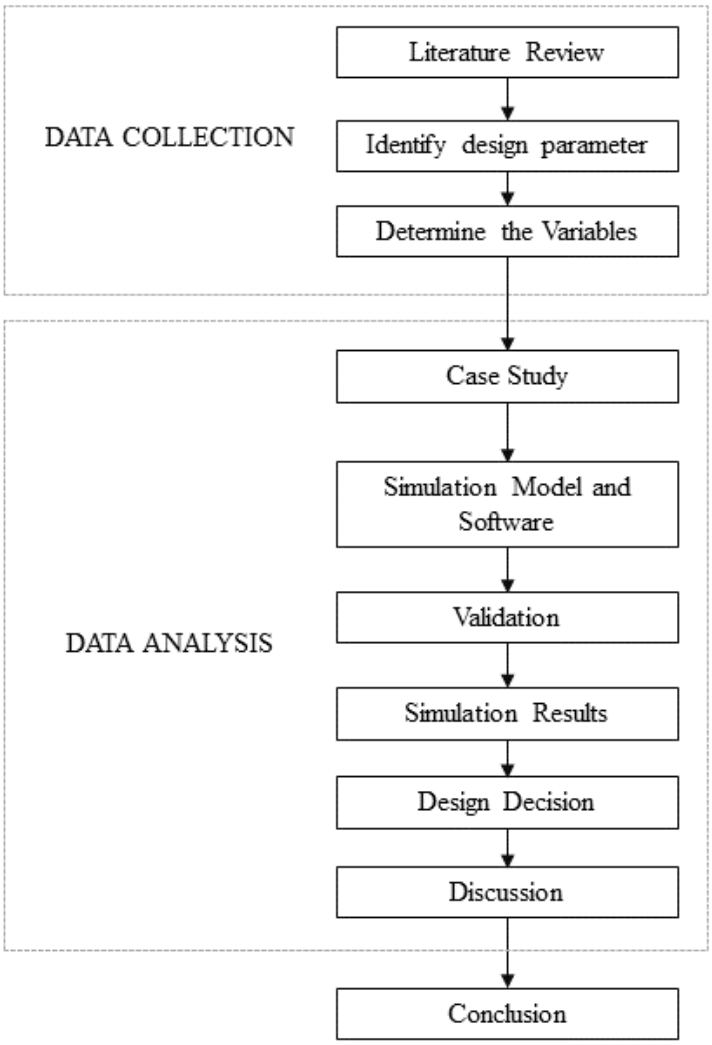

Figure 1.1 Flowchart of Study (Author, 2022)

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