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**BUILDING DESIGN AND MAINTENANCE FACTORS
CONTRIBUTING TO SICK BUILDING SYNDROME
(SBS) IN UNIVERSITI UTARA MALAYSIA (UUM)
BUILDING**



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**BUILDING DESIGN AND MAINTENANCE FACTORS
CONTRIBUTING TO SICK BUILDING SYNDROME (SBS) IN
UNIVERSITI UTARA MALAYSIA (UUM) BUILDING**

By

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**Thesis submitted to
College of Business
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in Partial Fulfillment of the Requirement for the
Master of Sciences (Project Management)**



Kolej Perniagaan
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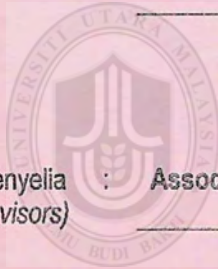
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ABSTRAK

Kajian ini meneliti bagaimana faktor reka bentuk bangunan dan amalan penyelenggaraan menyumbang kepada kejadian Sindrom Bangunan Sakit (SBS) di bangunan universiti di Universiti Utara Malaysia (UUM). Kajian ini bertujuan untuk mengenal pasti ciri reka bentuk dan sistem bangunan yang berkaitan dengan SBS, menentukan jenis dan ciri bangunan universiti yang lebih berisiko, serta menilai langkah penambahbaikan reka bentuk dan penyelenggaraan bagi mengurangkan risiko SBS. Walaupun kebanyakan kajian SBS memberi tumpuan kepada pengukuran kuantitatif kualiti udara dalaman, kajian ini menggunakan pendekatan kualitatif untuk memahami bagaimana keputusan reka bentuk, prestasi sistem bangunan, dan pengurusan penyelenggaraan mempengaruhi kejadian SBS dalam persekitaran universiti. Temu bual separa berstruktur telah dijalankan dengan profesional bangunan dari Jabatan Pembangunan dan Penyelenggaraan (JPP), UUM, termasuk arkitek, jurutera mekanikal, dan jurutera awam yang berpengalaman dalam bangunan universiti. Data dianalisis menggunakan analisis tematik bagi mengenal pasti pola dan isu berulang berkaitan SBS. Dapatan kajian menunjukkan bahawa SBS banyak dipengaruhi oleh masalah kelembapan, kualiti pembinaan yang lemah, sistem HVAC yang uzur, pengudaraan tidak mencukupi, serta penyelenggaraan yang tidak konsisten. Bangunan berusia, khususnya perpustakaan, bangunan akademik, dan dewan kuliah, serta bangunan yang bergantung sepenuhnya kepada sistem HVAC, dikenal pasti lebih terdedah kepada SBS. Kajian ini menekankan kepentingan perancangan reka bentuk awal, penyelenggaraan pencegahan, dan kerjasama antara profesional bangunan bagi meningkatkan kualiti persekitaran dalaman dan kesejahteraan pengguna di bangunan universiti.

Kata Kunci:

Sindrom Bangunan Sakit; Reka Bentuk Bangunan; Penyelenggaraan; Kualiti Persekitaran Dalaman; Bangunan Universiti

ABSTRACT

This study examines how building design and maintenance practices contribute to the occurrence of Sick Building Syndrome (SBS) in university buildings at Universiti Utara Malaysia (UUM). The study aims to identify design and building system characteristics associated with SBS, determine the types and features of university buildings most vulnerable to SBS, and examine measures to reduce SBS risks. While most SBS studies focus on quantitative indoor air quality measurements, this research adopts a qualitative approach to better understand how design decisions, building system performance, and maintenance management influence SBS in a university context. Semi-structured interviews were conducted with building professionals from the Department of Development and Maintenance (JPP), UUM, including architects, mechanical engineers, and civil engineers with experience in university buildings. The interview data were analysed using thematic analysis to identify recurring patterns and key issues related to SBS. The findings indicate that SBS is mainly associated with moisture problems, poor construction quality, ageing HVAC systems, inadequate ventilation, and inconsistent maintenance practices. Ageing buildings, particularly libraries, academic buildings, and lecture halls, as well as buildings that rely fully on HVAC systems, were found to be more vulnerable to SBS. The study highlights the importance of early design planning, preventive maintenance strategies, and interdisciplinary collaboration among building professionals to improve indoor environmental quality and occupant well-being in higher education facilities.

Keywords:

Sick Building Syndrome; Building Design; Maintenance Practices; Indoor Environmental Quality; University Buildings



DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; and any editorial work, paid or unpaid, carried out by a third party is acknowledged.



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LIST OF ABBREVIATIONS

AC	Air Conditioning
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
CIBSE	Chartered Institution of Building Services Engineers
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
ISO	International Organization for Standardization
JPP	Jabatan Pembangunan dan Pengurusan Infrastruktur
R1, 2 & 3	Respondent 1, 2 & 2
RH	Relative Humidity
SBS	Sick Building Syndrome
UUM	Universiti Utara Malaysia
VOC	Volatile Organic Compounds
WHO	World Health Organization
-	Until To
>	More Than
<	Less Than
%	Percentage
CO ₂	Carbon Dioxide
°C	Degree Celsius
dB	Decibel
Lux	Illumination Level

CHAPTER ONE: INTRODUCTION

1.1. Introduction

Buildings play an important role in supporting daily human activities, comfort, health, and productivity, especially in institutional and educational environments where occupants spend long hours indoors. In recent years, modern buildings have been designed to improve energy efficiency and functional performance through compact layouts, sealed building envelopes, and reliance on mechanical ventilation systems. While these approaches help reduce energy consumption, they may also negatively affect indoor environmental quality if not properly designed, operated, and maintained (Francis & Adewumi, 2024).

One common indoor environmental health issue is Sick Building Syndrome (SBS). SBS refers to a collection of nonspecific symptoms, such as headaches, fatigue, eye and throat irritation, dizziness, and difficulty concentrating, that occur while occupants are inside a building and typically improve after leaving the space (Igwe et al., 2023; Shao et al., 2024). Although SBS is not linked to a specific disease, it is widely associated with poor indoor environmental conditions and building-related factors (Goudarzi & Reshadatian, 2024).

Previous studies indicate that SBS is closely related to inadequate ventilation, thermal discomfort, poor air circulation, and exposure to chemical and biological pollutants (Ismail et al., 2022; Johari & Abdul Rahman, 2024). Building design characteristics such as ventilation layout, window design, spatial configuration, and material selection also play a significant role in influencing indoor environmental quality and SBS occurrence (Jung & El Samanoudy, 2023; Francis & Adewumi, 2024). However, most existing studies rely on quantitative approaches, with limited qualitative exploration of design and maintenance practices. Therefore, this study examines building design and maintenance factors contributing to SBS to address this research gap.

1.2. Background of Study

SBS has become an important issue in the built environment, particularly in buildings where occupants spend long periods indoors. SBS is commonly associated with symptoms such as headaches, fatigue, eye irritation, and difficulty concentrating, which are related to time spent indoors rather than a specific medical condition (Igwe et al., 2023; Shao et al., 2024). Research has shown that SBS is influenced by indoor environmental conditions, including inadequate ventilation, uncomfortable temperature, limited air movement, and exposure to chemical and biological pollutants (Ismail et al., 2022; Johari & Abdul Rahman, 2024). In recent years, attention has expanded to include the role of building design characteristics, such as spatial layout, window placement, ventilation strategy, and material selection, in shaping indoor environmental quality (Jung & El Samanoudy, 2023; Francis & Adewumi, 2024).

Building design and maintenance are closely linked in determining indoor environmental performance. Design decisions influence airflow patterns, thermal comfort, and pollutant distribution, while maintenance practices ensure that these design intentions function effectively throughout the building lifecycle. Poor maintenance of ventilation systems, weak moisture control, delayed repairs, and ageing building components may reduce indoor environmental quality and increase the risk of SBS (Igwe et al., 2023; Goudarzi & Reshadatian, 2024).

Although SBS has been widely studied, most existing research focuses on quantitative measurements of indoor air quality and symptom prevalence (Ismail et al., 2022; Samsul Rijal et al., 2023). There is limited qualitative research on SBS, particularly on how building design decisions and maintenance practices contribute to SBS conditions. In addition, many studies do not adequately account for differences in building type, age, and operational practices (Francis & Adewumi, 2024).

Universiti Utara Malaysia (UUM) is a public university established in 1984 and located in Sintok, Kedah. The campus has many types of buildings, including academic buildings, offices, and student hostels. These buildings were built at different times, so they differ in age, design, ventilation systems, and maintenance needs. As buildings age and continue to be used, these differences may affect indoor environmental quality and occupant comfort. Although SBS has been studied previously, there remains a limited qualitative understanding of how building design and maintenance factors contribute to SBS in a university setting. Therefore, a qualitative study is needed to better understand these issues and to help improve building design and maintenance practices in university buildings.

1.3. Problem Statement

SBS is a condition experienced by building occupants who report health and comfort-related symptoms such as headaches, fatigue, eye irritation, and difficulty concentrating while occupying a building (Igwe et al., 2023; Shao et al., 2024). SBS has been reported in various building types, including educational institutions where occupants spend extended periods indoors (Ismail et al., 2022).

Previous studies have shown that SBS can negatively affect occupants' well-being, comfort, and productivity. In educational environments, SBS symptoms may reduce concentration and affect academic or work performance (Samsul Rijal et al., 2023). Existing research has identified indoor air quality factors, such as ventilation rate, thermal comfort, humidity, and exposure to pollutants, as contributors to SBS (Ismail et al., 2022; Johari & Abdul Rahman, 2024).

More recent studies have highlighted the role of building design characteristics, including ventilation layout, spatial configuration, window design, and material selection, as well as maintenance practices, such as HVAC system upkeep and moisture control, in influencing SBS occurrence (Jung & El Samanoudy, 2023; Goudarzi & Reshadatian, 2024). However, most existing studies adopt quantitative approaches and examine these factors separately.

There is limited qualitative research on how building design and maintenance factors interact to contribute to SBS, particularly in complex institutional environments. Without this understanding, SBS may persist even in buildings that meet basic indoor air quality standards (Abu Mansor et al., 2024; Johari & Abdul Rahman, 2024). Therefore, a qualitative study is needed to explore the building design and maintenance factors contributing to Sick Building Syndrome in university buildings, to support more effective prevention and improvement strategies.

1.4. Research Questions

This study aims to understand how building design and maintenance factors contribute to the occurrence of SBS in university buildings. To guide this study, several research questions have been developed. These questions focus on building design characteristics, building types, and possible design improvement measures related to SBS. The research questions are as follows:

1. What architectural and environmental design characteristics contribute to Sick Building Syndrome (SBS) in UUM buildings?
2. Which types of buildings within Universiti Utara Malaysia (UUM) are more vulnerable to Sick Building Syndrome?
3. What design improvement measures have been proposed in recent studies to prevent the occurrence of Sick Building Syndrome among building users?

1.5. Research Objectives

Based on the research questions, this study is guided by several objectives. The objectives aim to explore how building design and maintenance factors influence the occurrence of Sick Building Syndrome in university buildings. The objectives of this study are as follows:

1. To identify the design characteristics of buildings that are associated with Sick Building Syndrome in UUM.
2. To explore the types of buildings in Universiti Utara Malaysia (UUM) that have the potential to cause Sick Building Syndrome.
3. To examine recent design improvement measures that can help prevent the occurrence of Sick Building Syndrome among building users.

1.6. Significance of the Study

This study is significant as it contributes to a better understanding of SBS from the perspective of building design and maintenance, particularly within university environments. While many previous studies focus mainly on indoor air quality measurements and symptom prevalence, this study adopts a qualitative approach to explore how design characteristics, building types, and maintenance practices contribute to SBS. This provides a deeper, more contextual understanding of SBS as a built-environment issue.

From an academic perspective, the findings of this study contributed to the existing body of knowledge on SBS by highlighting the role of architectural, civil, and mechanical design factors, as well as maintenance practices, in influencing indoor environmental quality. The study also helps to bridge the gap between environmental health research and built environment studies by integrating design and operational perspectives.

From a practical perspective, this study is important for architects, engineers, and facilities management personnel, as it provides insights into common design and maintenance issues that may contribute to SBS in buildings. The findings can assist building professionals in identifying potential design weaknesses and maintenance challenges that affect occupant comfort and health. In addition, the study may help building managers and decision-makers to plan more effective design improvements and maintenance strategies to reduce SBS risks.

Furthermore, the study is significant for building users, including students and staff, as an improved understanding of SBS-related factors may contribute to healthier, more comfortable, and more productive indoor environments. Overall, the findings of this study can support better decision-making in building design, operation, and maintenance to enhance indoor environmental quality and occupant well-being.

1.7. Scope and Limitations of the Study

This study focuses on building design and maintenance factors that contribute to SBS at Universiti Utara Malaysia, Sintok, Kedah. The scope includes architectural design, civil and structural conditions, and mechanical ventilation and HVAC systems that affect indoor environmental quality. The study involves various buildings on the UUM campus, including administrative and office buildings, academic and lecture buildings, and student residential colleges (Inasis). library & IT buildings, and support & public facilities

The study uses a qualitative research approach with semi-structured interviews as the main data collection method. The participants are UUM professionals directly involved in building design, construction, operation, and maintenance, including architects, civil engineers, mechanical engineers, and facilities management personnel. The study focuses on their experiences and views on SBS issues in university buildings.

This study does not include physical measurements of indoor air quality or medical assessments of building occupants. As the number of participants is limited, the findings are specific to UUM and may not apply to other universities or building types. Despite these limitations, the study provides useful insights into how building design and maintenance contribute to SBS and helps guide improvements in indoor environmental quality at UUM.

1.8. Definition of Key Terms

1.8.1. Sick Building Syndrome

Sick Building Syndrome is a condition in which individuals who spend time in a building develop temporary health issues, including headaches, dizziness, fatigue, or irritation of the eyes, nose, or throat. The symptoms usually appear when the person is in the house and tend to resolve when they relocate. Instead of a specific disease or infection, SBS is typically identified because of poor indoor air quality, inadequate ventilation, and substandard building construction. The SBS concept in this research paper addresses health discomfort among UUM students caused by ineffective ventilation, design flaws, and inadequate building maintenance. (World Health Organisation, 1983)

1.8.2. Building Design Factors

Building Design Factors refer to the physical and architectural elements of a building that directly impact indoor comfort, air quality, and the health of the building occupants. These include the ventilation plan, lighting, selection of building materials, space management, and control of temperature and humidity. The poorly built building is likely to restrict airflow, trap pollutants, and create an unbalanced heat, which can lead to SBS. The building design factors in this study are the physical and environmental features of buildings that affect IEQ. (Ismail et al., 2022)

1.8.3. Maintenance Practices

Maintenance Practices involve planned, regular actions to keep a building in a safe, efficient, and comfortable state of operation. Effective maintenance means fewer dust, mould, and bacteria accumulate, which can negatively affect air quality and cause SBS symptoms such as headaches and fatigue. On the other hand, inadequate or poor maintenance can render the indoor environment inferior, leading to discomfort for occupants. In the present study, the term 'maintenance practices' is used to denote the activity of UUM maintenance staff in maintaining the facilities and preventing the incidence of SBS through attention to them, observation of the system, and its proper conditioning. (Johari & Abdul Rahman, 2024)

1.8.4. Indoor Environmental Quality

Indoor Environmental Quality refers to the overall condition of a building's interior environment, focusing on its impact on the comfort, health, and functionality of individuals within. It encompasses vital factors such as air quality, lighting, temperature, humidity, noise level, and ventilation rate. The control of temperature, humidity, ventilation, and lighting must be balanced to ensure students in the university hostel have comfortable conditions. Within the framework of this work, the term IEQ refers to the combined impact of air quality, ventilation, temperature, and humidity in UUM buildings, which interact with one another and influence the physical comfort and well-being of the student groups. (Abu Mansor et al., 2024)

1.9. Organization of the Thesis

This thesis comprises five chapters, organized logically, beginning with the introduction and concluding with the conclusion. The research structure helps make the research clear, organized, and straightforward to follow.

i. Chapter 1: Introduction

This chapter presents the background of the study, the problem, the research objectives, the research questions, and the relevance of the study. It also describes the extent, concepts, and significant terms used in the research.

ii. Chapter 2: Literature Review

The chapter is based on a review of the previous research on the SBS, maintenance, and indoor environmental quality. It discusses the major theories, concepts, and findings in research on SBS, highlighting gaps that warrant further investigation.

iii. Chapter 3: Research Methodology

This chapter elaborates on the qualitative research design employed in the study. It explains the process of collecting data through interviews, data collection, sample selection, and data analysis.

iv. Chapter 4: Data Analysis and Findings

This chapter presents the findings from interviews with UUM's building personnel. It highlights important themes related to maintenance issues, problems, and potential ways to improve and minimize SBS in UUM buildings.

v. Chapter 5: Conclusion and Recommendations

In this chapter, these findings are discussed and connected to the literature and research objectives. It provides findings and recommendations for maintaining the buildings to prevent SBS. It also serves as a guide for further research on SBS and indoor air quality in university structures.



CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter reviews relevant literature on SBS to provide a clear and comprehensive understanding of indoor environmental quality issues in institutional buildings. The discussion focuses on the definition of SBS, its common symptoms, and the types of buildings that are more vulnerable to SBS, particularly educational buildings and residential environments such as student hostels. It explains how poor indoor environmental conditions, including inadequate ventilation, thermal discomfort, and poor air circulation, can negatively affect occupants' health, comfort, and productivity during long periods of indoor occupancy.

In addition, this chapter examines previous studies on building design and maintenance factors that contribute to SBS. Key aspects reviewed include ventilation and indoor air quality, building materials and furnishings, humidity and temperature control, lighting and acoustic conditions, and maintenance and cleaning practices. The chapter also discusses the role of maintenance management in supporting building performance and preventing SBS-related problems over time. Overall, this chapter provides a strong literature-based foundation that supports the study objectives and guides the analysis in the following chapters without relying on a specific theoretical framework.

2.2. Study Area

This section describes the study area to provide contextual understanding for the investigation of SBS in university buildings. The description focuses on the location and campus background, building characteristics and orientation, and occupancy characteristics. These elements are important because SBS is influenced by environmental conditions, building design, and how buildings are used.

2.2.1. Background of Study Area

Universiti Utara Malaysia is a public university located in Sintok, Kedah, in the northern region of Peninsular Malaysia. The university was established in 1984 and operates on a large residential campus covering approximately 1,061 hectares. The campus comprises academic, administrative, residential, and support buildings, distributed across a wide, open landscape, with natural vegetation surrounding it.



Figure 2.2:1
Location of UUM



Figure 2.2:2
Universiti Utara Malaysia

Since its establishment, UUM has undergone several phases of development. Early campus developments were constructed using design standards and building technologies available at the time, while later developments reflect more recent construction practices. Differences in building age may result in variations in ventilation systems, materials, and maintenance requirements, which are relevant factors in SBS research.

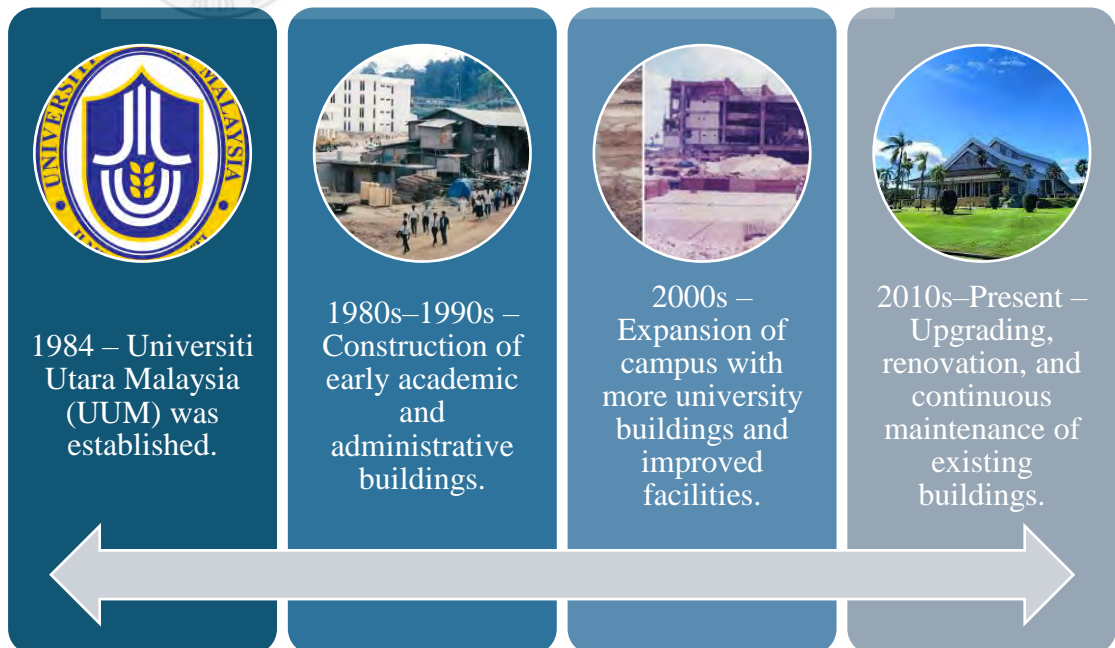


Figure 2.2:3
Timeline of Campus Development at UUM

UUM is located in a tropical climate characterised by consistently high temperatures, high relative humidity, and significant annual rainfall. These climatic conditions are commonly associated with indoor environmental challenges, including thermal discomfort, moisture accumulation, and microbial growth. Previous studies indicate that buildings in tropical climates require effective ventilation design and moisture control to maintain acceptable indoor environmental quality (Ismail et al., 2022; Johari & Abdul Rahman, 2024).

2.2.2. Description of Selected Buildings

UUM consists of various types of university buildings, including academic buildings, administrative offices, libraries, laboratories, and other support facilities. These buildings differ in size, layout, construction materials, ventilation systems, and maintenance practices, depending on their function and the period of construction.



Figure 2.2:4
Dewan Muadzam Shah



Figure 2.2:5
Anjung Tamu



Figure 2.2:6
Perpustakaan Sultanah Bahiyah



Figure 2.2:7
Masjid Sultan Badlishah



Figure 2.2:8
Varsity Mall



Figure 2.2:9
STML Building



Figure 2.2:10
Pusat Sukan UUM



Figure 2.2:11
Inasis (Residential Colleges)

Building orientation plays an important role in influencing indoor environmental quality. The orientation of buildings affects sunlight exposure, heat gain, and natural airflow. In tropical climates, poorly oriented buildings may experience excessive solar heat gain and reduced ventilation efficiency, leading to increased reliance on mechanical ventilation and air conditioning.

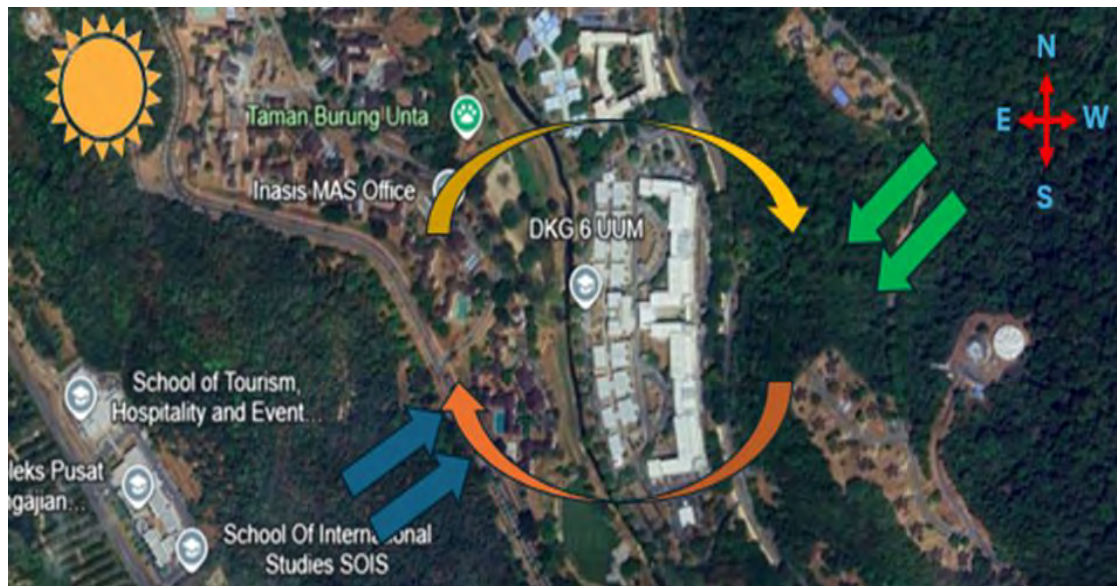


Figure 2.2:12
Typical Building Orientation at UUM

Figure 2.4 shows the building orientation and the sun and wind directions affecting the STML (DKG 6) building at Universiti Utara Malaysia. The building is mainly oriented east–west, with the east side receiving morning sunlight and the west side receiving stronger afternoon sunlight. In a tropical climate, this afternoon sun can increase indoor heat and cause thermal discomfort. The curved arrows represent the sun's path, showing continuous solar exposure throughout the day. The straight arrows indicate the prevailing wind directions from the northeast and southwest monsoon seasons. However, the surrounding vegetation and terrain may limit natural wind flow to the building, reducing natural ventilation. Although a building design with limited window openings may improve energy efficiency, it can also restrict fresh air circulation if mechanical ventilation and maintenance are ineffective. This condition may lead to poor air circulation and thermal discomfort, increasing the risk of SBS.

2.2.3. Occupancy Characteristics

Occupancy characteristics play a crucial role in SBS occurrence, as SBS symptoms are closely related to exposure duration, occupant density, and activity patterns. At UUM, students typically spend many hours per day inside hostels, classrooms, and study areas. Such prolonged exposure increases sensitivity to poor ventilation, thermal discomfort, odours, and indoor pollutants. Research by Ismail et al. (2022) demonstrated that SBS symptoms are more frequently reported in buildings with high occupancy density and insufficient fresh air supply. Similarly, Samsul Rijal et al. (2023) found that students living in hostels reported higher levels of fatigue, discomfort, and concentration difficulties than users of short-stay educational spaces. Critically, most SBS studies acknowledge occupancy as a contributing factor but often treat it as a background variable rather than a central issue. This study recognises occupancy characteristics as an important contextual factor that interacts with building design and maintenance performance, particularly in residential university environments such as UUM.

2.3. Concept of Sick Building Syndrome (SBS)

Understanding Sick Building Syndrome is essential before examining the design and maintenance factors that contribute to its occurrence. SBS is a multidisciplinary issue involving environmental health, building science, and facilities management, and its definition has evolved over time.

2.3.1. Definition of SBS

SBS is defined as a condition in which building occupants experience a range of non-specific health and comfort symptoms linked to time spent in a building but not explained by a specific illness or medical diagnosis (World Health Organisation, 1983). These symptoms commonly include headaches, fatigue, eye and throat irritation, dizziness, and difficulty concentrating, and they usually improve or resolve once the individual leaves the building.

This definition has been widely adopted in SBS research and remains relevant in recent studies, particularly those focusing on indoor environmental quality in institutional and educational buildings. Ismail et al. (2022) emphasised that SBS should be viewed as a response to prolonged exposure to poor indoor environmental conditions rather than as a medical disease. Although SBS research relies largely on subjective symptom reporting, which may differ between individuals and cultural contexts, recent studies suggest that occupants' perceptions provide meaningful insights into building performance. Johari and Abdul Rahman (2024) further argued that combining subjective experiences with evaluations of building design and maintenance practices strengthens the understanding of SBS. This perspective supports the use of qualitative approaches in SBS research, especially in complex building environments such as universities.

2.3.2. Symptoms of SBS

SBS refers to a range of health and comfort-related symptoms experienced by building occupants while they are inside a building. These symptoms usually reduce or disappear after leaving the building. SBS lacks a specific medical cause and is commonly linked to long-term exposure to poor indoor environmental conditions (World Health Organisation, 1983; Igwe et al., 2023). In institutional and educational buildings, SBS symptoms may affect both physical comfort and mental functioning (Ismail et al., 2022; Samsul Rijal et al., 2023).

Previous studies commonly group SBS symptoms into three main categories: physical symptoms, cognitive and psychological symptoms, and environmental discomfort symptoms (World Health Organisation, 1983; Johari & Abdul Rahman, 2024). This classification helps researchers compare SBS symptoms across different building types. Importantly, these symptoms may affect productivity, learning performance, and overall well-being, especially in educational environments where concentration is important (Samsul Rijal et al., 2023; Goudarzi & Reshadatian, 2024). Table 2.1 summarises the common SBS symptom categories, examples of symptoms, and their potential impacts on occupants based on findings from previous studies.

Table 2.3.2:1
SBS Symptoms and Impacts

Symptom Category	Common Symptoms	Impact on Occupants
Physical symptoms	Headache, fatigue, dizziness, eye, nose, and throat irritation, dry or itchy skin	Causes physical discomfort, reduced alertness, frequent rest needs, and increased health complaints

Symptom Category	Common Symptoms	Impact on Occupants
Cognitive and psychological symptoms	Difficulty concentrating, mental fatigue, stress, irritability, reduced motivation	Affects learning performance, memory, decision-making ability, and overall productivity
Environmental discomfort symptoms	Stuffy air, unpleasant odour, thermal discomfort (too hot or too cold), noise annoyance	Leads to dissatisfaction with the indoor environment, increased stress, and lower tolerance to indoor conditions

Sources:

WHO (1983); Ismail et al. (2022); Samsul Rijal et al. (2023); Johari and Abdul Rahman (2024); Goudarzi and Reshadatian (2024)

From a comparative perspective, physical symptoms are the most reported SBS symptoms across different building types, particularly in air-conditioned institutional buildings. However, recent studies show that cognitive and psychological symptoms are particularly important in educational environments because they affect students' ability to concentrate and perform academically (Samsul Rijal et al., 2023). This is different from office buildings, where SBS is often linked to reduced work productivity. Many studies focus on how often symptoms occur but pay less attention to how they affect daily activities. In university buildings, especially student residential colleges, SBS symptoms can have a greater impact due to long periods spent indoors and limited control over ventilation and temperature. As a result, students may experience ongoing discomfort, fatigue, and reduced well-being, which can affect both their academic performance and daily life. Understanding these symptoms and their effects is important for this study, as it helps explain how building design and maintenance factors influence occupants' experiences in university residential colleges.

2.3.3. Types of Institutional Buildings Prone to SBS

Institutional buildings are among the environments most frequently associated with Sick Building Syndrome (SBS), mainly due to high occupancy density, long indoor exposure, and heavy reliance on mechanical ventilation systems. The World Health Organization (WHO, 1983) reported that approximately 30% of occupants in newly constructed or renovated buildings worldwide experience SBS-related complaints. Studies further indicate that 20–50% of occupants in air-conditioned institutional buildings report at least one SBS symptom, depending on ventilation quality and maintenance practices (Gao et al., 2021).

Within educational institutions, residential colleges and classrooms are consistently identified as high-risk building types. Research in tropical and Asian contexts shows that over 40% of occupants in enclosed educational buildings experience SBS symptoms, particularly in hostels where sleeping, studying, and leisure activities occur within the same space (Nguyen et al., 2020; Samsul Rijal et al., 2023). In contrast, administrative offices tend to show lower SBS prevalence due to shorter daily exposure periods. These findings highlight that building function and usage patterns significantly influence SBS occurrence, yet many studies still generalise results without clearly differentiating building types.

2.3.4. SBS in Tropical University Building

Research on Sick Building Syndrome in tropical regions highlights challenges distinct from those in temperate climates. High humidity, high ambient temperatures, and frequent rainfall increase the risk of moisture accumulation within buildings, which can lead to mould growth, dampness, and poor indoor air quality. To manage thermal comfort, university buildings in tropical countries often rely heavily on air-conditioning systems. However, continuous use of air conditioning, especially in sealed buildings, can disrupt ventilation balance and worsen indoor environmental conditions if systems are poorly designed or poorly maintained (Goudarzi & Reshadatian, 2024).

In Malaysian university buildings, studies have consistently reported high SBS prevalence. Ismail et al. (2022) found that up to 45% of occupants in learning institutions experienced SBS-related symptoms, mainly due to inadequate ventilation, poor airflow distribution, and weak maintenance practices. Johari and Abdul Rahman (2024) further reported that SBS symptoms can persist even when indoor air quality parameters meet recommended standards, indicating that isolated compliance is insufficient. Instead, effective integration between building design, system operation, and maintenance management is crucial. These findings emphasise the need for context-specific SBS studies in tropical university environments, where thermal comfort control, moisture management, and long-term maintenance are the primary concerns.

2.4. Design and Maintenance Factors in SBS

Previous studies show that SBS is influenced by a combination of building design and maintenance factors that affect indoor environmental quality. In institutional buildings such as universities, poor design decisions and inadequate maintenance can reduce indoor comfort and increase the likelihood of SBS symptoms (Ismail et al., 2022; Johari & Abdul Rahman, 2024). Building design determines how ventilation, thermal comfort, lighting, and materials perform within a building, while maintenance ensures that these systems continue to function effectively over time. When either design or maintenance is weak, indoor environmental conditions may deteriorate, especially in tropical climates where high humidity, high temperatures, and heavy reliance on air-conditioning systems increase the risk of SBS (Francis & Adewumi, 2024).

The literature consistently identifies several building-related factors that contribute to SBS in educational and institutional buildings. These factors can be grouped into 6 main categories: (1) ventilation and indoor air quality, (2) maintenance and cleaning practices, (3) building materials and furnishings, (4) humidity and temperature control, (5) lighting and acoustic conditions, and (6) architectural and design deficiencies (Ismail et al., 2022; Samsul Rijal et al., 2023). These categories provide a structured framework for discussing how building design and maintenance characteristics contribute to Sick Building Syndrome, as elaborated in the following subsections.

2.4.1. Ventilation and Indoor Air Quality

Ventilation and indoor air quality (IAQ) are consistently identified in the literature as the primary contributors to SBS, particularly in institutional buildings with high occupancy levels. Ventilation systems are responsible for supplying fresh air, diluting indoor pollutants, removing odours, and maintaining acceptable carbon dioxide (CO₂) levels. When ventilation is insufficient or poorly distributed, pollutants such as CO₂, volatile organic compounds (VOCs), and particulate matter accumulate, creating conditions that trigger SBS symptoms.

Studies in educational buildings demonstrate that SBS symptoms are not only related to pollutant concentration but also to air movement and ventilation effectiveness. Ismail et al. (2022) found that CO₂ concentration, air motion, and chemical pollutants were significantly associated with SBS symptoms among occupants of educational buildings. This finding contrasts with some office-based studies that focus mainly on CO₂ as an indicator of ventilation adequacy. In university environments, however, high occupancy density and long exposure duration mean that air distribution and perceived freshness are equally important. Critically, several studies report that SBS symptoms may persist even when measured IAQ parameters fall within recommended limits. This suggests that compliance with standards alone does not guarantee occupant comfort, and that ventilation design must be responsive to actual usage patterns and supported by effective operation and maintenance (Johari & Abdul Rahman, 2024). For residential colleges, where occupants remain indoors for long hours, inadequate ventilation may lead to cumulative discomfort and health complaints.

Table 2.4.1:1:
Ventilation and IAQ Factors Related to SBS

Ventilation / IAQ Factor	Mechanism	SBS-Related Outcome
Low fresh air supply	Pollutant and CO ₂ accumulation	Headache, fatigue
Poor air distribution	Local air stagnation	Eye and throat irritation
High CO ₂ concentration	Overcrowding indicator	Reduced concentration
Ineffective ventilation control	Unstable IAQ	Persistent discomfort

Sources:

Ismail et al. (2022); Abu Mansor et al. (2024); Johari & Abdul Rahman (2024)

Table 2.4.1.1 shows that inadequate fresh air supply, poor air distribution, and ineffective ventilation control can lead to pollutant build-up and unstable indoor air conditions. These issues are strongly linked to common SBS symptoms such as headaches, fatigue, and reduced concentration.

2.4.2. Maintenance and Cleaning Practices

Maintenance and cleaning practices play an important role in ensuring that building systems continue to function properly over time. Even if a building has good ventilation design, poor maintenance can cause systems to deteriorate, leading to dust build-up, microbial growth, and reduced airflow. These conditions are commonly linked to Sick Building Syndrome (SBS) symptoms in institutional buildings. Studies show clear differences between preventive and reactive maintenance approaches. Hussin et al. (2020) reported that many Malaysian institutional buildings depend on reactive maintenance, where action is taken only after a system fails, resulting in longer exposure to poor indoor conditions. In contrast, preventive maintenance practices such as regular HVAC servicing, filter replacement, and duct cleaning have

been shown to reduce SBS complaints and help maintain stable indoor environmental quality (Johari & Abdul Rahman, 2024). However, maintenance is often treated as a secondary factor in SBS studies, even though poor maintenance can reduce the benefits of good building design. This highlights the need to view SBS as a life-cycle issue, where maintenance quality is as important as initial design decisions.

Table 2.4.2:1:
Maintenance Activities for SBS Prevention

Maintenance Action	Work Description	Impact on Indoor Environmental Quality (IEQ)	SBS Risk
Irregular HVAC servicing	HVAC systems are serviced only when faults occur	Dust, dirt, and microbial build-up reduce airflow and air quality	High
Reactive maintenance	Repairs are carried out after system failure	Prolonged exposure to poor ventilation and thermal discomfort	High
Preventive HVAC maintenance	Scheduled inspection and servicing of HVAC systems	Stable ventilation performance and controlled temperature	Low
Filter replacement	Regular replacement of air filters	Reduction of dust, allergens, and airborne pollutants	Low
Duct cleaning	Periodic cleaning of air ducts	Improved air circulation and reduced microbial growth	Lower
Poor cleaning routines	Infrequent cleaning of indoor spaces	Accumulation of dust and allergens	Increased discomfort
Moisture inspection	Checking and repairing leaks and damp areas	Prevention of mould growth and humidity-related issues	Low

Sources:
Hussin et al. (2020); Johari & Abdul Rahman (2024); Goudarzi & Reshadatian (2024)

In short, Table 2.4.2.1 shows that maintenance actions directly affect indoor environmental quality and the risk of SBS. Reactive and irregular maintenance practices increase SBS risk by allowing dust, moisture, and pollutants to accumulate. In contrast, preventive maintenance actions such as regular HVAC servicing, filter replacement, and duct cleaning help maintain stable indoor conditions and reduce SBS complaints.

2.4.3. Building Materials and Furnishings

Building materials and furnishings contribute to Sick Building Syndrome (SBS) mainly through dust retention, pollutant accumulation, and material deterioration. Materials such as carpets and old furnishings are commonly discussed in SBS literature because they can negatively affect indoor air quality over time.

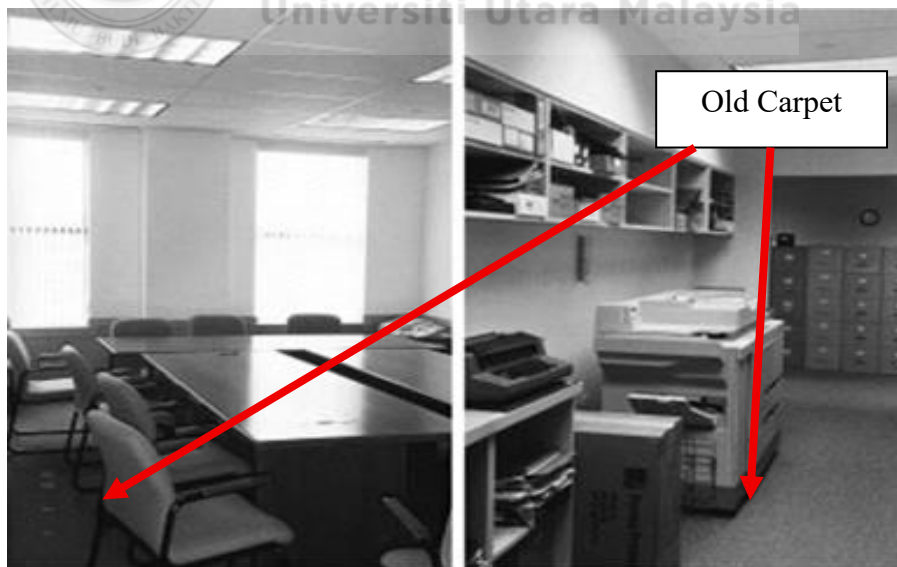


Figure 2.4:1
Carpet

Figure 2.4.3.1 shows a general example of carpet used in institutional buildings. Carpets are often installed for comfort and noise reduction; however, they can trap dust, allergens, and moisture, especially in areas with high foot traffic. When carpets are not regularly cleaned or replaced, trapped pollutants may be released back into the indoor environment through movement and air circulation. This condition may cause respiratory irritation, headaches, and general discomfort, which are commonly reported SBS symptoms (Ismail et al., 2022; Goudarzi & Reshadatian, 2024).



Figure 2.4:2
Old Furnishing

Figure 2.4.3.2 shows examples of old furnishings commonly found in institutional buildings. Old furniture and worn materials can collect dust and indoor pollutants over time. As these materials age, they become harder to clean and may cause indoor discomfort. Francis and Adewumi (2024) reported that buildings with old or poorly maintained furnishings often have higher SBS complaints than buildings using well-maintained or low-emission materials. The literature shows that both the type and condition of materials are important in reducing SBS risk. Even with good ventilation and building design, the continued use of old carpets and furnishings without proper maintenance or replacement can reduce indoor environmental quality and increase SBS symptoms.

Table 2.4.3:1:
Building Materials and SBS Effects

Material Type	Indoor Impact	SBS Outcome
Carpets	Dust and allergen retention	Respiratory irritation
Paints & adhesives	VOC emissions	Headache, eye irritation
Composite furniture	Formaldehyde release	Fatigue, nausea
Old furnishings	Pollutant accumulation	Increased discomfort

Sources:

Ismail et al. (2022); Francis & Adewumi (2024); Goudarzi & Reshadatian (2024)

Table 2.4.3.1 shows that certain building materials and furnishings, especially those that emit volatile organic compounds or trap dust, can negatively affect indoor air quality. These materials may contribute to SBS symptoms, including respiratory irritation, headaches, and general discomfort.

2.4.4. Humidity and Temperature Control

Humidity and temperature control are critical components of indoor environmental quality and are particularly important in tropical climates such as Malaysia. According to the Chartered Institution of Building Services Engineers (CIBSE) Guide A, acceptable indoor environments require stable temperature and relative humidity ranges to ensure occupant comfort and to prevent microbial growth (CIBSE, 2021). CIBSE (2021) recommends maintaining indoor temperatures typically between 22–26°C and relative humidity within 40–70% for comfort and health. When humidity exceeds recommended levels, mould growth and microbial activity are more likely to occur, while low humidity may cause dryness and irritation of the skin and respiratory system. Temperature instability may also lead to fatigue, discomfort, and reduced concentration.

Empirical studies in Malaysian educational buildings support these guidelines. Ismail et al. (2022) found that unstable thermal conditions and high humidity were associated with increased SBS complaints. Abu Mansor et al. (2024) similarly reported that humidity and temperature imbalance contributed to SBS symptoms even when other IAQ parameters were within acceptable limits. This suggests that thermal comfort control must be prioritised alongside ventilation, rather than treated as a secondary factor.

Table 2.4.4:1:
Temperature Comfort Standards

Parameter	Recommended Range
Temperature (Dry Bulb)	19–23°C
Relative Humidity	40–70%
Sound Level	<46 dB
Lighting Level	500–750 Lux

Sources:
Chartered Institution of Building Services Engineers (CIBSE, 2021); Ismail et al. (2022); Abu Mansor et al. (2024)

Table 2.4.4.1 shows that indoor environments outside recommended temperature and humidity ranges increase the risk of SBS symptoms. High humidity, low humidity, and unstable temperature conditions can cause discomfort, fatigue, and irritation among occupants.

2.4.5. Lighting and Acoustic Conditions

Lighting and acoustic conditions influence occupant comfort and may intensify SBS-related complaints. Poor lighting quality, glare, or insufficient illumination can cause eye strain and headaches, while excessive noise may increase stress and fatigue. In educational environments, inadequate lighting and noise from mechanical systems or shared spaces may interfere with learning and rest, especially in residential colleges. Samsul Rijal et al. (2023) noted that discomfort from lighting and noise reduced students' concentration. Although these factors do not directly affect IAQ, they interact with other environmental stressors to worsen overall indoor comfort.

Table 2.4.5:1:
Lighting and Acoustic Factors

Environmental Factor	Poor Condition	Impact
Insufficient lighting	Eye strain	Headache, fatigue
Glare	Visual discomfort	Reduced focus
High noise level	Acoustic stress	Irritability
Poor insulation	Noise transmission	Dissatisfaction

Sources:

Francis & Adewumi (2024); Samsul Rijal et al. (2023)

Table 2.4.5.1 summarises how poor lighting and excessive noise can increase occupant discomfort and stress. Although indirect, these conditions may worsen SBS-related complaints by affecting concentration and overall indoor comfort.

2.4.6. Architectural and Design Deficiencies

Architectural and design deficiencies are key factors that contribute to Sick Building Syndrome (SBS). Poor space layout, limited window openings, unsuitable building orientation, and heavy reliance on mechanical ventilation can reduce natural airflow and daylight, increasing dependence on building systems that may decline over time. Ismail et al. (2022) noted that many institutional buildings focus more on cost efficiency and energy performance than on occupant health, which can lead to poor indoor conditions despite meeting design standards. Johari and Abdul Rahman (2024) also highlighted that design decisions that do not consider ease of maintenance often result in long-term SBS issues, as systems become difficult to access, clean, or upgrade. These findings show that SBS prevention should start at the design stage by giving attention to effective ventilation, natural lighting, and maintainable building systems.

Table 2.4.6:1:
Architectural Design Factors and SBS Risk

Design Deficiency	Effect on IEQ	SBS Risk
Poor spatial layout	Air stagnation	Increased symptoms
Limited window openings	Reduced ventilation	Stuffy air
Over-sealed design	Pollutant build-up	Higher SBS complaints
Poor maintainability	System deterioration	Long-term IEQ decline

Sources:

Ismail et al. (2022); Johari & Abdul Rahman (2024); Francis & Adewumi (2024)

As a final point, Table 2.4.5.1 summarises how poor lighting and excessive noise can increase occupant discomfort and stress. Although indirect, these conditions may worsen SBS-related complaints by affecting concentration and overall indoor comfort. Overall, the literature shows that factors ranging from ventilation and indoor air quality to architectural and design deficiencies are clear examples of building-related characteristics that contribute to Sick Building Syndrome. These factors interact through building design and maintenance practices to shape indoor environmental quality and occupant comfort, particularly in university buildings.

2.5. Maintenance Management and SBS Prevention

Maintenance management plays a critical role in ensuring that building design intentions related to indoor environmental quality (IEQ) are sustained throughout the building life cycle. While building design establishes the initial potential for healthy indoor conditions, maintenance determines whether ventilation, thermal comfort, lighting, and material performance continue to function effectively over time. Numerous SBS studies emphasise that poor maintenance can undermine even well-designed buildings, leading to deteriorated IEQ and increased SBS symptoms (Ismail et al., 2022; Johari & Abdul Rahman, 2024). From a qualitative research perspective, the consistency of findings across multiple SBS studies enhances the credibility of maintenance-related factors as key contributors to SBS. Studies conducted in different institutional settings repeatedly report that maintenance quality directly influences occupant comfort and health outcomes, strengthening confidence in these conclusions.

2.5.1. Preventive Maintenance in Buildings

Preventive maintenance involves planned and regular activities to prevent building system failures. Studies show that buildings with preventive maintenance have better indoor conditions and fewer SBS complaints. Hussin et al. (2020) found that such buildings reported fewer SBS symptoms than those using reactive maintenance. Regular inspection of HVAC systems and moisture-prone areas also helps reduce SBS risk, even in older buildings (Johari & Abdul Rahman, 2024).

Table 2.5.1:1
Preventive Maintenance Actions and SBS Impact

Preventive Action	Contribution to Building Health	SBS Impact
Scheduled HVAC servicing	Stable ventilation performance	Reduced SBS symptoms
Filter and duct cleaning	Lower dust and microbial growth	Improved IAQ
Moisture inspection	Prevention of mould growth	Reduced irritation
Routine system checks	Early detection of faults	Lower SBS risk

Sources:

Hussin et al. (2020); Johari & Abdul Rahman (2024); Goudarzi & Reshadatian (2024)

Table 2.5.1.1 shows that regular preventive maintenance helps building systems function properly and supports good indoor environmental quality. It also indicates that early detection and timely maintenance can reduce SBS symptoms before they affect building occupants.

2.5.2. Role of Maintenance Staff and Facility Managers

Maintenance staff and facility managers are directly responsible for implementing maintenance strategies that affect IEQ and SBS prevention. Their role includes monitoring ventilation performance, responding to occupant complaints, and ensuring timely cleaning and servicing of building systems. Francis and Adewumi (2024) highlighted that trained maintenance personnel with an adequate understanding of IEQ principles are better equipped to proactively prevent SBS-related issues. From a critical standpoint, while many SBS studies acknowledge the importance of maintenance personnel, fewer studies examine their decision-making processes in detail. This limitation suggests a need for qualitative exploration to better understand how professional judgement and experience influence SBS outcomes. Addressing this gap improves the confirmability of SBS research by linking findings more clearly to professional practices rather than assumptions.

2.5.3. Maintenance Documentation and Monitoring Systems

Maintenance documentation and monitoring systems support effective maintenance management by providing records of inspections, servicing history, and indoor environmental conditions. These systems allow maintenance teams to identify recurring issues, monitor trends, and plan long-term improvements. Johari and Abdul Rahman (2024) emphasised that systematic documentation enhances early detection of SBS risks and improves response efficiency.

Abu Mansor et al. (2024) further noted that monitoring parameters such as temperature, humidity, and ventilation performance provide objective evidence that complements occupant feedback. The use of documented records and monitoring data strengthens the confirmability of SBS-related decisions by reducing reliance on subjective judgment alone.

Table 2.5.3:1 |
Maintenance Record and SBS Control

System	Function	Contribution to SBS Control
Maintenance logs	Record servicing history	Identify recurring problems
IAQ monitoring	Track IEQ parameters	Early detection of SBS risks
Complaint records	Capture occupant feedback	Guide corrective actions
Inspection reports	Assess system condition	Improve long-term planning

Sources:
Johari & Abdul Rahman (2024); Abu Mansor et al. (2024)

Table 2.5.3.1 highlights the role of maintenance records and monitoring systems in tracking building conditions and identifying indoor environmental issues. The table shows that proper documentation, such as maintenance logs and inspection reports, helps maintenance teams recognise recurring problems and system deterioration. In addition, monitoring systems and occupant complaint records support informed maintenance decisions by allowing early corrective action before indoor environmental problems develop into SBS-related issues.

2.5.4. Cost Efficiency and Sustainability

Effective maintenance management contributes to cost efficiency and sustainability by reducing emergency repairs, extending equipment lifespan, and improving energy efficiency. Goudarzi and Reshadatian (2024) highlighted that preventive maintenance reduces long-term operational costs while improving IEQ. Francis and Adewumi (2024) further argued that sustainable maintenance practices, such as efficient ventilation operation and regular servicing, support occupant health and reduce environmental impact. These findings are transferable across institutional contexts, supporting the transferability of maintenance-related SBS strategies to other universities with similar building characteristics.

2.5.5. Maintenance Management as a Preventive Approach to SBS

Maintenance management should be viewed as a preventive approach that addresses SBS risks before symptoms become widespread. Johari and Abdul Rahman (2024) noted that SBS symptoms may persist even when measured IAQ parameters appear acceptable, highlighting the importance of continuous monitoring and proactive maintenance. From a qualitative trustworthiness perspective, the alignment of findings across studies enhances credibility, while consistent maintenance practices across different institutions support transferability. Maintenance management, therefore, represents a practical and evidence-based strategy for SBS prevention.

2.6. Relationship Between Design, Maintenance, and SBS

The relationship between building design, maintenance practices, and Sick Building Syndrome is complex and interdependent. Building design establishes the initial conditions for IEQ, while maintenance ensures these conditions are sustained over time. SBS often emerges when there is a mismatch between design intent and maintenance performance (Ismail et al., 2022). The consistency of this relationship across multiple SBS studies strengthens the credibility of design–maintenance interaction as a core contributor to SBS.

2.6.1. Influence of Building Design on SBS

Building design plays an important role in indoor environmental quality and the occurrence of SBS. Design factors such as ventilation layout, window size and placement, lighting, space arrangement, and material selection influence air movement, thermal comfort, and indoor pollutant levels. Poor design choices, including limited natural ventilation, fixed or small windows, and heavy reliance on mechanical ventilation, can reduce fresh air circulation and increase SBS symptoms among occupants (Johari & Abdul Rahman, 2024). Many studies show that buildings designed mainly to reduce costs and save energy, especially those with sealed building envelopes, often report more SBS complaints when occupant comfort is not fully considered. Similar findings have been reported in educational, office, and residential buildings, indicating that building design is a key factor contributing to SBS across different building types (Johari & Abdul Rahman, 2024).

2.6.2. Role of Maintenance in Sustaining Design Performance

Maintenance plays a key role in ensuring that building design continues to perform as intended throughout the building's life cycle. Even buildings with good design can experience indoor air quality and comfort problems if maintenance activities are poorly managed or carried out irregularly. Hussin et al. (2020) reported that inadequate maintenance of ventilation and air-conditioning systems can reduce ventilation efficiency, disrupt thermal comfort, and increase complaints related to Sick Building Syndrome (SBS).

Regular maintenance activities, such as scheduled HVAC servicing, filter replacement, moisture control, and routine system inspections, are essential for maintaining stable indoor environmental quality. These activities help prevent the build-up of dust, pollutants, and moisture that may contribute to SBS symptoms. Many studies indicate that SBS issues often arise not only from design weaknesses but also from poor maintenance practices that allow building systems to deteriorate over time. Similar maintenance-related SBS problems have been observed in universities, office buildings, and residential facilities, underscoring the critical role of effective, consistent maintenance in sustaining design performance and reducing SBS risk (Hussin et al., 2020).

2.6.3. Integrating Design and Maintenance for SBS Prevention

Effective prevention of SBS requires good coordination between building design and maintenance practices. Building design establishes the initial indoor environmental quality, while maintenance ensures it is maintained throughout the building's life cycle. When design and maintenance are not well integrated, building systems may not function as intended, increasing the risk of SBS symptoms among occupants.

Francis and Adewumi (2024) highlighted that early collaboration between designers and maintenance teams can improve long-term indoor environmental quality (IEQ). Involving maintenance personnel during the design stage helps ensure that ventilation systems are practical, building services are easy to access, and performance targets are realistic. This approach reduces operational problems and supports effective maintenance after occupancy. Similar findings have been reported in institutional building studies, showing that integrated design and maintenance practices can reduce SBS risks across different building types (Ismail et al., 2022).

Table 2.6.3:1
Design–Maintenance Integration for SBS

Integration Aspect	Design Role	Maintenance Role
Ventilation strategy	Provide adequate airflow	Maintain airflow performance
Material selection	Use low-emission materials	Clean and replace materials
System accessibility	Ensure easy access	Enable effective servicing
IEQ targets	Define comfort criteria	Monitor and maintain conditions

Sources:
Ismail et al. (2022); Francis & Adewumi (2024)

Table 2.6.3.1 shows that SBS risk can be reduced when design and maintenance work together. Designers focus on providing good ventilation and selecting low-emission materials, while maintenance teams ensure these systems continue to perform through regular servicing and monitoring. This integration supports better indoor environmental quality and improves occupant comfort and health over the building's life cycle (Francis & Adewumi, 2024; Ismail et al., 2022).

2.6.4. Conceptual Relationship Between Design, Maintenance, and SBS

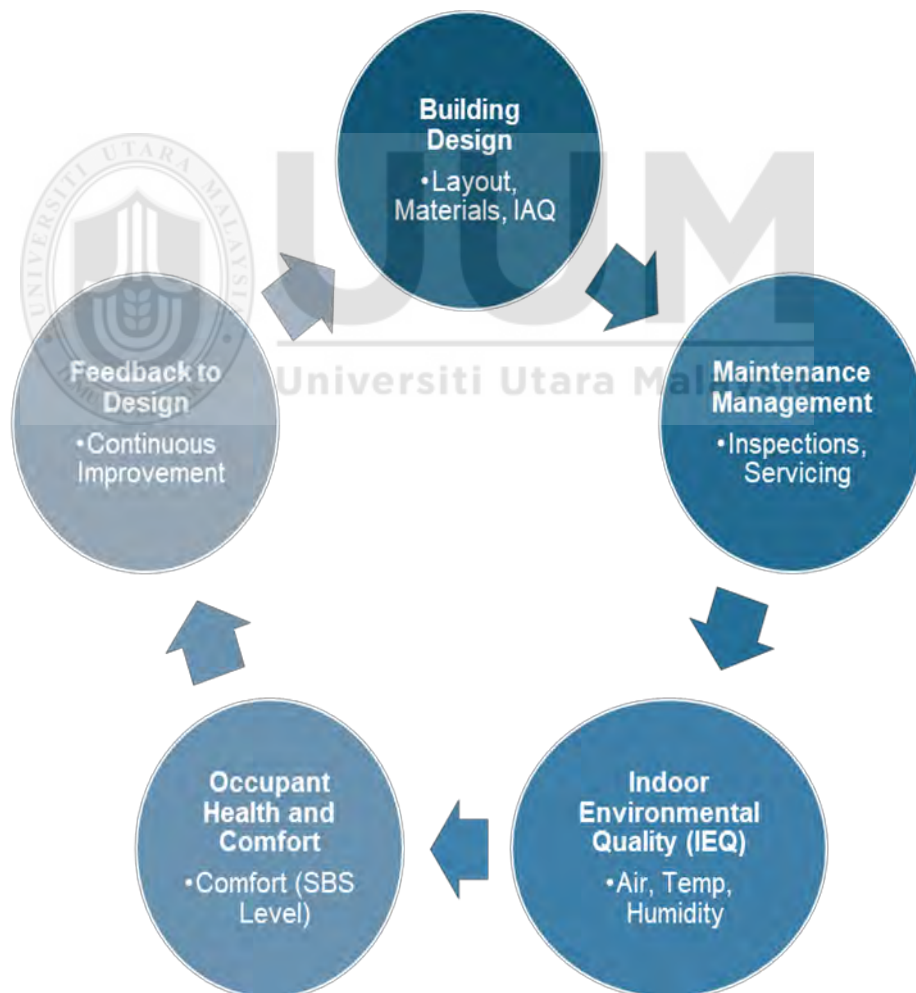
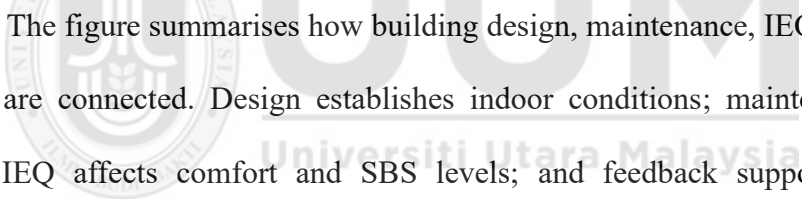


Figure 2.6:1
Relationship Between Design, Maintenance, and SBS

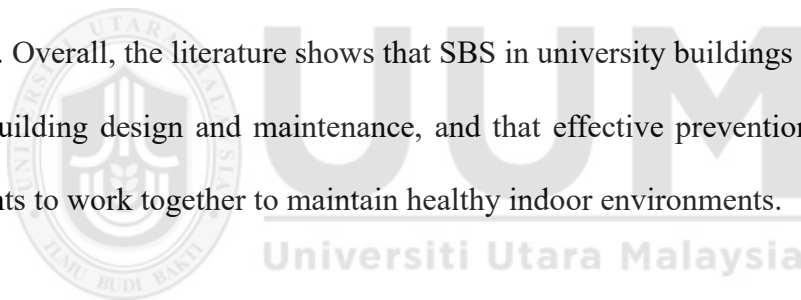
Figure 2.6.4.1 shows the relationship between building design, maintenance management, indoor environmental quality (IEQ), and SBS as a continuous cycle. Building design establishes the basic indoor conditions by determining layout, materials, ventilation, and air quality. Maintenance management helps ensure that these design features continue to work properly through regular inspection and servicing. IEQ reflects how well design and maintenance perform together. Good IEQ supports occupant comfort and health, while poor IEQ increases discomfort and SBS symptoms. Occupant health and comfort, therefore, indicate whether building design and maintenance are effective. Feedback from occupants, such as complaints or reported SBS symptoms, provides useful information for improving future design and maintenance practices.



The figure summarises how building design, maintenance, IEQ, and occupant health are connected. Design establishes indoor conditions; maintenance sustains them; IEQ affects comfort and SBS levels; and feedback supports continuous improvement. This cycle supports credibility because it reflects findings commonly reported in SBS studies. It shows transferability, as the same process can apply to other institutional buildings. The repeated interaction between design, maintenance, and IEQ demonstrates dependability, while the use of occupant feedback strengthens confirmability by linking improvements to observable experiences.

2.7. Summary

In summary, this chapter reviewed previous studies on Sick Building Syndrome in university buildings to provide an understanding of how indoor environmental quality affects occupant health and comfort. It discussed the concept and symptoms of SBS, as well as the types of institutional buildings commonly associated with SBS. The chapter also described the study context at Universiti Utara Malaysia, highlighting how its tropical climate, building characteristics, and occupancy patterns may influence SBS occurrence. The key building design and maintenance factors were reviewed, including ventilation and indoor air quality, maintenance practices, building materials, thermal comfort, lighting, and architectural design. Overall, the literature shows that SBS in university buildings is influenced by both building design and maintenance, and that effective prevention requires these elements to work together to maintain healthy indoor environments.



CHAPTER THREE: METHODOLOGY

3.1. Introduction

This chapter explains the research methodology used to examine how building design and maintenance practices influence Sick Building Syndrome in university buildings. A clear, systematic methodology is important to ensure that research findings are credible, reliable, and aligned with the research objectives. Since SBS is influenced by building design, indoor environmental conditions, and maintenance practices, an appropriate research approach is needed to capture these interacting factors effectively (Ismail et al., 2022; Johari & Abdul Rahman, 2024).

This study adopts a qualitative research approach to obtain in-depth insights from building professionals involved in the design, construction, and maintenance of university buildings. Qualitative methods are suitable because SBS is not only related to measurable environmental factors but also shaped by professional decisions and operational practices that require expert interpretation (Braun & Clarke, 2006). This chapter outlines the research design, research instruments, population and sampling strategy, data collection and analysis methods, and ethical considerations, providing a structured framework for addressing the research objectives and supporting the analysis in the next chapter.

3.2. Research Design

This study adopts a qualitative research design to explore how building design and maintenance practices contribute to SBS in UUM buildings. A qualitative approach is suitable because SBS is a complex issue influenced by human perception, professional judgement, and specific building conditions, which cannot be fully explained using numerical data alone. Previous studies have shown that understanding SBS requires insights from building professionals directly involved in design, operation, and maintenance (Ismail et al., 2022; Johari & Abdul Rahman, 2024).

Qualitative research is appropriate when the aim is to explore experiences and explanations rather than to measure variables or test hypotheses. In the context of SBS, issues such as ventilation performance, indoor comfort, moisture problems, ageing materials, and maintenance challenges are best understood through the perspectives and experiences of professionals who manage these buildings (Braun & Clarke, 2006). The research design follows a structured process, as shown in Figure 3.2.1, outlining the progression from problem identification to data analysis and conclusions, ensuring a systematic and logical approach.

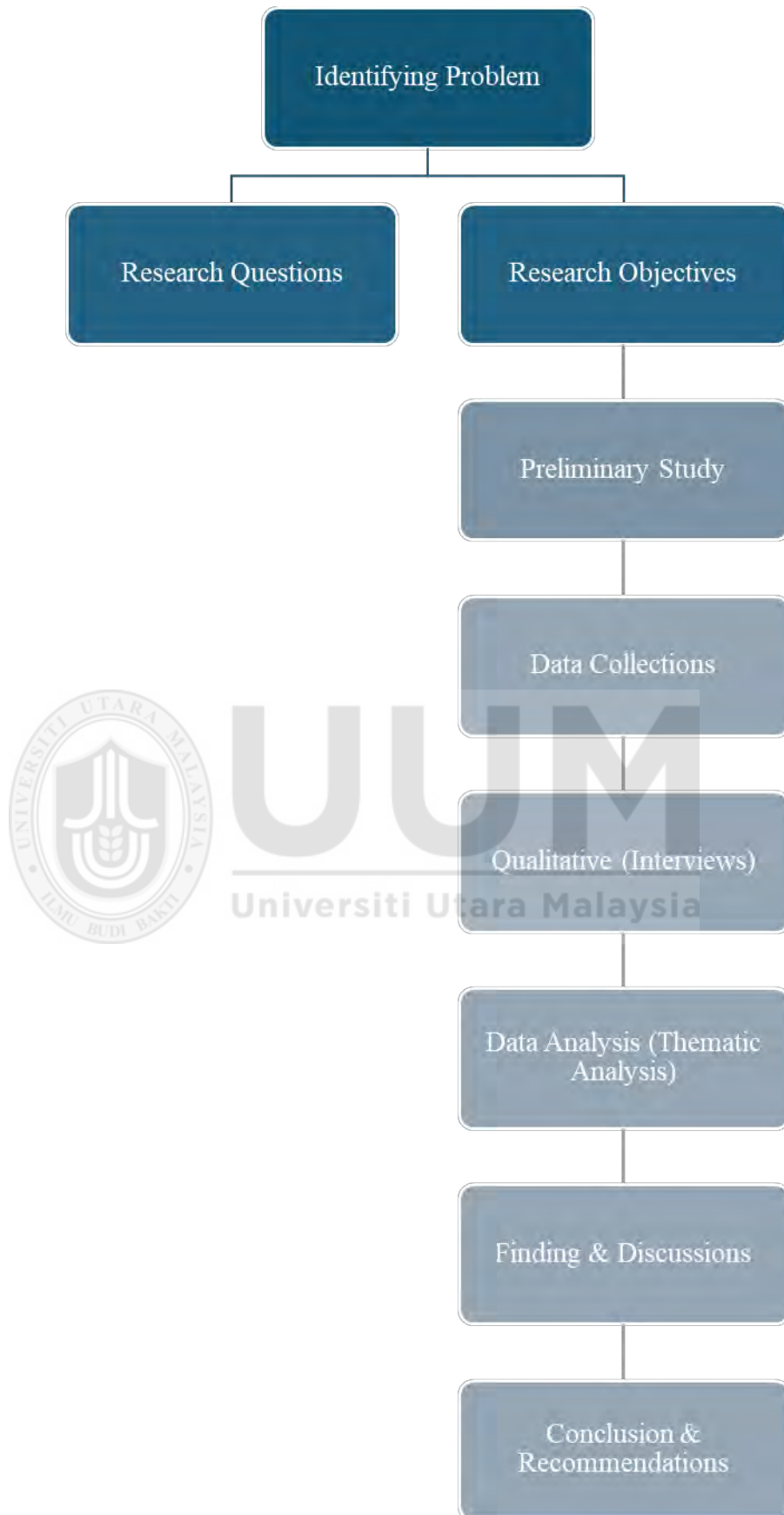


Figure 3.2:1
Research Design Flowchart

Figure 3.2.1 illustrates the overall methodological framework adopted in this study. The flowchart presents a clear, systematic sequence of research activities, beginning with the identification of the research problem and ending with conclusions and recommendations. Each stage is interconnected and contributes directly to achieving the research objectives.

(I) Identifying Research Problem

The research process begins with identifying the research problem related to Sick Building Syndrome in university buildings at Universiti Utara Malaysia. The problem focuses on poor indoor air quality, inadequate ventilation, moisture accumulation, and recurring occupant discomfort, particularly in student hostels and academic facilities. This stage defines the scope of the study and ensures that the research remains focused on SBS-related building performance issues.

(II) Research Objectives and Research Questions

After identifying the research problem, the research objectives and research questions are formulated. The objectives outline what the study aims to achieve, including identifying design and maintenance factors contributing to SBS, determining which buildings are prone to SBS, and exploring feasible preventive measures. The research questions guide the qualitative inquiry and ensure that data collection and analysis are aligned with the study aims.

(III) Preliminary Study

The preliminary study serves as the foundation for the research. At this stage, a review of existing literature on SBS, indoor environmental quality, building design, and maintenance practices is conducted. This stage helps identify research gaps, refine the study's focus, and develop relevant interview questions for building professionals.

(IV) Data Collection

Following the preliminary study, the research proceeds to the data collection stage. Data collection is carefully planned to ensure that the information gathered is relevant and supports the research objectives. In this study, qualitative data are collected because they are suitable for capturing professional experiences and contextual explanations related to SBS.

(V) Qualitative Interviews

Qualitative interviews are the main data collection method used in this study. Semi-structured, face-to-face interviews are conducted with selected building professionals from JPP UUM, including architects, mechanical engineers, and civil engineers. This method allows participants to explain their experiences with building design decisions, maintenance practices, and SBS-related issues in detail.

(VI) Data Analysis – Thematic Analysis

After data collection, the interview data are analysed using thematic content analysis. Interview transcripts are systematically examined to identify recurring patterns, key issues, and themes related to SBS. This stage transforms raw qualitative data into organised themes that capture the study's main findings.

(VII) Findings and Discussions

At this stage, the identified themes are presented as research findings and discussed in relation to the research objectives and existing literature. The discussion highlights key design deficiencies, maintenance limitations, high-risk building conditions, and potential improvement strategies related to SBS in UUM buildings.

(VIII) Conclusion and Recommendations

The final stage involves drawing conclusions based on the findings of the thematic analysis. Conclusions summarise the study's main contributions, while recommendations propose practical actions to improve building design, strengthen maintenance practices, and reduce SBS risks in UUM buildings. This stage ensures that the study provides practical value for building management and facilities planning.

3.3. Research Approach

The primary research instrument used in this study is a semi-structured interview guide. This instrument is selected because it allows the researcher to obtain in-depth and detailed information from building professionals while maintaining a consistent structure across all interviews. Semi-structured interviews are particularly suitable for qualitative research, as they allow participants to elaborate on their experiences, opinions, and professional judgments regarding complex issues such as SBS (Braun & Clarke, 2006; Coates et al., 2021).

In this study, the use of a semi-structured interview guide ensures that all key aspects of building design, maintenance practices, and SBS risks are systematically explored, while still allowing respondents to introduce additional insights from their practical experience with UUM buildings. This approach supports the objective of understanding SBS from a professional and contextual perspective rather than from a purely technical or numerical viewpoint (Creswell, 2014).

3.3.1. Structure of the Interview Guide

The interview guide is organised into several sections to ensure clarity, logical flow, and alignment with the research objectives. Each section guides the interview in a clear, flexible way, allowing participants to share their professional experiences and views. This approach ensures that important topics in building design, maintenance practices, and SBS are consistently covered, while still allowing open discussion and follow-up questions.

i. Background Information

This section gathers basic details about the participants, including their job roles, years of experience, and involvement in the design, maintenance, or management of UUM buildings. This information helps explain their professional background and supports the relevance of their responses.

ii. Building Design Factors Related to SBS

This section focuses on building design elements, including ventilation, windows, building orientation, materials, daylighting, space layout, and building age. The questions aim to understand how these design factors affect indoor environmental quality and contribute to SBS in UUM buildings (WHO, 1983; Francis & Adewumi, 2024).

iii. Maintenance Practices and Operational Issues

This section examines maintenance practices, including HVAC servicing, maintenance schedules, defect response time, moisture control, and cleanliness. It aims to identify maintenance issues or weaknesses that may increase the risk of SBS (Hussin et al., 2020).

iv. Buildings Prone to SBS and Improvement Measures

This section explores which types of UUM buildings are more likely to experience SBS and the reasons for this. It also discusses practical improvement measures suggested by building professionals to reduce SBS risks, such as better ventilation, improved maintenance, and upgrading building materials (Igwe et al., 2023; Subri et al., 2024).

3.3.2. Development and Validation of the Instrument

The interview questions were developed based on the literature review and aligned with the research objectives and research questions. To enhance clarity and relevance, the interview guide was reviewed and refined with input from the research supervisor. A pilot interview was conducted to test the clarity, flow, and appropriateness of the questions. Minor adjustments were made based on feedback to ensure that the questions were easily understood and capable of eliciting meaningful responses. Overall, the semi-structured interview guide serves as a reliable and flexible instrument for collecting rich qualitative data, enabling the researcher to capture professional insights into the relationship between building design, maintenance practices, and the occurrence of Sick Building Syndrome in UUM buildings (Braun & Clarke, 2006; Coates et al., 2021).

3.4. Population and Sampling

The study population comprises building professionals directly involved in the design, maintenance, and management of buildings at Universiti Utara Malaysia. These individuals are considered appropriate respondents because they possess technical knowledge, professional experience, and practical experience with building performance issues closely related to Sick Building Syndrome, such as ventilation effectiveness, moisture control, and maintenance response (Ismail et al., 2022).

3.4.1. Population

The target population includes professionals from the Jabatan Pembangunan dan Penyelenggaraan (JPP) at Universiti Utara Malaysia. These professionals are involved in planning, inspection, maintenance, and upgrading of university buildings. They include architects, engineers, and maintenance officers who understand building conditions and indoor environmental quality. Their experience helps explain how building design and maintenance practices contribute to Sick Building Syndrome in UUM buildings.

i. Sampling Technique

This study uses purposive sampling to select suitable participants. Participants are selected based on their experience and knowledge in building design, maintenance, and SBS issues. The aim is to obtain detailed, meaningful information rather than to make statistical comparisons (Braun & Clarke, 2006).

ii. Sampling Criteria

To ensure suitable participants are selected, the following criteria are applied:

1. Participants must be directly involved in the design, inspection, maintenance, or management of UUM buildings.
2. Participants must have at least two years of professional experience in building-related roles, such as facilities management, engineering, or architecture.

3. Participants must be familiar with building issues related to ventilation, humidity, HVAC systems, and overall building conditions that may contribute to SBS.

iii. Sample Size and Participant Roles

Given the qualitative nature of the study, the sample size is intentionally kept small to allow for in-depth exploration of each participant's experience. The study involves two to three key informants representing different professional roles within JPP UUM, such as:

1. An Architect who provides insight into building design decisions, layout, materials, and environmental considerations.
2. A Mechanical Engineer or Maintenance Officer, who contributes knowledge on HVAC systems, ventilation performance, and preventive maintenance practices.
3. A Building or Civil Maintenance Officer, who addresses structural issues, moisture problems, and ageing building components.

Although the number of participants is limited, the inclusion of different professional roles ensures a range of perspectives. This diversity of expertise enhances the depth and credibility of the findings and enables the study to provide a more comprehensive understanding of SBS issues in UUM buildings (Creswell, 2014).

3.5. Data Collection Method

In this study, data are collected using qualitative, face-to-face semi-structured interviews. This method is selected because it enables the researcher to obtain detailed, context-specific information from building professionals regarding SBS issues in UUM buildings. Face-to-face interviews are particularly suitable for exploring complex building-related problems, as they enable direct interaction, immediate clarification of responses, and deeper probing of professional experiences (Coates et al., 2021).

3.5.1. Interview Procedure

The data collection process is carried out in several structured stages to ensure consistency, clarity, and reliability throughout the interview sessions. These stages are designed to support systematic data gathering and accurate documentation of participants' responses. These stages include (i) pre-interview preparation, (ii) briefing and consent, (iii) conduct of the interview, (iv) recording and documentation, and (v) post-interview data handling (Braun & Clarke, 2006).

i. Pre-interview Preparation

Before conducting the interviews, selected participants are contacted and informed of the study's purpose, the interview format, and the estimated duration. An interview appointment is arranged at a convenient time and location on the UUM campus to ensure a comfortable, professional environment.

ii. Briefing and Consent

At the beginning of each interview, the researcher explains the study's objectives and the participant's role. Participants are informed that their participation is voluntary and that they may withdraw at any time. Written informed consent is obtained prior to the interview, and permission is sought to audio-record the session.

iii. Conduct of the Interview

Each interview is conducted face-to-face using the semi-structured interview guide. Open-ended questions encourage participants to share their experiences and professional views on building design, maintenance practices, and SBS-related issues. Where necessary, probing questions are asked to clarify responses or obtain further details. Each interview is expected to last approximately 30 to 60 minutes, depending on the depth of discussion.

iv. Recording and Documentation

All interviews are audio-recorded to ensure accurate capture of responses. In addition, brief field notes are taken during the interview to record key points, emphasis, and contextual observations that may support data interpretation.

v. Post-interview Data Handling

After each interview, the audio recordings are transcribed verbatim. The transcripts are reviewed for accuracy and anonymised by assigning codes to participants (e.g., R1, R2, R3). All data are securely stored in password-protected files and are used solely for academic purposes.

The use of face-to-face semi-structured interviews enables the researcher to explore not only the SBS-related problems that occur in UUM buildings, but also why they arise and how they are addressed in practice. This method ensures that the data collected are rich, reliable, and directly aligned with the research objectives, making it suitable for in-depth qualitative analysis in this study.

3.6. Trustworthiness of the Study

In qualitative research, the concepts of reliability and validity are addressed through the principle of trustworthiness. Trustworthiness ensures that the study's findings are credible, consistent, and grounded in the data collected from participants. This study adopts four key criteria of trustworthiness, namely credibility, transferability, dependability, and confirmability, to strengthen the quality of the research findings (Braun & Clarke, 2006).

(I) Credibility

Credibility refers to how well the findings represent the participants' views and experiences. In this study, credibility is enhanced by selecting participants who are directly involved in the design and maintenance of UUM buildings. Face-to-face semi-structured interviews allow participants to explain their experiences clearly, while probing questions help clarify responses. All interviews are audio-recorded and transcribed verbatim to ensure accuracy.

(II) Transferability

Transferability refers to the extent to which the findings may apply to other similar contexts. This study supports transferability by providing clear descriptions of the UUM setting, participant roles, and research procedures, allowing others to assess the relevance of the findings to similar university buildings.

(III) Dependability

Dependability relates to the consistency of the research process. In this study, dependability is ensured by using the same interview guide for all participants and following a consistent data collection and analysis procedure. The steps of transcription, coding, and thematic analysis are clearly documented.

(IV) Confirmability

Confirmability refers to ensuring that findings are based on participants' responses rather than on the researcher's bias. This is achieved by maintaining an audit trail that includes recordings, transcripts, and coding records. The use of direct quotations and regular discussion with the research supervisor further supports objective interpretation. Overall, the application of credibility, transferability, dependability, and confirmability ensures that the findings of this study are trustworthy, systematic, and grounded in reliable qualitative evidence.

3.7. Ethical Considerations

Ethical considerations are an essential component of this study, as it involves human participants and the collection of professional opinions on building performance and maintenance practices at Universiti Utara Malaysia. Ethical principles are applied throughout the research process to ensure that participants' rights, dignity, and confidentiality are protected, and that the research is conducted responsibly and transparently.

(I) Voluntary Participation and Informed Consent

Participation in this study is entirely voluntary. Prior to data collection, all participants are clearly informed of the study's purpose, the nature of their involvement, and the expected duration of the interview. Participants are also informed of their right to decline to answer any question or to withdraw from the study at any stage, without any negative consequences. Written informed consent is obtained from each participant before the interview.

(II) Confidentiality and Anonymity

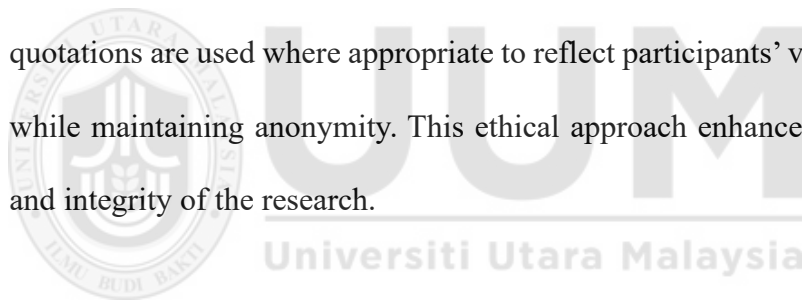
Participants' confidentiality is strictly maintained throughout the study. Participants' identities are anonymised by using codes such as R1, R2, and R3 instead of real names. Any information that could potentially identify individuals or sensitive building-related issues is handled carefully and is reported in a general manner. This ensures that participants can share their professional experiences openly without concern for personal or organisational repercussions.

(III) Data Security and Storage

All interview data, including audio recordings and transcripts, are securely stored in password-protected digital files. Access to the data is restricted to the researcher only and is used solely for academic purposes. The data are not shared with unauthorised parties and are handled in accordance with university research ethics requirements.

(IV) Ethical Reporting of Findings

The findings of this study are reported honestly and objectively. The researcher ensures that the data are not manipulated or misrepresented and that interpretations are supported by evidence from the interview transcripts. Direct quotations are used where appropriate to reflect participants' views accurately, while maintaining anonymity. This ethical approach enhances the credibility and integrity of the research.



3.8. Data Analysis Method

The data collected from the face-to-face semi-structured interviews are analysed using thematic analysis. Thematic analysis is a qualitative data analysis method that is suitable for identifying, analysing, and interpreting patterns or themes within textual data. This method is appropriate for the present study because it allows the researcher to systematically examine professional experiences and perceptions related to building design, maintenance practices, and SBS in UUM buildings (Braun & Clarke, 2006).

Thematic analysis is chosen because it provides flexibility while maintaining analytical rigour. It enables the researcher to move from raw interview data to meaningful interpretations that are directly linked to the research objectives. In this study, thematic analysis helps explain how and why certain building conditions and maintenance practices contribute to SBS, based on participants' lived experiences and professional judgments. The thematic analysis in this study follows five main steps to ensure a systematic, clear, and easy-to-follow data analysis (Braun & Clarke, 2006; Coates et al., 2021).

(I) Step 1: Transcription and Familiarisation with the Data

All interview recordings are transcribed verbatim to preserve the original meaning of participants' responses. The researcher then reads the transcripts several times to become familiar with the data. During this stage, initial ideas and common SBS-related issues, such as ventilation problems, moisture issues, maintenance delays, and occupant complaints, are documented.

(II) Step 2: Generating Initial Codes

The next step involves coding the data by identifying meaningful sections of the transcripts and assigning short labels (codes) that describe the main ideas. Examples of codes include poor air circulation, reactive maintenance, water leakage, inadequate ventilation design, and delayed defect response. Coding helps organise data into smaller, manageable units.

(III) Step 3: Searching for Themes

After coding, related codes are grouped into broader themes. For example, codes related to ventilation and airflow may be grouped under Design-Related Deficiencies, while codes related to maintenance issues may form the theme Maintenance Limitations. This step helps identify patterns across the data.

(IV) Step 4: Reviewing and Refining Themes

The identified themes are reviewed to ensure they accurately represent the data. Similar or overlapping themes are refined or merged, while unclear themes are improved. This step ensures that each theme is clear, distinct, and supported by sufficient evidence.

(V) Step 5: Defining, Naming, and Interpreting Themes

In the final step, each theme is clearly defined and named. The researcher then interprets the themes in relation to the research objectives and questions, explaining how building design and maintenance practices contribute to SBS in UUM buildings. These interpretations form the basis for the findings and discussion in the following chapters.

Overall, the use of thematic analysis allows the interview data to be analysed systematically and transparently. By following the five-step process, the study ensures that the findings are well-organised, grounded in participants' experiences, and directly aligned with the research objectives, providing a strong foundation for the presentation of results in the following chapters.

3.9. Summary

In summary, this chapter presents the research methodology used to investigate the influence of building design and maintenance practices on the occurrence of SBS in UUM buildings. A qualitative research design was adopted to explore professional experiences and contextual factors related to SBS, with data collected through face-to-face semi-structured interviews with selected building professionals from JPP, UUM. The chapter described the purposive sampling strategy, data collection procedures, and measures taken to ensure trustworthiness through credibility, transferability, dependability, and confirmability, as well as ethical considerations such as voluntary participation, confidentiality, and data security. Finally, the thematic analysis process was outlined to explain how interview data were analysed systematically, providing a strong foundation for the presentation of research findings in Chapter 4, which focuses on key themes related to building design deficiencies, maintenance limitations, high-risk building conditions, and improvement strategies to reduce SBS in UUM buildings.

CHAPTER FOUR:

RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter presents the findings and analysis from the semi-structured interviews conducted with building professionals at Universiti Utara Malaysia. The purpose of this chapter is to examine how building design, technical systems, and maintenance practices contribute to the occurrence of SBS in university buildings. The interview data were analysed using inductive content analysis, which allows themes to emerge directly from participants' responses and is widely used in qualitative research to understand complex issues (Braun & Clarke, 2006; Creswell, 2014).

Three professionals participated in the study, representing civil engineering, mechanical engineering, and architecture, each with more than 10 years of experience in managing university buildings. The findings are organised based on the interview questions and aligned with the research objectives. Tables are used to present key themes and selected quotations to support clarity and credibility. The chapter ends with a discussion and a summary before moving to the next chapter.

4.2. Descriptive Findings

This section presents the descriptive findings from the semi-structured interviews conducted with building professionals at UUM. The focus of this section is to describe observable patterns and recurring issues related to SBS before deeper interpretation is undertaken in subsequent sections. The findings are structured according to the interview questions S1-S5, beginning with respondents' professional background, followed by design and technical factors, additional indoor environmental factors, building types at risk, and the influence of building age.

4.2.1. Respondents' Professional Background

Understanding the respondents' professional backgrounds is a critical first step in qualitative analysis, as it establishes the credibility, relevance, and reliability of the data. In the context of SBS studies, insights from professionals directly involved in the planning, design, construction, operation, and maintenance of buildings are particularly valuable, as SBS often results from long-term, cumulative building performance issues rather than isolated incidents. The respondents' professional roles and length of experience in university buildings were considered to establish the credibility of their views. They represent three key disciplines, civil engineering, mechanical engineering, and architecture, which collectively influence building performance throughout the building life cycle. These perspectives provide a comprehensive understanding of SBS from structural, mechanical, and design viewpoints.

Table 4.2.1:1
Respondents' Professional Background

Interview Question	Theme	Respondent	Key Experience	Supporting Quote
S1: Professional role and experience	Professional Experience in Building Life Cycle	R1	Civil engineering, construction & maintenance	<i>"I have 12 years of experience... supervising contractors... from planning until project completion."</i>
		R2	Mechanical systems & HVAC maintenance	<i>"I supervise mechanical system development and maintenance... preventive maintenance."</i>
		R3	Architectural design & upgrading works	<i>"I have 15 years of experience... planning, designing, and supervising architectural works."</i>

The findings indicate that all respondents have more than 10 years of professional experience and are actively involved at different stages of the building life cycle. The civil engineer focuses on construction quality and maintenance issues; the mechanical engineer specialises in HVAC and mechanical systems; and the architect is responsible for design decisions and spatial planning. This multidisciplinary experience strengthens the reliability of the findings, as respondents have long-term exposure to recurring building performance problems that contribute to SBS. Their varied professional backgrounds also allow SBS issues to be examined from multiple technical and design perspectives.

4.2.2. Design and Technical Factors Contributing to SBS

Design and technical decisions made early in a building project play a significant role in determining long-term indoor environmental quality. Poor decisions at this stage often result in persistent problems such as moisture intrusion, inadequate ventilation, and inefficient system performance, which are commonly associated with SBS. The discussion explored how specific design and technical decisions contribute to SBS in university buildings. Respondents reflected on recurring issues encountered in practice, particularly those related to construction quality, dependence on HVAC systems, and architectural design. The responses indicate that SBS is closely linked to the interaction between physical building conditions and system operation, rather than a single isolated factor.

Table 4.2.2:1
Design and Technical Factors Contributing to SBS

Interview Question	Theme	Respondent	Main Factor	Supporting Quote
S2: Design and technical decisions causing SBS	Construction Quality	R1	Poor workmanship & roof defects	<i>“Poor roof finishes and structural cracks... leading to dampness and mould growth.”</i>
	HVAC Dependence	R2	Excessive use of air-conditioning	<i>“Buildings that rely too heavily on air conditioning can increase indoor humidity.”</i>
	Architectural Design	R3	Lack of daylight & ventilation	<i>“Buildings should receive at least 35% natural lighting... sealed buildings trap moisture.”</i>

To explain the design and technical factors shown in Table 4.2.2.1, selected quotes from the respondents are presented below. These quotes describe how construction quality, reliance on air conditioning, and building design contribute to indoor environmental problems and SBS.

“Poor roof finishes and structural cracks allow water to enter the building, leading to dampness and mould growth.” – R1

This quote shows that poor construction quality causes moisture problems. Water entering through roof defects and cracks makes indoor spaces damp and promotes mould growth. These conditions reduce indoor air quality and are linked to SBS.

“Buildings that rely too heavily on air conditioning can increase indoor humidity.” – R2

This quote highlights the problem of over-reliance on air conditioning. Without enough fresh air, humidity increases and air circulation becomes poor. This raises the risk of SBS, especially in buildings that operate for long hours.

“Buildings should receive at least 35% natural lighting... sealed buildings trap moisture.” – R3

This quote highlights the importance of natural lighting and ventilation. Sealed buildings restrict airflow and trap moisture, increasing indoor humidity. Poor daylight also reduces user comfort and increases the risk of SBS.

Overall, the findings show that SBS is strongly influenced by early design and technical decisions. Poor workmanship, heavy use of air conditioning, and sealed building designs together create damp and poorly ventilated indoor environments.

4.2.3. Other Factors Affecting Indoor Environmental Quality

While design and technical systems are key contributors to SBS, indoor environmental quality is also influenced by a range of additional factors that develop over time. These include building age, maintenance practices, material selection, and space usage patterns. Such factors often interact with design and system issues, worsening indoor conditions and increasing occupant discomfort. The analysis also considered secondary but reinforcing factors that affect indoor environmental quality. By examining issues beyond core design and building systems, the findings provide a more holistic understanding of Sick Building Syndrome as a multi-dimensional problem influenced by both physical and operational conditions.

Table 4.2.3:1
Other Factors Affecting Indoor Environmental Quality

Interview Question	Theme	Respondent	Factor	Supporting Quote
S3: Other elements affecting IEQ	Building Age	R1	Old construction methods	<i>“Buildings from the 1980s... single-layer walls.”</i>
	Air Filtration	R2	Dust & allergen accumulation	<i>“Lecture halls... accumulate dust and allergens.”</i>
	Materials & Layout	R3	High VOC & overcrowding	<i>“High VOC materials... overcrowding.”</i>

To explain the other factors affecting indoor environmental quality shown in Table 4.2.3.1, selected quotes from the respondents are presented below. These quotes describe how building age, air filtration, and material and space design influence indoor conditions and contribute to SBS.

“Buildings from the 1980s, such as those with single-layer walls, are more likely to have moisture problems.” – R1

This quote shows that older buildings use outdated construction methods. Single-layer walls lack moisture control, increasing indoor humidity. This makes buildings more likely to experience dampness and SBS, especially when upgrades are limited.

“Older lecture halls that are less frequently used tend to accumulate dust and allergens.” – R2

This quote highlights the role of air filtration and maintenance. Lecture halls that are rarely used often collect dust and allergens due to weak airflow. Poor air quality in these spaces can cause discomfort and breathing problems, which are common SBS symptoms.

“High-VOC materials, overcrowding, and sealed spaces worsen indoor air quality.” – R3

This quote shows that building materials and space layout affect indoor air quality. High-VOC materials emit pollutants, while crowded, poorly ventilated spaces trap them. These conditions reduce comfort and increase the risk of SBS. Overall, SBS is caused by several related factors. Building age, poor air filtration, high-emitting materials, and poor space design often co-occur, leading to poor indoor air quality and increased SBS risk.

4.2.4. Building Types More Prone to SBS

Different types of buildings have different levels of SBS risk due to differences in design, use, maintenance, and moisture exposure. Some university buildings are therefore more likely to experience SBS than others. The findings identify which building types at UUM are most at risk and explain the reasons for this. Understanding these vulnerable buildings helps the university focus its maintenance and improvement efforts more effectively.

Table 4.2.4:1
Building Types More Prone to SBS

Interview Question	Theme	Respondent	Building Type	Supporting Quote
S4: SBS-prone building types	High-Risk Buildings	R1	Library	<i>“Libraries... roof leakage... indoor moisture.”</i>
	Operational Factors	R2	Library	<i>“Space usage is low, but air-conditioning continues operating.”</i>
	Combined Issues	R3	Library / Academic buildings	<i>“Roof leaks cause water accumulation and mould growth.”</i>

The following quotes present respondents' views on building types at UUM that are more prone to SBS. These quotes explain how building conditions, system operation, and design characteristics influence indoor environmental quality and SBS risk.

“Libraries are more prone to SBS due to ageing roof leakage, which causes high indoor humidity.” – R1

This statement shows that libraries are more exposed to SBS due to moisture issues. Roof leaks allow water to enter the building, increasing indoor humidity. High humidity encourages mould growth, which can cause SBS symptoms such as breathing discomfort and irritation.

“After the COVID-19 period, space usage decreased, but air-conditioning systems continued operating, increasing humidity and reducing indoor air quality.” – R2

This quote explains how changes in building use affect SBS risk. Although fewer people used the space, air-conditioning systems kept running. This increased humidity and reduced fresh air circulation, especially in buildings designed for higher occupancy.

“Roof leakage causes water accumulation and mould growth... buildings near toilets, with low roof design, and buildings that rely fully on HVAC systems are also at risk due to moisture retention and poor ventilation.” – R3

This response shows that SBS risk increases when multiple factors co-occur. Roof leakage, waterproofing failure, low roof design, proximity to wet areas, and full reliance on HVAC systems all contribute to moisture buildup and limited airflow.

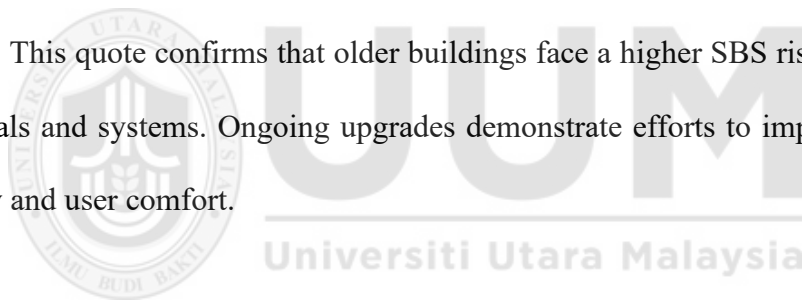
These conditions increase the risk of mould growth and poor indoor air quality, which can lead to SBS.

“Older lecture halls were previously at risk, but the risk has reduced after upgrading works.” – R1

This statement shows that SBS risk can be reduced. Upgrading and maintenance works helped improve indoor conditions in older lecture halls and reduced previous SBS problems.

“Older buildings such as Masjid UUM and old Inasis are at risk; therefore, upgrading works are being carried out.” – R3

This quote confirms that older buildings face a higher SBS risk due to ageing materials and systems. Ongoing upgrades demonstrate efforts to improve indoor air quality and user comfort.



Overall, the findings show that libraries, older academic buildings, lecture halls, religious buildings, and older Inasis at UUM are more likely to experience SBS. This is mainly due to ageing structures, moisture problems, heavy reliance on HVAC systems, and changes in space usage. However, the findings also show that SBS risk can be reduced through proper upgrading, regular maintenance, and better building operation strategies.

4.2.5. Influence of Building Age on SBS Risk

Building age plays an important role in SBS risk. Ageing buildings often have deteriorated materials, inefficient systems, and outdated designs that no longer meet current health and performance standards. The findings examine the relationship between building age and SBS by comparing older and newer buildings. The results show that delayed maintenance and outdated construction practices increase the risk of SBS in university buildings.

Table 4.2.5:1
Influence of Building Age on SBS Risk

Interview Question	Theme	Respondent(s)	Key Issue	Supporting Quote
S5: Effect of building age on SBS	Age-Related Performance Decline	R1, R2, R3	Old materials & systems	<i>“Older buildings are more likely to experience SBS compared to newer buildings.”</i>

The following quote reflects the respondents' shared views on the influence of building age on SBS in university buildings. It highlights how ageing structures and systems affect indoor environmental quality.

“Older buildings are more at risk of SBS compared to newer buildings due to outdated construction methods and materials that do not support good indoor air quality. In addition, the technical systems in older buildings often experience performance decline and require high upgrading costs to achieve high-performance building standards, increasing the likelihood of SBS.” – R1, R2 & R3

This shared response shows that all respondents agree that building age increases the risk of SBS. Ageing buildings use outdated construction methods and materials that have poor moisture control, insulation, and ventilation. As these materials age, indoor conditions become harder to control.

Technical systems such as HVAC in older buildings also become less efficient over time. Upgrading these systems is costly, and when upgrades are delayed, humidity, airflow, and indoor air quality continue to worsen.

Overall, ageing university buildings are more likely to experience SBS than newer buildings. Ageing materials, outdated construction practices, and declining system performance reduce indoor environmental quality. This highlights the need for planned upgrading and long-term investment to reduce SBS risk in older buildings.

4.3. Additional Findings

This section presents additional findings from the interviews that go beyond the basic patterns discussed in Section 4.2. While earlier findings focused on design, systems, and building types, this section highlights how early design and system decisions affect long-term maintenance and indoor environmental quality. These findings, based on professional experience, show how early decisions continue to influence building performance over time. They help to explain why SBS problems often persist or reoccur in university buildings.

4.3.1. Early Design Decisions and Long-Term Performance

The findings highlight how early design and system selection decisions influence building performance over time. Respondents emphasised long-term impacts rather than short-term outcomes. The findings show that decisions related to construction quality, waterproofing, mechanical systems, and building layout strongly influence maintenance needs and indoor environmental quality. Poor early decisions increase maintenance work, operating costs, and SBS-related problems, while good early decisions support better building performance and occupant comfort throughout the building life cycle.

Table 4.3.1:1
Early Design Decisions and Long-Term Performance

Interview Question	Theme	Respondent	Key Issue Highlighted	Supporting Quote
S6: Influence of early design and system decisions on long-term performance	Life-Cycle Design and Maintenance	R1	Construction quality and waterproofing	<i>“Design decisions affect construction quality and waterproofing, which influence maintenance needs and long-term moisture control.”</i>
		R2	Mechanical system efficiency	<i>“Early selection of mechanical systems affects maintenance frequency, energy use, and indoor air quality.”</i>

Interview Question	Theme	Respondent	Key Issue Highlighted	Supporting Quote
S6: (Cont')		R3	Architectural layout and ventilation	<i>“Ventilation, lighting, and space layout affect indoor comfort and ease of maintenance throughout the building’s life cycle.”</i>

The following quotes explain how early design and technical decisions affect building performance and the risk of SBS throughout the building life cycle.

“Early design decisions affect construction quality and waterproofing systems, which influence maintenance requirements and long-term moisture control.” – R1

This statement shows that decisions made during the design stage are important for controlling moisture. Poor construction quality and weak waterproofing allow water to enter the building, increasing maintenance needs and indoor dampness. Over time, poor moisture control reduces indoor air quality and increases the risk of SBS.

“Early selection of mechanical systems determines system efficiency, maintenance costs, and indoor air quality throughout the building life cycle.” – R2

This quote highlights the long-term impact of choosing mechanical systems at the design stage. Poor system selection leads to low efficiency, high maintenance costs, and weak ventilation. These problems reduce indoor air quality and increase the likelihood of SBS.

“Architectural design decisions such as ventilation, lighting, and space layout affect occupant comfort and ease of maintenance throughout the building life cycle.” – R3

This statement shows that architectural design affects comfort and maintenance. Poor ventilation and lighting reduce comfort, while poor layout makes maintenance difficult. These issues allow indoor problems, such as moisture and poor airflow, to persist, increasing SBS risk.

Overall, the findings show that early design decisions strongly affect long-term building performance. Construction quality, waterproofing, mechanical systems, and building layout influence maintenance needs, operating costs, and indoor environmental quality. Poor early decisions increase SBS risk, while good design supports healthier and more sustainable indoor environments.

4.4. Semi-Structured Interview Findings

This section focuses on issues related to the daily operation of university buildings, based on responses from the semi-structured interviews. Unlike earlier sections that discussed design and life-cycle factors, this section highlights practical problems encountered during building use and the solutions proposed by the respondents. The interviews allowed respondents to describe real operational issues and suggest improvement measures based on their professional experience. This section discusses SBS-related problems in existing university buildings and identifies possible measures to reduce these issues in line with the research objectives.

4.4.1. Common Operational SBS Issues

The findings identify common design, structural, and mechanical issues encountered during the operation of university buildings that may contribute to Sick Building Syndrome. This question aimed to identify recurring practical issues rather than theoretical causes, highlighting problems that persist during daily building use. The respondents described a range of issues related to moisture intrusion, ageing HVAC systems, poor air filtration, and inappropriate building design. These operational problems were often linked to earlier design and construction decisions, as well as inconsistent maintenance practices.

Table 4.4.1:1
Common Operational SBS Issues

Interview Question	Theme	Respondent	Main Problem Identified	Supporting Quote
S7: Common problems contributing to SBS	Structural & Moisture-Related Issues	R1	Roof leakage and persistent dampness	<i>“Roof leakage, high moisture levels, and poor construction finishes.”</i>
	HVAC System Deficiencies	R2	Old HVAC systems and poor air filtration	<i>“Old HVAC systems, ineffective air filtration, and inconsistent maintenance.”</i>
	Design-Related Risks	R3	Sealed buildings and waterproofing failure	<i>“Sealed building design... buildings near toilets with waterproofing failure.”</i>

The following quotes describe operational factors that contribute to SBS during building use. They highlight how moisture problems, mechanical system performance, and design features affect indoor environmental quality.

“Roof leakage, high humidity levels, and poor construction finishes often contribute to SBS.” – R1

This quote shows that moisture problems are a main cause of SBS. Roof leaks let water enter the building, making indoor spaces damp and humid. Poor construction finishes trap moisture and slow drying. These conditions encourage mould growth and reduce indoor air quality, causing discomfort and SBS symptoms.

“The main issues are old HVAC systems, ineffective air filtration, and inconsistent mechanical maintenance.” – R2

This quote highlights problems with building systems. Old HVAC systems cannot control humidity well or supply enough fresh air. Poor air filtration allows dust and pollutants to build up, while irregular maintenance weakens system performance. These problems reduce indoor air quality and increase the risk of SBS.

“Sealed building design, high-VOC materials, low roof height, and buildings near toilets with waterproofing failure increase SBS risk.” – R3

This response explains how design issues affect indoor conditions. Sealed buildings limit airflow, and high-VOC materials release harmful pollutants. Low roof height and nearby wet areas increase moisture when waterproofing fails. These factors create unhealthy indoor environments that increase the risk of SBS.

Overall, SBS during the operational stage is mainly caused by moisture problems, weak mechanical systems, and poor design features. Roof leakage, high humidity, ageing HVAC systems, poor air filtration, and sealed designs work together to reduce indoor air quality and comfort. SBS development is driven by a combination of these ongoing issues, especially when maintenance is inconsistent.

4.4.2. SBS Improvement Measures

The findings highlight practical improvement measures that can be implemented to reduce SBS risk in existing university buildings. Respondents were encouraged to propose solutions based on their professional experience in managing, upgrading, and maintaining institutional buildings. The responses indicate that effective SBS mitigation requires a combination of structural upgrades, system improvements, and preventive design strategies. Rather than relying on short-term corrective actions, respondents emphasised the importance of sustainable and preventive measures.

Table 4.4.2:1
SBS Improvement Measures

Interview Question	Theme	Respondent	Proposed Improvement	Supporting Quote
S8: Improvement measures to reduce SBS	Structural Upgrading	R1	Improve construction quality and waterproofing	<i>“Repair waterproofing systems and upgrade old buildings.”</i>

Interview Question	Theme	Respondent	Proposed Improvement	Supporting Quote
S8: (Cont')	HVAC Modernisation	R2	Upgrade HVAC systems and improve air filtration	<i>“Use VRV systems and efficient water chillers.”</i>
	Preventive Architectural Design	R3	Improve ventilation, lighting, and use low-VOC materials	<i>“Improve natural ventilation... use low-VOC materials... extend roof overhangs.”</i>

The following quotes present respondents’ recommendations for reducing SBS in university buildings. These suggestions focus on improving construction quality, building systems, and architectural design to enhance indoor environmental quality.

“Improve construction quality, repair waterproofing systems, and upgrade old buildings to reduce moisture problems.” – R1

This recommendation focuses on moisture control. Better construction quality and proper waterproofing help prevent water leakage and dampness. Upgrading older buildings reduces mould growth and improves indoor air quality, lowering the risk of SBS.

“Upgrade HVAC systems, improve air filtration, and implement regular preventive maintenance, including the use of VRV systems and more efficient water chillers.” – R2

This quote highlights the importance of improving mechanical systems. Modern HVAC systems with better air filtration improve ventilation and control humidity. Regular maintenance and efficient systems, such as VRV and modern water chillers, help maintain good indoor air quality and reduce the risk of SBS.

“Optimise natural ventilation and daylighting, use low-VOC materials, improve space layout, and extend roof overhangs to reduce weather impact and moisture.”
– R3

This recommendation focuses on building design. Better natural ventilation and daylight improve airflow and comfort. Low-VOC materials reduce indoor pollutants, while better space layout and roof overhangs help control moisture. These measures support healthier indoor environments.

Overall, the findings show that reducing SBS requires combined actions. Structural improvements, HVAC upgrades, and better architectural design must work together to improve indoor air quality and provide long-term solutions for SBS in university buildings.

4.5. Discussion

This section discusses the interview findings by integrating the results from Sections 4.2 to 4.4. The discussion explains how building design, technical systems, and maintenance practices influence the occurrence of SBS in university buildings. The findings are interpreted in relation to the research objectives and existing SBS literature.

4.5.1. Design Quality and SBS

The findings show that building design and construction quality are important factors in the occurrence of SBS. Respondents identified poor workmanship, roof leakage, and weak waterproofing as the main causes of moisture and dampness in buildings. These conditions encourage mould growth, which is often linked to SBS symptoms such as headaches, breathing irritation, and general discomfort (WHO, 1983; Goudarzi & Reshadatian, 2024).

These findings are consistent with the World Health Organization (WHO, 1983), which identified moisture and biological contaminants as major indoor environmental hazards. Previous studies also reported that poor construction quality and defects in the building envelope increase SBS risk, particularly in institutional buildings with long operating hours (Igwe et al., 2023; Francis & Adewumi, 2024). The findings further suggest that SBS often begins at the design and construction stages, indicating that early prevention is more effective than corrective actions during building operation.

4.5.2. HVAC Performance and SBS

HVAC systems were identified as a key factor influencing SBS. Respondents noted that ageing HVAC systems, excessive air-conditioning use, and poor air filtration increase indoor humidity and pollutant levels. These problems are more common in older buildings and low-occupancy spaces such as libraries and lecture halls. These findings support previous research showing that buildings relying heavily

on mechanical ventilation without adequate fresh air are more prone to SBS (WHO, 1983; Ismail et al., 2022). Poor HVAC maintenance further worsens indoor air quality by allowing dust and allergens to circulate indoors (Johari & Abdul Rahman, 2024). This highlights the need for efficient HVAC system selection, adaptive operation based on occupancy, and regular preventive maintenance to reduce SBS risk (CIBSE, 2021).

4.5.3. Architectural Design and SBS

Architectural design factors such as ventilation, daylight access, space layout, and material selection were found to influence indoor environmental quality. Respondents explained that sealed buildings with limited openings restrict airflow and trap moisture, leading to high humidity and mould growth. These findings are consistent with previous studies showing that natural ventilation and daylight improve indoor air quality and reduce SBS symptoms (Jung & El Samanoudy, 2023; Francis & Adewumi, 2024). Poor space planning, overcrowding, and the use of high-VOC materials were also identified as contributors to SBS, supporting evidence that chemical pollutants and spatial density affect occupant health and comfort (Subri et al., 2024).

4.5.4. Building Age, Use, and SBS

The findings show that ageing buildings are more vulnerable to SBS than newer buildings. Ageing materials, outdated construction methods, and declining system performance increase moisture retention and reduce indoor air quality (Hussin et al., 2020). Changes in building usage patterns, especially after COVID-19, were

also identified as an SBS risk factor. Reduced occupancy, combined with continuous HVAC operation, caused humidity imbalances and poor air circulation, particularly in libraries and academic buildings. This finding aligns with studies showing that altered occupancy patterns affect indoor environmental quality and SBS occurrence (Shao et al., 2024; Samsul Rijal et al., 2023).

4.5.5. Professional Collaboration and SBS

The findings show that collaboration among architects, engineers, and maintenance teams plays an important role in reducing SBS. SBS is influenced by the combined effects of design, construction, building systems, and maintenance rather than a single factor. The findings show that effective collaboration allows problems to be identified early and managed more effectively throughout the building life cycle. Working together helps ensure better building performance and healthier indoor environments.

Table 4.5.5:1
Professional Collaboration and SBS

Interview Question	Theme	Respondent(s)	Key View	Supporting Quote
S9: Role of collaboration in reducing SBS	Interdisciplinary Collaboration	R1, R2, R3	Early identification and coordinated solutions	<i>“Collaboration helps identify construction issues early and ensures system coordination.”</i>

The following quote highlights the importance of collaboration among building professionals in reducing the risk of SBS. It explains how teamwork across different disciplines supports better building performance and indoor environmental quality.

“Collaboration between architects, civil engineers, mechanical engineers, and maintenance teams helps identify construction and structural issues early, ensures coordination between mechanical systems and building design, and ensures architectural design meets technical and occupant health requirements throughout the building life cycle.” – R1, R2 & R3

This statement shows that working together across disciplines is important for SBS prevention. Early collaboration helps identify construction and structural problems before they become serious indoor environmental issues. Good coordination between architectural design and mechanical systems ensures proper ventilation, humidity control, and airflow.

Involving maintenance teams also ensures that buildings are designed for easy maintenance and long-term operation. When design teams consider maintenance needs, systems can be serviced more easily and perform better over time. This helps improve indoor air quality, reduce moisture problems, and support healthier indoor environments.

Overall, the findings show that SBS prevention is more effective when architects, engineers, and maintenance teams collaborate from the design stage through building operation. This integrated approach helps reduce risks, improve system performance, and protect occupant health over the building life cycle.

4.5.6. Early Prevention of SBS

The findings highlight the importance of preventing SBS during the early planning and design stages and identify key lessons for future university projects. Respondents consistently emphasised that decisions made early in a building project have long-term impacts on building performance, maintenance requirements, and occupant health.

Table 4.5.6:1
Early Prevention of SBS

Interview Question	Theme	Respondent(s)	Key Lesson	Supporting Quote
S10: Importance of early SBS prevention	Preventive Design Approach	R1, R2, R3	Early design decisions determine long-term performance.	<i>“Initial design decisions determine long-term building performance.”</i>

The following quote reflects the respondents’ shared view on the importance of preventing SBS from the early stages of building development. It highlights how early planning and design decisions affect long-term building performance and occupant health.

“Early SBS prevention is very important because initial design decisions determine long-term building performance. Future university projects should prioritise occupant health, ease of maintenance, and indoor air quality during planning and design.” – R1, R2 & R3

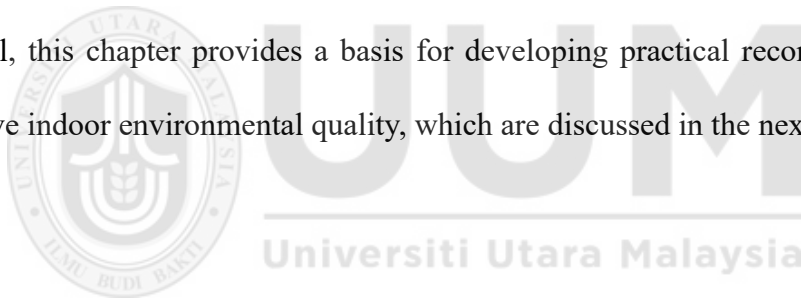
This statement shows strong agreement among the respondents that SBS should be addressed early in the design stage. Decisions made during planning affect ventilation, moisture control, material performance, and indoor air quality throughout the building life cycle. When occupant health is prioritised early, the risk of SBS is reduced.

Considering maintenance needs during design also helps buildings perform better over time. Systems that are easy to access and maintain are more reliable and less likely to fail. This reduces indoor environmental problems and improves long-term building performance.

Overall, the findings show that early prevention is the most effective way to manage SBS in university buildings. Planning and design decisions have long-term effects on indoor air quality, maintenance efficiency, and occupant health. Prioritising these factors from the outset helps reduce SBS risk and supports healthier, more sustainable university buildings.

4.6. Summary

This chapter analysed findings from semi-structured interviews with building professionals at UUM to understand factors contributing to SBS in university buildings. The results show that SBS is mainly influenced by construction quality, moisture problems, HVAC performance, architectural design, building age, and maintenance practices, with older buildings and libraries being more prone to SBS. Early design and system decisions were found to affect long-term indoor environmental quality, while operational issues, such as roof leaks and outdated HVAC systems, further increase SBS risk. The findings also highlight the importance of preventive design, building upgrades, and professional collaboration to reduce SBS. Overall, this chapter provides a basis for developing practical recommendations to improve indoor environmental quality, which are discussed in the next chapter.



CHAPTER FIVE:

CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This chapter presents the study's recommendations and conclusions, based on the findings from the semi-structured interviews discussed in Chapters 3 and 4. The main purpose of this chapter is to propose practical and realistic measures to reduce the occurrence of SBS in university buildings at UUM. The recommendations are developed in line with the research objectives and are informed by insights from building professionals, including architects, engineers, and maintenance personnel. They focus on key areas identified in the findings, such as building design quality, HVAC system performance, maintenance practices, building age, and usage patterns. Emphasis is placed on adopting a preventive, integrated, and life-cycle-based approach to improve indoor environmental quality and occupant comfort. In addition to recommendations, this chapter summarises the study's overall conclusions and discusses the implications for building and facilities management practices at UUM. The chapter also provides suggestions for future research to enhance further the understanding and management of SBS in university buildings.

5.2. Summary of Key Findings

This section summarises the study's key findings in relation to the Research Objectives. The findings are based on semi-structured interviews with building professionals at UUM. They are supported by previous studies on SBS and indoor environmental quality.

i. Objective 1: Identifying Building Design Factors Contributing to SBS

The findings show that building design and technical decisions strongly influence the risk of SBS. Poor workmanship, roof leakage, and weak waterproofing allow moisture to enter buildings, leading to dampness and mould growth. Moisture and mould are well-known causes of SBS symptoms (WHO, 1983; Goudarzi & Reshadatian, 2024). From a mechanical perspective, ageing HVAC systems, excessive use of air conditioning, and poor air filtration reduce indoor air quality and increase humidity. Similar findings have been reported in university buildings where poor ventilation and HVAC performance increase SBS symptoms (Ismail et al., 2022; Johari & Abdul Rahman, 2024). In addition, architectural factors such as sealed buildings, limited natural ventilation, low daylight, poor space layout, and the use of high-VOC materials were also found to worsen indoor comfort. Previous studies confirm that good ventilation and daylight help reduce SBS in educational buildings (Jung & El Samanoudy, 2023; Francis & Adewumi, 2024).

ii. Objective 2: Types of UUM Buildings with Potential to Cause SBS

The findings show that ageing buildings, particularly libraries and academic buildings (more than 25 years old) such as Inasis Maybank, DKG 1 to 4, and Mosques, have a higher potential to experience Sick Building Syndrome at Universiti Utara Malaysia. These buildings often contain ageing materials, outdated construction methods, and mechanical systems that no longer perform efficiently. As a result, indoor air quality is reduced, and issues such as moisture accumulation and poor ventilation are more common. This finding is consistent with previous studies, which reported that older public and institutional buildings frequently experience indoor environmental problems due to material deterioration and limited upgrading (Hussin et al., 2020).

In addition to building age, building usage patterns also influence SBS potential. Respondents explained that reduced occupancy combined with continuous HVAC operation, particularly after the COVID-19 period, can lead to humidity imbalance and poor air circulation. Spaces such as libraries and lecture halls were identified as more vulnerable because air-conditioning systems continue to operate even when occupancy is low. Previous studies support this finding, showing that changes in occupancy patterns can increase SBS symptoms when ventilation systems are not adjusted accordingly (Shao et al., 2024; Samsul Rijal et al., 2023). These findings indicate that the potential for SBS in UUM buildings is influenced by building type, age, and usage characteristics.

iii. Objective 3: Design Improvement Measures to Prevent SBS

The findings indicate that SBS in university buildings is commonly associated with moisture-related problems, ageing HVAC systems, ineffective ventilation, and delayed maintenance. Issues such as roof leakage, dampness, and waterproofing failure allow moisture to accumulate, creating conditions that encourage mould growth and degrade indoor air quality. Moisture-related problems have long been recognised as major contributors to SBS and occupant discomfort (WHO, 1983; Subri et al., 2024).

To prevent SBS, respondents emphasised the need for early and integrated design improvement measures rather than isolated corrective actions. Suggested measures include improving waterproofing design, selecting durable and low-emission materials, upgrading HVAC systems, and ensuring adequate ventilation and daylight access. These approaches are supported by previous studies that highlight the importance of proactive, integrated design strategies for reducing SBS risk (CIBSE, 2021; Igwe et al., 2023).

Respondents also highlighted the importance of collaboration among architects, engineers, and maintenance teams during the planning and design stages. Effective collaboration enables the identification of potential SBS risks early, improves coordination among building systems, and supports long-term building performance. This integrated, life-cycle-oriented approach reduces reliance on reactive maintenance and is critical for preventing SBS in future university building projects (Hussin et al., 2020).

5.3. Practical Recommendations

The findings indicate that SBS in UUM buildings results from the combined effects of building design weaknesses, unfavourable indoor environmental conditions, and inconsistent maintenance practices. Therefore, the recommendations focus on improving IEQ through integrated design, maintenance, technology, governance, and occupant-related strategies, guided by established building science principles and recognised IAQ guidelines.

i. Building Design and Architectural Enhancements

It is recommended that future building design and upgrading works at UUM prioritise moisture control and indoor environmental quality. Special attention should be given to construction quality, roof detailing, and waterproofing systems to prevent water leakage and dampness. Poor workmanship and weak waterproofing were identified as major SBS contributors, and similar findings have been reported in previous studies (WHO, 1983; Goudarzi & Reshadatian, 2024). Architectural design should also encourage natural ventilation and daylight access, where possible. Increasing window openings, improving airflow paths, and avoiding fully sealed building designs can help reduce indoor humidity and improve air quality. Studies have shown that buildings with better natural ventilation and daylight experience fewer SBS symptoms (Jung & El Samanoudy, 2023; Francis & Adewumi, 2024). In addition, the use of low-VOC materials during renovation and refurbishment should be prioritised to minimise chemical exposure and improve occupant comfort (Subri et al., 2024).

ii. HVAC Systems and Mechanical Performance

Upgrading ageing HVAC systems is essential to improve indoor air quality in existing UUM buildings. Old, inefficient systems should be replaced with energy-efficient, adaptable HVAC systems that respond to actual occupancy levels. Respondents highlighted that continuous HVAC operation during low occupancy increases humidity and worsens SBS, a finding supported by recent studies (Ismail et al., 2022; Shao et al., 2024). Regular preventive maintenance of HVAC systems, including filter replacement, duct cleaning, and system inspection, should be strengthened. Poor air filtration and inconsistent maintenance allow dust, allergens, and microorganisms to circulate indoors, increasing SBS risk (Johari & Abdul Rahman, 2024). CIBSE (2021) also recommends routine system monitoring and maintenance to ensure good indoor environmental quality.

iii. Maintenance Management and Operation

UUM should move from reactive maintenance to planned and preventive maintenance. This includes regular inspections, routine servicing, and early repair of defects. Areas such as roofs, wet areas, drainage systems, and building envelopes should be checked regularly to prevent water leakage, dampness, and mould growth. Poor maintenance has been widely identified as a major cause of SBS in public buildings (Hussin et al., 2020; Igwe et al., 2023). Maintenance planning should also reflect how buildings are actually used. HVAC systems should be operated and maintained according to occupancy levels, with adjustments to operating hours, airflow, and filter cleaning, especially in libraries and academic buildings. Good

coordination between maintenance teams and building users helps improve ventilation performance and reduce humidity levels, which can reduce SBS symptoms (Shao et al., 2024; Samsul Rijal et al., 2023).

iv. Professional Collaboration and Management

Effective collaboration between architects, engineers, and maintenance teams should be strengthened throughout the building life cycle. Regular coordination and shared information can help ensure that design plans, system performance, and maintenance needs are well aligned, allowing SBS issues to be identified and addressed early (Hussin et al., 2020). In addition, basic SBS awareness and indoor environmental training should be provided to maintenance staff and building managers to ensure potential risks are recognised and managed properly. Studies show that integrated management and informed decision-making are important in reducing SBS in institutional buildings (Igwe et al., 2023; Francis & Adewumi, 2024). Overall, a preventive and integrated approach is recommended, in which building design, HVAC systems, maintenance, and teamwork are improved together to support better long-term building performance and compliance with established SBS guidelines (WHO, 1983; CIBSE, 2021).

5.4. Recommendations for Future Research

Based on the findings, this study provides useful insights into Sick Building Syndrome in UUM buildings. However, future research is needed to further improve the understanding of SBS and building performance in university environments. Future studies should include more buildings and participants, such as faculties, hostels, offices, and support facilities. Involving occupants, students, and administrative staff would provide a broader perspective on SBS symptoms and indoor environmental quality. Future research should also combine interviews with physical measurements such as temperature, humidity, carbon dioxide (CO₂), and particulate matter to better link building conditions with SBS symptoms (WHO, 1983; Ismail et al., 2022; Samsul Rijal et al., 2023).

In addition, future research may focus on specific high-risk building types, including libraries, residential colleges, and older academic buildings. Studying building performance before and after preventive measures, such as HVAC upgrades and improved maintenance, would help evaluate the effectiveness of SBS mitigation strategies. Overall, future studies should support a preventive and life-cycle approach to SBS management to improve indoor environmental quality and occupant well-being (CIBSE, 2021; Igwe et al., 2023).

5.5. Conclusion

In conclusion, this study demonstrates that SBS in UUM buildings arises from the combined effects of building design, technical systems, and maintenance practices rather than a single isolated factor. The findings show that poor construction quality, roof leakage, inadequate waterproofing, ageing HVAC systems, limited ventilation, and inconsistent maintenance contribute to moisture accumulation, poor indoor air quality, and occupant discomfort. Ageing buildings, including libraries, academic buildings, and lecture halls, are more vulnerable due to deteriorating materials, outdated construction methods, and declining system performance. In addition, buildings that rely entirely on HVAC systems, particularly sealed buildings with limited natural ventilation, face a higher risk of SBS due to humidity imbalances and reduced fresh-air circulation. The study also highlights that early design decisions, preventive maintenance, and strong collaboration among architects, engineers, and maintenance teams are critical in reducing SBS risk. Overall, the findings emphasise the importance of an integrated, preventive, and life-cycle-based approach to building design, operation, and maintenance to improve indoor environmental quality and support healthier learning environments at UUM.

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APPENDICES

Appendix A: Interview Application Letter

Tarikh: 26 Oktober 2025

Kepada:

Mohd Suhaili Bin Rejab
Menjalankan Fungsi Pengarah
Jabatan Pembangunan dan Pengurusan Infrastruktur
Universiti Utara Malaysia,
06010 Sintok, Kedah Darul Aman, Malaysia

Tuan,

PER: PERMOHONAN UNTUK SESI TEMUDUGA BAGI KAJIAN SARJANA

Saya, **Muhammad Amirul Hakim Bin Sabri**, pelajar Sarjana Pengurusan Projek (M275) di Universiti Utara Malaysia (UUM) di bawah penyeliaan **Prof. Madya Ts. Dr. Nurul Azita Bt. Salleh**. Saya kini menjalankan kajian bertajuk:

“Faktor Reka Bentuk dan Penyelenggaraan yang Menyumbang kepada Sindrom Bangunan Sakit (SBS) di Bangunan Universiti Utara Malaysia.”

Kajian ini bertujuan mengenal pasti bagaimana reka bentuk dan amalan penyelenggaraan bangunan mempengaruhi kualiti persekitaran dalaman serta kesihatan penghuni asrama universiti.

Sehubungan itu, saya ingin memohon kerjasama pihak JPPI untuk ditemu bual bagi mendapatkan pandangan dan pengalaman berhubung perkara ini. Temu bual dijangka mengambil masa sekitar 30 hingga 45 minit dan boleh dijalankan secara bersemuka atau atas talian (Zoom/Google Meet) mengikut keselesaan pihak Tuan.

Sebagai cadangan awal, berikut tiga tarikh yang dicadangkan:

1. **Ahad, 9 November 2025 – jam 12.00 tengah hari**
2. **Ahad, 16 November 2025 – jam 12.00 tengah hari**
3. **Ahad, 23 November 2025 – jam 12.00 tengah hari**

Sekiranya tarikh-tarikh ini tidak sesuai, saya amat menghargai sekiranya Tuan dapat mencadangkan masa lain yang lebih sesuai.

Segala maklumat yang diberikan akan dirahsiakan sepenuhnya dan digunakan hanya untuk tujuan akademik. Saya amat menghargai masa dan kerjasama yang diberikan.

Sekian, terima kasih atas perhatian dan pertimbangan pihak Tuan.

Yang benar,

Amirul Hakim

Muhammad Amirul Hakim Bin Sabri
Pelajar Sarjana Pengurusan Projek (M275),
Universiti Utara Malaysia (UUM)
834736
Emel: aremirulhakiem2001@gmail.com
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Appendix B: Interview Guide

Topik:

“Faktor Reka Bentuk dan Penyelenggaraan Bangunan yang Menyumbang kepada Sindrom Bangunan Sakit (SBS) di Bangunan Universiti Utara Malaysia (UUM)”

Tujuan Temubual:

Tujuan temu bual ini adalah untuk meneroka hubungan antara reka bentuk bangunan, amalan penyelenggaraan dan kejadian Sindrom Bangunan Sakit (SBS) di bangunan Universiti Utara Malaysia (UUM). Tujuan temu bual ini adalah untuk mendapatkan pengetahuan tentang profesional yang terlibat dalam reka bentuk, operasi dan penyelenggaraan bangunan bagi memahami faktor-faktor yang mempengaruhi kualiti persekitaran dalaman (IEQ) dan kesihatan penghuni.

Semua jawapan akan dirahsiakan dan digunakan semata-mata untuk tujuan akademik. Peserta berhak untuk menarik diri pada bila-bila masa tanpa sebarang akibat.

Arahan kepada Peserta:

- Temu bual mengambil masa kira-kira 30–60 minit.
- Sila jawab soalan berdasarkan pengalaman profesional anda dalam pengurusan atau penyelenggaraan bangunan.
- Tiada jawapan betul atau salah; pendapat jujur anda adalah berharga.
- Dengan persetujuan anda, temu bual ini telah dirakam audio untuk transkripsi dan analisis.
- Identiti anda kekal tanpa nama dalam semua laporan atau penerbitan.

Appendix C: Interview Questions:

Bahagian A: Latar Belakang Peserta

- Bolehkah tuan/puan ceritakan secara ringkas peranan dan pengalaman tuan/puan bangunan universiti atau institusi?

Bahagian B: Faktor Reka Bentuk Bangunan Yang Mungkin Menyebabkan SBS

- Pada pandangan profesional tuan/puan, bagaimana keputusan reka bentuk atau teknikal bangunan boleh menyumbang kepada berlakunya Sindrom Bangunan Sakit (SBS) di bangunan universiti?
- Apakah elemen lain yang boleh mempengaruhi kualiti persekitaran dalaman dan keselesaan penghuni?

Bahagian C: Jenis Bangunan di UUM yang Berisiko SBS

- Berdasarkan pengalaman tuan/puan, jenis bangunan universiti yang manakah lebih cenderung mengalami masalah SBS, dan apakah faktor reka bentuk atau teknikal yang menyumbang kepada keadaan tersebut?
- Pada pendapat tuan/puan, bagaimana faktor usia bangunan (bangunan lama berbanding baharu) mempengaruhi prestasi reka bentuk, sistem teknikal, dan kebarangkalian berlakunya SBS?

Bahagian D: Hubungan Reka Bentuk, Sistem & Penyelenggaraan

- Bagaimanakah keputusan reka bentuk dan sistem teknikal pada peringkat awal mempengaruhi kerja penyelenggaraan serta prestasi kualiti persekitaran dalaman dalam jangka panjang?

Bahagian E: Langkah Penambahbaikan untuk Mencegah SBS

- Apakah masalah reka bentuk, struktur, atau sistem mekanikal yang paling kerap ditemui semasa operasi bangunan dan berpotensi menyumbang kepada SBS?
- Apakah cadangan penambahbaikan reka bentuk, struktur, atau sistem HVAC yang tuan/puan syorkan untuk mengurangkan risiko SBS di bangunan universiti sedia ada?
- Bagaimanakah kerjasama antara arkitek, jurutera awam, jurutera mekanikal, dan pasukan penyelenggaraan boleh membantu mencegah atau mengurangkan SBS sepanjang kitaran hayat bangunan?

Bahagian F: Pencegahan Awal & Penutup (Integratif)

- Sejauh manakah pentingnya pencegahan SBS di peringkat awal perancangan dan reka bentuk bangunan, dan apakah pengajaran utama yang boleh diaplikasikan dalam projek universiti pada masa hadapan?

Appendix D: Interview Answer

Bahagian A: Latar Belakang Peserta

S1. Bolehkah tuan/puan ceritakan secara ringkas peranan dan pengalaman tuan/puan sebagai arkitek / jurutera awam / jurutera mekanikal dalam bangunan universiti atau institusi?

R1:

Saya merupakan Jurutera Awam di Unit Kejuruteraan Awam dan mempunyai 12 tahun pengalaman. Saya bertanggungjawab dalam menyelia dan memantau kerja kontraktor bagi projek pembangunan dan penyenggaraan bangunan universiti. Selain itu, saya terlibat dalam penyediaan reka bentuk, anggaran kos, dan memberi khidmat nasihat kejuruteraan dari peringkat perancangan hingga projek siap.

R2:

Saya merupakan seorang Jurutera Mekanikal di Unit Kejuruteraan Mekanikal dan mempunyai 10 tahun pengalaman. Saya bertanggung jawab dalam menyelia kerja kontraktor bagi projek pembangunan dan penyenggaraan sistem mekanikal universiti, termasuk pengurusan kenderaan. Saya juga terlibat dalam penyediaan reka bentuk, anggaran kos, serta kerja pembaikan dan penyenggaraan pencegahan sistem mekanikal.

R3:

Saya merupakan seorang Arkitek di Unit Arkitek dan mempunyai 15 tahun pengalaman. Saya bertanggungjawab merancang, mereka bentuk, dan menyelia kerja seni bina bagi bangunan baharu serta kerja pengubahsuaian dan naik taraf kemudahan universiti. Selain itu, saya menyediakan lukisan dan dokumen tender serta memberi khidmat rundingan reka bentuk bangunan dan imej universiti.

Bahagian B: Faktor Reka Bentuk & Teknikal Berkaitan SBS

S2. Pada pandangan profesional tuan/puan, bagaimana keputusan reka bentuk atau teknikal bangunan boleh menyumbang kepada berlakunya Sindrom Bangunan Sakit (SBS) di bangunan universiti?

R1:

Pada pendapat saya, kualiti pembinaan merupakan faktor penting yang menyumbang kepada SBS. Kemasan bumbung yang tidak kemas serta masalah retakan struktur boleh membenarkan air masuk ke dalam bangunan, seterusnya menyebabkan kelembapan dan pertumbuhan kulat.

R2:

Pada pendapat saya, bangunan yang terlalu bergantung sepenuhnya kepada penghawa dingin boleh meningkatkan kelembapan dalaman dan seterusnya menyumbang kepada berlakunya SBS.

R3:

Pada pendapat saya, reka bentuk pencahayaan semula jadi dan bukaan seperti tingkap serta ventilasi sangat penting dalam mencegah SBS. Setiap bangunan sepatutnya menerima sekurang-kurangnya 35% pencahayaan semula jadi bagi mengelakkan pertumbuhan kulat, manakala bangunan tanpa bukaan (sealed building) cenderung meningkatkan kelembapan dan pertumbuhan kulat yang menyebabkan ketidakelesaan kepada pengguna.

S3. Apakah elemen lain yang boleh mempengaruhi kualiti persekitaran dalaman dan keselesaan penghuni?

R1:

Selain itu, usia bangunan dan kaedah pembinaan turut menyumbang kepada SBS, terutamanya bagi bangunan lama yang tidak dinaik taraf. Bangunan yang dibina pada era 1980-an menggunakan standard dan kaedah pembinaan yang berbeza, seperti dinding satu lapis di Bangunan IT UUM, yang boleh meningkatkan kelembapan dalaman dan seterusnya meningkatkan risiko berlakunya SBS.

R2:

Pada pendapat saya, penapisan udara juga sangat penting dalam mengawal SBS. Sebagai contoh, dewan kuliah seperti DKG 1 hingga DKG 4 yang merupakan bangunan lama dan kurang digunakan cenderung mengumpul habuk serta alergen, yang boleh menjejaskan keselesaan dan kesihatan pengguna.

R3:

Bagi saya, pemilihan bahan binaan dan kemasan dalaman turut menyumbang kepada SBS, terutamanya bahan yang mempunyai kandungan VOC tinggi seperti karpet, cat, perekat, dan papan komposit, serta bahan lama atau uzur yang menyimpan habuk dan pencemar. Selain itu, susun atur ruang yang tidak sesuai, kepadatan ruang yang tinggi (overcrowding), dan ruang tertutup tanpa pengudaraan semula jadi boleh memburukkan kualiti udara dalaman dan menjejaskan kesihatan pengguna.

Bahagian C: Jenis Bangunan & Risiko SBS

S4. Berdasarkan pengalaman tuan/puan, jenis bangunan universiti yang manakah lebih cenderung mengalami masalah SBS (contohnya asrama, pejabat, bangunan akademik), dan apakah faktor reka bentuk atau teknikal yang menyumbang kepada keadaan tersebut?

R1:

Perpustakaan lebih cenderung mengalami SBS kerana kebocoran bumbung yang uzur, yang menyebabkan kelembapan dalaman menjadi tinggi.

R2:

Perpustakaan berisiko mengalami SBS terutamanya selepas era pasca COVID-19 apabila penggunaan ruang berkurangan tetapi sistem penghawa dingin masih beroperasi, menyebabkan kelembapan meningkat dan kualiti udara dalaman menurun.

R3:

Perpustakaan berisiko mengalami SBS kerana kebocoran bumbung yang menyebabkan pengumpulan air dan pertumbuhan kulat. Selain itu, penggunaan sistem dalam talian sejak era COVID-19 mengurangkan penggunaan buku fizikal, dan penyelenggaraan bahan yang kurang baik turut menyebabkan ketidakselesaan. Bangunan akademik yang banyak menggunakan penghawa dingin, reka bentuk bumbung yang rendah, serta bangunan yang berhampiran tandas juga berisiko SBS akibat kelembapan tinggi dan kegagalan lapisan kalis air yang menghalang pertumbuhan kulat.

R1:

Dewan Kuliah seperti DKG 1 hingga DKG 4 sebelum ini berisiko SBS kerana merupakan bangunan lama, namun risiko tersebut telah berkurang selepas kerja naik taraf dilaksanakan.

R3:

Bangunan lama seperti Masjid UUM dan Inasis lama seperti Inasis Maybank juga berisiko mengalami SBS. Oleh itu, pihak JPP sedang melaksanakan kerja naik taraf bagi mengurangkan SBS serta meningkatkan keselesaan dan kesihatan pengguna.

S5. Pada pendapat tuan/puan, bagaimana faktor usia bangunan (bangunan lama berbanding baharu) mempengaruhi prestasi reka bentuk, sistem teknikal, dan kebarangkalian berlakunya SBS?

R1, R2 & R3:

Bangunan lama lebih berisiko mengalami SBS berbanding bangunan baharu kerana menggunakan kaedah dan bahan binaan lama yang kurang menyokong kualiti udara dalaman. Selain itu, prestasi sistem teknikal bangunan lama biasanya menurun dan memerlukan kos yang tinggi untuk dinaik taraf bagi mencapai prestasi bangunan berprestasi tinggi (high performance), sekali gus meningkatkan kebarangkalian berlakunya SBS.

Bahagian D: Hubungan Reka Bentuk, Sistem & Penyelenggaraan

S6. Bagaimanakah keputusan reka bentuk dan sistem teknikal pada peringkat awal mempengaruhi kerja penyelenggaraan serta prestasi kualiti persekitaran dalaman dalam jangka panjang?

R1:

Keputusan reka bentuk awal mempengaruhi kualiti binaan dan sistem kalis air, yang memberi kesan kepada keperluan penyelenggaraan serta kawalan kelembapan dalam jangka panjang.

R2:

Pemilihan sistem mekanikal pada peringkat awal menentukan kecekapan sistem, kos penyelenggaraan, dan kualiti udara dalaman sepanjang hayat bangunan.

R3:

Keputusan reka bentuk seni bina seperti pengudaraan, pencahayaan, dan susun atur ruang mempengaruhi tahap keselesaan pengguna serta kemudahan penyelenggaraan sepanjang kitaran hayat bangunan.

Bahagian E: Langkah Penambahbaikan & Penyelesaian

S7. Apakah masalah reka bentuk, struktur, atau sistem mekanikal yang paling kerap ditemui semasa operasi bangunan dan berpotensi menyumbang kepada SBS?

R1:

Masalah kebocoran bumbung, kelembapan tinggi, dan kualiti kemas binaan yang rendah sering menyumbang kepada SBS.

R2:

Masalah utama ialah sistem HVAC yang lama, penapisan udara yang tidak berkesan, dan penyelenggaraan mekanikal yang tidak konsisten.

R3:

Reka bentuk bangunan yang tertutup, penggunaan bahan VOC tinggi, bumbung rendah, serta bangunan berhampiran tandas yang mengalami kegagalan kalis air meningkatkan risiko SBS.

S8. Apakah cadangan penambahbaikan reka bentuk, struktur, atau sistem HVAC yang tuan/puan syorkan untuk mengurangkan risiko SBS di bangunan universiti sedia ada?

R1:

Menambah baik kualiti binaan, membaiki sistem kalis air, serta menaik taraf bangunan lama bagi mengurangkan masalah kelembapan.

R2:

Menaik taraf sistem HVAC, meningkatkan penapisan udara, dan melaksanakan penyelenggaraan pencegahan secara berkala, termasuk penggunaan sistem VRV dan water chiller yang lebih efisien.

R3:

Mengoptimumkan reka bentuk pengudaraan dan pencahayaan semula jadi, menggunakan bahan binaan rendah VOC, menambah baik susun atur ruang, serta memanjangkan bumbung overhang bagi mengurangkan kesan cuaca dan kelembapan.

S9. Bagaimanakah kerjasama antara arkitek, jurutera awam, jurutera mekanikal, dan pasukan penyelenggaraan boleh membantu mencegah atau mengurangkan SBS sepanjang kitaran hayat bangunan?

R1, R2 & R3:

Kerjasama antara profesional seperti arkitek, jurutera awam, jurutera mekanikal, dan pasukan penyelenggaraan dapat mengurangkan SBS dengan membolehkan isu binaan dan struktur dikenal pasti lebih awal, memastikan penyelarasan sistem mekanikal dengan reka bentuk bangunan, serta menjamin reka bentuk seni bina memenuhi keperluan teknikal dan kesihatan pengguna sepanjang kitaran hayat bangunan.

Bahagian F: Pencegahan Awal & Penutup (Integratif)

S10. Sejauh manakah pentingnya pencegahan SBS di peringkat awal perancangan dan reka bentuk bangunan, dan apakah pengajaran utama yang boleh diaplikasikan dalam projek universiti pada masa hadapan?

R1, R2 & R3:

Pencegahan SBS di peringkat awal sangat penting kerana keputusan reka bentuk awal menentukan prestasi bangunan jangka panjang. Pengajaran utama ialah perancangan yang mengambil kira kesihatan pengguna, kemudahan penyelenggaraan, dan kualiti udara dalaman perlu menjadi keutamaan dalam projek universiti pada masa hadapan.