

## Determinant Factor Model for Effective Building Maintenance Management in Polytechnic Malaysia

W Mohd Haniff W Mohd Shaupil<sup>1</sup>, Rafikullah Deraman<sup>2</sup>, Mohd Nasrun Mohd Nawil<sup>3</sup>

### Abstract

Effective building maintenance management is crucial for ensuring the sustainability, safety, and functionality of educational infrastructure. However, the current maintenance management systems in Polytechnic Malaysia face significant challenges, including inadequate service delivery, budget constraints, inefficient maintenance practices, and accumulated maintenance backlogs. This study aims to develop a conceptual determinant factor model that outlines the key components influencing effective building maintenance management and their impact on maintenance performance in Polytechnic Malaysia. A systematic literature review was conducted, analyzing 18 scholarly articles from Emerald, ScienceDirect, Scopus, and SpringerLink, published between 2015 and 2025. The findings identified organizational, human, process, and technological factors as the four main determinants that collectively enhance maintenance strategy effectiveness. This study provides a foundational conceptual model that can serve as a basis for future empirical research and policy development in building maintenance management within Malaysian polytechnics.

**Keywords:** *Building Maintenance, Polytechnic Malaysia, Maintenance Performance, Facility Management, Determinant Factors.*

### Introduction

Polytechnics under the Ministry of Higher Education Malaysia serves as a leading institution in technical and vocational education and training (TVET), established to produce semi-professional graduates in various fields, including engineering, commerce, hospitality, information and communication technology (ICT), and services. These institutions play a crucial role in equipping students with the technical expertise and practical skills necessary to meet industry demands and adapt to evolving work environments.

To achieve this objective, polytechnic institutions require well-maintained infrastructure and facilities that support effective teaching, learning, and skill development. The availability of adequate, high-quality, and comprehensive assets is essential in ensuring that students receive optimal training and education. Without proper building maintenance management, institutional facilities may deteriorate, affecting not only the functionality of learning spaces but also the overall quality of education provided.

Since the establishment of the first polytechnic in Malaysia in 1969, the number of polytechnics has expanded to 36 institutions across the country. Many of these buildings, having been in operation for more than 50 years, continue to serve as essential facilities for teaching, learning and research activities. However, it has been observed that many of the pioneer polytechnic buildings suffer from poor maintenance with visible signs of neglect, structural deterioration and outdated facilities.

Research has shown that around 75% to 80% of a building's overall lifecycle expenses are spent during the operation and maintenance stages, especially for structures designed to last for 50 years [1]. The maintenance process is ongoing and plays a crucial role in keeping the infrastructure, amenities

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<sup>1</sup> Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn, 86400 Parit Raja, Johor, Malaysia, Civil Engineering Department, Polytechnic Kota Bharu, 16450 Ketereh, Kelantan, Malaysia

<sup>2</sup> Project and Facilities Management Research Group, Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn, 86400 Parit Raja, Johor, Malaysia, E-mail: rafikullah@uthm.edu.my, (corresponding author).

<sup>3</sup> Disaster Management Institute (DMI), School of Technology Management and Logistics, Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia

and systems of a building in good working condition and operating efficiently. Poor maintenance practices can lead to decreased user satisfaction and reduced building performance ultimately impacting the institution's effectiveness and the quality of services it provides.

To maintain a building's performance over time, it is essential to periodically replace aging components and systems. Although routine repairs and smaller replacements can typically be handled through preventive maintenance strategies, larger-scale tasks such as replacing the roof or upgrading mechanical and electrical systems demand careful financial preparation and should be allocated under capital renewal budgets. In the absence of adequate funding and strategic foresight, postponed maintenance can accumulate, eventually resulting in major repair and restoration costs that may reach millions of dollars [2].

The rising cost of maintaining infrastructure in higher education has become an increasing concern, especially for polytechnics that are dependent on government allocations. In response to this issue, the Malaysian Education Blueprint 2013–2025 (Higher Education) [3] highlights the importance of adopting sustainable financial practices within higher learning institutions. This includes enhancing the efficiency of maintenance spending to preserve the usability and lifespan of campus assets. The blueprint also presents strategic initiatives aimed at strengthening asset management and lowering operational expenses, all while ensuring that educational facilities remain conducive to quality teaching and learning.

Despite various initiatives, many higher education institutions still face escalating maintenance expenses due to aging buildings and growing repair requirements. Inadequate budget planning often results in the accumulation of deferred maintenance, which can lead to substantial financial strain. The prevailing budgeting method tends to be reactive, focusing on urgent maintenance tasks rather than incorporating long-term sustainability goals. This reactive funding model has been criticized for inefficiencies and frequent budget overruns. Consequently, there is a pressing need for a more strategic, data-informed financial planning framework to help polytechnics sustain a supportive educational environment while managing maintenance costs effectively.

As stated by Ismail [4], poor maintenance management remains a significant challenge for many organizations, often resulting in the degradation of facilities and reduced service standards. Within polytechnic institutions, such shortcomings in maintenance practices are frequently reported, revealing various areas in need of urgent enhancement especially regarding the adoption and implementation of technology within maintenance operations.

A number of past studies have consistently shown that maintenance performance in tertiary education institutions lags behind established best practice benchmarks [5]. Many universities and polytechnics often implement reactive maintenance methods instead of adopting proactive strategies, with limited consideration given to user satisfaction or service effectiveness during planning and decision-making. Most institutions still depend heavily on corrective and scheduled maintenance systems, which has led to an increasing backlog of unresolved maintenance issues. Furthermore, these activities are frequently influenced by the availability of financial resources, resulting in the postponement of scheduled maintenance until adequate funding is secured. This budgetary limitation not only worsens existing problems but also contributes to higher long-term operational expenses for the institutions.

The decline in the condition of polytechnic buildings and facilities is largely due to inadequate maintenance efforts in previous years, along with limited awareness about the critical role of proper maintenance [6]. Often, both property owners and the general public fail to recognize the value of effective maintenance management, which results in overlooked infrastructure needs and a gradual drop in overall facility performance.

Although the government has allocated considerable funding for building maintenance, there is still a noticeable absence of detailed guidelines and standardized operating procedures (SOPs) to guide building owners and facility managers effectively. This lack of a unified system has led to inconsistent and fragmented maintenance practices, which in turn worsens the difficulties related to sustaining infrastructure in polytechnic institutions. To improve maintenance effectiveness and extend the durability of institutional assets, it is crucial to establish a well-structured maintenance management system backed by clear policies and regulatory support.

Ismail [7] notes that polytechnic maintenance management still heavily depends on conventional methods like phone calls, manual forms, and email communications to report building issues. This

outdated system causes inefficiencies, uncoordinated processes, and slower response times to maintenance requests. In addition, the lack of a formalized preventive maintenance plan leads to unmonitored and reactive maintenance efforts, which accelerates the decline of building conditions.

To overcome these issues, it is essential to implement a modern and effective maintenance management system that facilitates prompt defect repairs, optimizes resource use, and minimizes dependence on manual procedures. The challenges faced by polytechnic maintenance systems are compounded by a lack of skilled technical staff capable of managing and overseeing newly introduced building and infrastructure technologies [7]. This problem is closely associated with the limited adoption of information and communication technology (ICT) tools, especially computerized systems designed for maintenance management.

At present, the Computerized Maintenance Management System (CMMS) is extensively used across multiple industries to streamline facility maintenance operations. Introducing this technology in polytechnic institutions has the potential to greatly enhance maintenance scheduling, defect monitoring, and overall efficiency of maintenance activities.

Human resource issues continue to pose a major obstacle to efficient maintenance management within polytechnic institutions. Many technicians do not possess adequate technical skills, especially when it comes to using information and communication technology (ICT) tools for maintenance tasks. Furthermore, senior technicians often lack proficiency in accurately identifying the root causes of defects in building components, resulting in poor decision-making and inappropriate maintenance approaches [8]. These deficiencies not only reduce maintenance effectiveness but also lead to higher operational expenses and accelerated deterioration of facilities. To overcome these challenges, focused training and capacity-building programs are needed to improve the technical skills and problem-solving capabilities of maintenance staff.

Human resource issues continue to be a major challenge for effective maintenance management in polytechnics. A significant number of technicians lack the technical proficiency needed to carry out maintenance tasks efficiently, especially when it comes to using information and communication technology (ICT) tools for such operations. Moreover, many senior technicians show limited skills in accurately identifying the underlying causes of defects in building components, which often results in poor decision-making and the wrong choice of maintenance methods [8]. These gaps not only hinder maintenance efficiency but also lead to higher operational costs and faster degradation of facilities. To address these problems, focused training and capacity development programs are essential to improve the technical knowledge and problem-solving skills of maintenance teams.

A thorough examination of existing literature on building maintenance management shows that the topic has been widely studied using various case studies, as well as qualitative and quantitative methods across different sectors such as higher education (universities), healthcare, commercial properties, and office buildings. Nevertheless, research specifically addressing building maintenance management in Malaysian polytechnics is still scarce. Current studies have yet to fully identify the critical factors that influence effective maintenance management and how these factors affect maintenance performance within Malaysian polytechnic settings. Most previous research tends to concentrate on isolated components of maintenance management, leaving a notable gap in the overall body of knowledge.

This study seeks to fill the existing gap by offering a comprehensive understanding of the key factors that contribute to effective building maintenance management within Malaysian polytechnics. Although maintaining buildings is vital for the sustainability and proper functioning of educational facilities, there is still a lack of sufficient knowledge regarding the critical elements of maintenance management that polytechnic administrators can apply effectively. Consequently, a detailed study of these factors is essential to create a well-organized and efficient maintenance management framework that supports both the operational needs and strategic objectives of Malaysian polytechnics.

This study intends to offer an in-depth insight into the essential challenges related to effective building maintenance management and its influence on maintenance performance in Malaysian polytechnics. By conducting a thorough review of the literature, the study aims to pinpoint the main factors that drive efficient maintenance practices and use these findings to formulate a conceptual framework for effective building maintenance management specifically tailored to the polytechnic sector.

Additionally, this study aims to offer important insights to the building maintenance sector, especially within higher education institutions, by helping maintenance stakeholders develop a deeper understanding of effective maintenance practices for educational facilities. The ultimate objective is to create a well-organized and efficient building maintenance management model tailored for Malaysian polytechnics, which will improve maintenance outcomes across all polytechnic campuses and contribute to the long-term sustainability and protection of government-owned properties.

**Factors for Effective Building Maintenance Management**

Maintenance management encompasses the organization, direction, and control of maintenance activities and services to maximize asset value and investment returns [9]. It plays a crucial role in determining the performance and quality of institutional assets and properties. To ensure that educational buildings and facilities remain in optimal condition, the effectiveness of building maintenance management is of paramount importance.

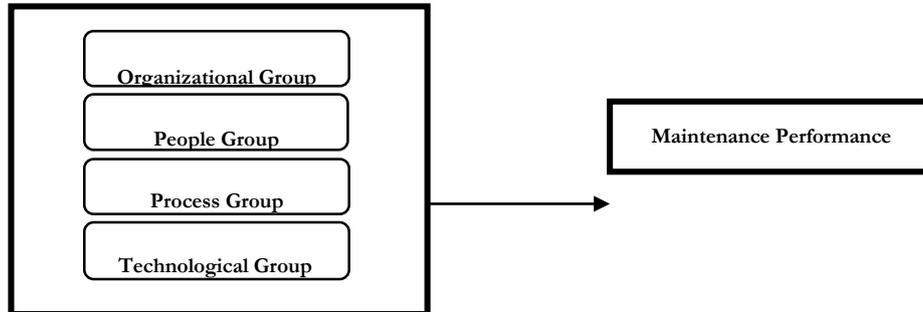
Identifying the key factors that contribute to effective building maintenance management is essential. Effective maintenance management consists of multiple interrelated components, each of which is critical to the overall success of maintenance activities. Furthermore, these factors serve as a foundation for future maintenance evaluations, guiding organizations in assessing maintenance performance and making informed decisions to enhance service delivery.

In an organizational setting, these key factors can be grouped into four main categories: organizational, human (people), technological, and process-related elements. This categorization is supported by Hauashdh et al. [10], whose research highlighted maintenance management issues concerning planning, staff skills, technology, and technical expertise. Based on an extensive review of the literature, this study has pinpointed twenty-three (23) crucial factors that affect building maintenance performance, which are outlined in Table 1.

**Table 1: Factors Affecting Building Maintenance Management That Synthesis from Literature Reviews.**

Factors	Literature															Total			
	[17]	[23]	[9]	[25]	[6]	[18]	[29]	[2]	[19]	[22]	[21]	[16]	[20]	[8]	[27]		[28]	[14]	[15]
Financial		1		1	1	1			1		1		1	1					8
Legislation		1											1						2
Policy		1	1		1	1			1					1			1	1	8
Management Support	1							1		1		1	1				1	1	7
Leadership					1												1		2
Training and Development	1								1				1	1					4
Experience and Knowledge				1		1			1			1	1	1			1		7
Attitude									1										1
Awareness				1					1				1						3
Supervision				1				1					1						3
Culture		1				1													2
Teamwork	1					1						1							3
Maintenance Personnel									1								1		2
Procurement		1		1		1			1				1						5
Maintenance Strategies			1		1	1			1	1			1	1					7
Planning and Scheduling			1		1	1			1	1		1		1					7
Assessment and Inspection		1			1									1					3
Monitoring												1					1		2
Performance Evaluation										1							1		2
Maintenance Record		1						1											2
Digital	1	1			1				1			1	1	1	1	1	1	1	9
Building Information Modelling (BIM)															1	1			2
Artificial Intelligent (AI)							1									1			2

Figure 1 illustrates the initial conceptual model that identifies the key group factors influencing effective building maintenance management within Malaysian polytechnic institutions. This model is developed based on the determinant factors discussed earlier and serves as the theoretical foundation for this study. It has been recognized as a critical framework that contributes to enhancing maintenance performance within polytechnic organizations in Malaysia.



**Fig. 1: Conceptual Model for Effective Building Maintenance Management in Polytechnic Malaysia**

### **Methodology**

A systematic literature review (SLR) was carried out to examine the current body of knowledge and uncover gaps in research related to building maintenance management. This review critically assessed earlier studies, concentrating on maintenance challenges faced by Malaysian higher education institutions and the improvement suggestions offered by previous researchers. The main goal of this review was to identify the essential factors that lead to effective building maintenance management in organizations and to investigate approaches for addressing maintenance problems in building operations.

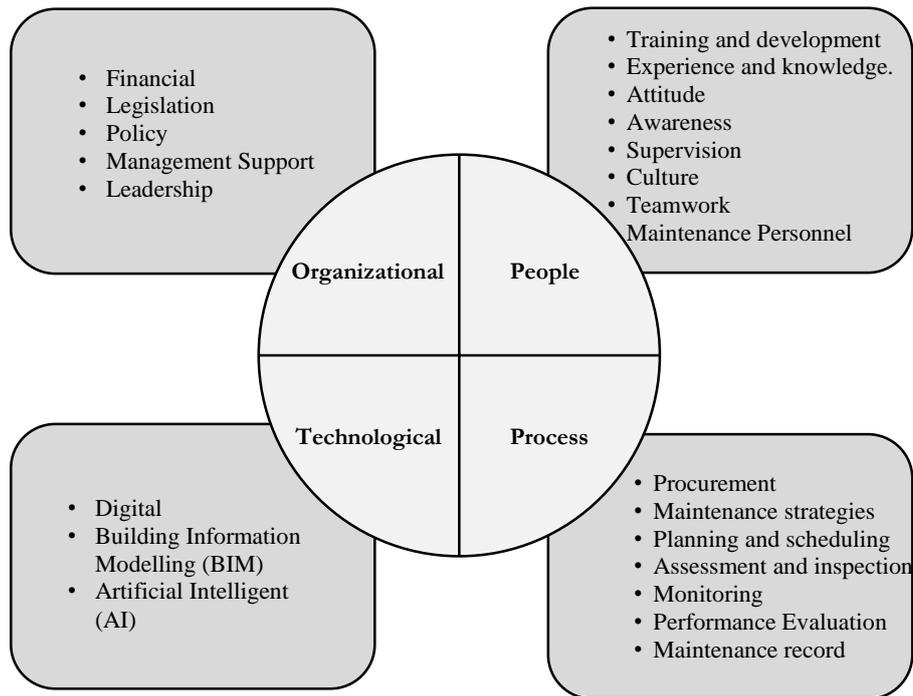
The literature search was conducted using four major research databases: Emerald, ScienceDirect, Scopus, and SpringerLink. To retrieve relevant studies, a combination of keywords was employed, including “maintenance” AND “building or facilities” AND “issues or problems” OR “determinant factors” AND “Malaysia” OR “world” AND “Polytechnic” OR “Higher Educational Institution” OR “university”. This initial search yielded 190 research articles.

To narrow the focus and improve the relevance of the selected studies, filters were applied based on publication date and topic suitability. This process resulted in the selection of 27 articles published between 2015 and 2025 for an in-depth review. The chosen articles comprised review papers, journal publications, and conference proceedings. Figure 2 illustrates the publication trends related to building maintenance management during this period. The approach for the systematic review, content analysis, and the development of the conceptual model in this research was adapted from Zid et al. [11], ensuring a comprehensive and well-structured methodology.

### **Result and Findings**

The main result of this research is the creation of a preliminary conceptual model, shown in Figure 3, which depicts the connections between the key factors influencing effective building maintenance management and their effects on maintenance performance in Malaysian polytechnics. This model was developed through a comprehensive synthesis of the literature review, offering an organized framework to better understand the essential elements that drive maintenance efficiency.

For future research, the proposed model will be empirically tested to examine the relationships between its key determinant factors and maintenance performance. Figure 3 provides a detailed overview of the twenty-three critical factors, grouped into four main categories: organizational, people, technological and process. These factors are further discussed in depth in the following sections of this paper.



**Fig. 3: Themed Categories of Factors Affecting Building Maintenance Management Performance.**

### Organizational Factors

Organizational factors refer to challenges associated with the management of maintenance processes, including their performance, implementation, and overall execution within an institution. The effectiveness of maintenance management strategies, particularly those directed by top management, plays a crucial role in ensuring high-quality maintenance operations and the sustainability of institutional assets. Strong organizational leadership, coupled with structured policies and strategic planning, is essential for achieving optimal maintenance performance and minimizing operational inefficiencies.

### Financial

Financial management is a critical aspect of effective maintenance operations, as it ensures that sufficient resources are allocated for the upkeep and sustainability of institutional infrastructure. Inadequate financial planning and budget constraints often result in delays in maintenance activities, leading to accelerated infrastructure deterioration and increased long-term repair costs.

One of the primary challenges in building maintenance management is the efficient allocation and utilization of financial resources, as insufficient funding can significantly hinder both preventive and corrective maintenance efforts. According to Prescilla (2019) [12], public higher education institutions have faced budget reductions since 2015, compelling them to conduct maintenance activities with limited financial planning and constrained resources.

This financial constraint highlights the urgent need for a strategic financial framework that prioritizes preventive maintenance, resource optimization, and cost-effective asset management. By implementing sustainable financial planning, institutions can ensure the long-term functionality and resilience of their facilities while minimizing operational disruptions and costly repairs.

### Legislation

Legislation plays a crucial role in regulating maintenance activities to ensure compliance with legal and regulatory frameworks that uphold public safety, infrastructure sustainability, and operational efficiency. Maintenance operations within an organization must adhere to established laws and standards to maintain optimal building functionality and occupant well-being [13].

Non-compliance with maintenance-related regulations can result in legal penalties, operational inefficiencies, and increased safety risks. Furthermore, ineffective enforcement of maintenance

legislation may lead to infrastructure deterioration, higher long-term costs, and disruptions to institutional operations. Therefore, adherence to legislative requirements is essential in ensuring systematic maintenance management, mitigating risks, and enhancing the overall longevity of built assets.

### **Policy**

A maintenance policy is a formalized document that outlines an organization's maintenance objectives, vision, and strategic goals, while also incorporating client expectations, resource allocation, and operational capabilities. Additionally, it defines the maintenance strategies that must be implemented to ensure optimal facility upkeep [14]. The primary purpose of a maintenance policy is to establish clear roles and responsibilities for the operation and maintenance team, as well as to facilitate effective financial planning to support sustainable maintenance practices.

The absence of a structured maintenance policy during the design phase can have long-term negative implications on building management and operational efficiency. Previous studies have extensively discussed the critical role of maintenance policies in influencing organizational performance and maintenance effectiveness [4]. A well-defined maintenance policy framework is, therefore, essential for ensuring systematic maintenance planning, resource optimization, and enhanced maintenance performance within an organization.

### **Management Support**

Management support plays a pivotal role in the successful implementation of maintenance strategies by providing clear direction, leadership, and resource allocation. Effective management support involves defining strategic objectives, promoting maintenance initiatives among employees, ensuring the availability of essential resources, and fostering active participation within the organization. Given that maintenance activities require substantial investments in human capital, financial resources, and time, top management must take responsibility for overseeing maintenance operations, establishing policies and standards, and ensuring adequate resource allocation [15].

Strong leadership and commitment from top management are fundamental to achieving high maintenance efficiency and performance. Proactive management involvement not only facilitates structured maintenance planning but also enhances productivity and operational effectiveness, ultimately aligning maintenance activities with the organization's long-term mission and vision.

### **Leadership**

Leadership is the process of influencing and guiding individuals to develop a shared understanding of organizational goals and the necessary actions to achieve them. Effective leadership involves motivating, directing, and coordinating both individual and collective efforts to enhance overall performance and operational efficiency [16].

In the context of maintenance management, strong leadership is essential in establishing a culture of accountability, ensuring adherence to maintenance best practices, and fostering continuous improvement. Leadership is fundamentally rooted in top management's commitment to serving as internal drivers of change, shaping employees' attitudes toward effectively performing and understanding maintenance responsibilities. A proactive leadership approach not only enhances workforce competency but also contributes to sustained maintenance performance and organizational success.

### **People Factors**

The human factor in maintenance management refers to the individuals responsible for executing maintenance tasks, encompassing their physical, physiological, psychological, and psychosocial attributes [16]. Effective maintenance performance is highly dependent on the capabilities and well-being of personnel, making it essential to consider both physical and cognitive aspects when assessing workforce efficiency.

In addition to technical competency, factors such as mental health, cognitive abilities, and social adaptability play a crucial role in determining workplace productivity and collaboration. Any limitations in these areas may negatively impact decision-making, problem-solving, and team interactions, ultimately affecting the overall maintenance performance. Therefore, organizations must adopt a holistic approach to workforce management, ensuring that maintenance personnel receive adequate training, mental health support, and skill development opportunities to enhance operational effectiveness.

## **Training and Development**

Training and development are essential components in enhancing workforce competency, improving skill levels, and fostering a high-performance work culture. Training is defined as a structured and deliberate effort to facilitate employee learning and the acquisition of job-related skills, ultimately leading to enhanced performance and operational efficiency [9].

A lack of adequate training has been shown to negatively impact maintenance workers' performance, as insufficient technical knowledge and skill gaps can hinder the effective execution of maintenance tasks. Consequently, many supervisors struggle to effectively oversee maintenance operations, leading to substandard maintenance quality and inefficiencies in facility management. Research has consistently demonstrated that training programs contribute significantly to improving maintenance performance, equipping workers with the necessary skills to execute tasks more effectively and efficiently [17]. Therefore, implementing comprehensive and continuous training initiatives is crucial for ensuring high-quality maintenance practices and workforce competency.

## **Experience and knowledge**

Knowledge refers to the ability to acquire, process, and interpret information to generate new insights or solve specific problems. In maintenance management, both technical knowledge and hands-on experience are crucial in ensuring the effectiveness of maintenance operations. The performance of a maintenance department is highly dependent on managers and employees possessing the necessary expertise, problem-solving skills, and practical experience to ensure optimal operational efficiency.

Employing experienced maintenance personnel plays a pivotal role in enhancing work quality, minimizing operational costs, and reducing task completion time [7]. Additionally, long-term industry experience, combined with technical proficiency, has been identified as a key determinant of maintenance performance and overall system reliability. Therefore, fostering continuous learning, skill enhancement, and professional development initiatives is essential for ensuring workforce competency and achieving sustainable maintenance excellence.

## **Attitude**

Attitude plays a crucial role in shaping the effectiveness of maintenance personnel and influencing the overall performance of maintenance operations. A positive attitude, characterized by proactiveness, accountability, and commitment to quality, contributes to efficient problem-solving and adherence to maintenance best practices. Employees with a strong sense of responsibility and professionalism are more likely to follow maintenance protocols, ensure timely task completion, and minimize operational disruptions.

Conversely, a negative attitude, such as negligence, lack of motivation, or resistance to change, can lead to substandard maintenance work, increased downtime, and higher operational costs. Studies have shown that employee attitude directly impacts organizational efficiency, particularly in sectors requiring continuous maintenance and asset management [18].

Therefore, fostering a positive work culture through leadership support, employee recognition programs, and continuous professional development is essential for enhancing workforce motivation and improving maintenance performance [19]. Encouraging a sense of ownership and pride in maintenance tasks can lead to higher service quality, prolonged asset lifespan, and overall institutional sustainability.

## **Awareness**

Awareness refers to an individual's understanding and responsiveness to their surroundings, as well as their informed interest in a particular issue or development. In the context of building maintenance management, several studies have highlighted a lack of awareness among both building management and facility users, which has contributed to inefficiencies in maintenance planning and execution. Notably, top management often overlooks the significance of maintenance, adopting a reactive approach rather than a proactive strategy in addressing maintenance concerns [19].

As a consequence, maintenance departments frequently receive low budgetary priority, leading to resource constraints and inadequate maintenance execution. To ensure building functionality, occupant safety, and business continuity, it is essential for maintenance personnel to fully understand the importance of maintenance operations and adopt a strategic, well-planned approach to facility

management. Enhancing awareness among decision-makers and stakeholders is crucial for establishing a sustainable and effective maintenance management system.

### **Supervision**

Supervision serves as the first level of management, where employees are expected to complete their tasks effectively through coordination and oversight. Within the maintenance department, supervision is considered one of the most critical roles, as it ensures adherence to maintenance protocols, quality standards, and operational efficiency.

One of the primary challenges in maintenance management in Malaysia is the lack of effective supervision, which has been identified as a major contributing factor to poor maintenance outcomes [4]. Inadequate supervision often leads to substandard work quality, delays, and inefficiencies in maintenance execution. Therefore, maintenance personnel involved in implementation activities must ensure strict supervision of all maintenance tasks, guaranteeing compliance with top management's requirements and industry best practices. Strengthening supervisory roles and accountability is essential in improving overall maintenance performance and service quality.

### **Culture**

Maintenance culture refers to the collective values, mindset, behaviors, perceptions, and underlying assumptions of individuals, groups, or societies that prioritize maintenance as an essential practice and integrate it into their daily operations [16]. A strong maintenance culture fosters skill development, perseverance, and diligence among maintenance personnel, ensuring that best practices are consistently applied.

Research has identified maintenance culture as a critical determinant in enhancing maintenance quality and prolonging the lifespan of assets and facilities. Organizations that cultivate a proactive maintenance culture are more likely to minimize operational disruptions, reduce long-term costs, and optimize asset performance. Therefore, fostering a culture that emphasizes preventive and systematic maintenance is essential for achieving sustainable and efficient facility management.

### **Teamwork**

Teamwork is defined as the collaborative effort of a group of individuals working towards a shared goal to ensure the efficient delivery of high-quality services. In the context of maintenance management, personnel are often required to interact with individuals from diverse educational backgrounds and varying levels of technical expertise. Effective teamwork is essential for facilitating communication, coordination, and problem-solving in maintenance operations.

A lack of teamwork can lead to miscommunication, conflicts among team members, and inefficiencies in task execution, ultimately resulting in subpar maintenance outcomes that fail to meet expected performance standards [20]. Therefore, fostering a strong team-oriented culture through collaborative training, clear role assignments, and effective leadership is crucial in enhancing maintenance efficiency and overall service quality.

### **Maintenance Personnel**

A competent maintenance manager must determine the appropriate number of maintenance staff to be employed in order to avoid understaffing or overstaffing. A shortage of staff can lead to an increased workload for existing personnel, which may affect the quality of work—even if all staff members are capable of performing maintenance tasks.

In addition, certain maintenance tasks, such as lift systems and fire protection systems, require specialists. However, these specialists are sometimes not available locally and need to be hired from overseas, which can result in delays in carrying out maintenance work [15].

According to Mong [6], building maintenance generally focuses on service systems and facilities. Therefore, maintenance personnel are usually equipped with technical knowledge in fields such as mechanical and electrical engineering. As a result, architectural defects are often overlooked due to a lack of knowledge in civil and structural engineering.

### **Process Factors**

Process factors refer to a structured series of actions or steps that must be implemented to achieve maintenance objectives effectively. A well-defined maintenance process ensures consistency, efficiency, and reliability in executing maintenance tasks. Without clear and standardized procedures,

maintenance personnel may struggle to make informed decisions, leading to inefficiencies and suboptimal maintenance performance.

Establishing comprehensive maintenance processes is essential for enhancing workflow coordination, minimizing operational disruptions, and improving overall facility management outcomes. A structured approach to planning, execution, and monitoring enables maintenance teams to optimize resources, reduce downtime, and extend the lifespan of assets.

### **Procurement**

Procurement plays a crucial role in ensuring overall client satisfaction and the successful execution of maintenance projects. Previous studies have established that effective maintenance performance is highly dependent on the selection and implementation of appropriate procurement strategies.

In Malaysia, government-funded maintenance projects typically adopt an open tender process to select contractors that best meet project requirements. However, contracts are often awarded to the lowest bidder, which may compromise service quality and long-term maintenance effectiveness. According to Ali and Chua, [21] a significant portion of outsourced maintenance work fails to meet expected quality standards, primarily due to inadequate contractor selection and ineffective procurement oversight.

Proper procurement management directly influences the cost, quality, and timely completion of maintenance projects. Therefore, implementing a strategic procurement framework, which prioritizes contractor competency, quality assurance, and long-term sustainability, is essential for enhancing maintenance performance and ensuring optimal asset management.

### **Maintenance Strategies**

A maintenance strategy is a systematic and structured approach designed to ensure the effective upkeep of facilities and equipment, with variations depending on the specific needs of each facility. Maintenance strategies are generally categorized into planned and unplanned maintenance, each serving a distinct role in asset management and operational sustainability [22].

A well-defined maintenance strategy encompasses all aspects of maintenance management, providing a clear direction for maintenance programs and outlining organizational action plans to achieve the desired operational efficiency. The absence of a structured maintenance strategy often results in unbudgeted expenditures, which can negatively impact the total funds allocated for maintenance activities. In many cases, this leads to resource shortages and delays in executing maintenance tasks.

Implementing the right maintenance strategy is crucial for improving maintenance performance, optimizing resource utilization, and ensuring long-term asset sustainability. A proactive and well-planned strategy enables organizations to reduce unexpected failures, enhance cost efficiency, and maintain high-quality facility operations.

### **Planning and Scheduling**

Planning and scheduling are fundamental components of effective maintenance management, ensuring that maintenance activities are executed systematically and efficiently. Before a maintenance task begins, several preliminary steps may be required to facilitate smooth execution and resource optimization. In this regard, maintenance scheduling is equally as important as job planning, as it enables proper allocation of resources, workforce coordination, and timely task execution.

When planning and scheduling are implemented effectively, maintenance costs are reduced, resource utilization is optimized, and overall maintenance quality is enhanced [23]. A well-structured planning and scheduling framework contributes to minimizing downtime, preventing unexpected failures, and extending asset lifespan, ultimately leading to improved operational efficiency in maintenance management.

### **Assessment and Inspection**

Assessment serves as the initial and fundamental step in achieving effective maintenance management, as it provides a comprehensive evaluation of a facility's condition. The outcomes of an assessment help determine the extent and severity of defects, which subsequently inform the development of strategic maintenance plans to address identified issues [24].

Meanwhile, inspection plays a crucial role in detecting minor defects at an early stage, preventing them from escalating into major structural failures or costly repairs. Regular assessment and inspection are essential to ensure that buildings and facilities remain in optimal condition, thereby reducing maintenance costs, prolonging asset lifespan, and improving overall operational efficiency. Establishing a systematic assessment and inspection framework enables organizations to enhance preventive maintenance efforts and ensure sustainable facility management.

### **Monitoring**

Monitoring and inspection play a critical role in maintaining the reliability and functionality of buildings, ensuring that all essential maintenance tasks are carried out effectively [25]. Regular inspection and monitoring activities enable the early detection of potential defects and performance issues, allowing for timely interventions before problems escalate into major failures.

Frequent monitoring and inspection contribute to the reduction of system failures and facility downtime, thereby enhancing operational efficiency and prolonging asset lifespan. Implementing a structured monitoring framework allows organizations to track maintenance performance, optimize resource utilization, and ensure compliance with safety and regulatory standards.

### **Performance Evaluation**

Performance evaluation is a crucial component of maintenance management, as it enables organizations to assess the effectiveness of maintenance activities and ensure that facilities meet user expectations. When buildings fail to meet functional and operational standards, users often report maintenance-related complaints, which serve as valuable feedback for evaluating maintenance performance and service efficiency.

However, challenges arise when incomplete or inaccurate information is provided, requiring the maintenance management team to conduct additional verification, such as identifying the facility type and precise location of the issue. This leads to delays in maintenance planning and execution, ultimately affecting overall performance. To enhance maintenance efficiency, transitioning from traditional reporting methods to a structured performance evaluation system, such as a centralized database system, is essential. The integration of digital monitoring tools and automated reporting mechanisms can significantly improve response times, maintenance accuracy, and overall service quality [26].

### **Maintenance Record**

Maintenance records are a crucial element of effective maintenance management, providing systematic documentation of past maintenance activities, asset conditions, and repair history. Accurate and well-maintained records enable data-driven decision-making, predictive maintenance planning, and efficient resource allocation. Organizations that systematically track maintenance activities can identify recurring issues, optimize maintenance schedules, and enhance overall facility performance [27]. Additionally, proper record-keeping supports regulatory compliance, budget forecasting, and long-term asset sustainability. The absence of structured maintenance records can lead to operational inefficiencies, increased downtime, and higher maintenance costs, as maintenance teams may struggle to diagnose recurring failures without historical data.

### **Technological Factors**

The rapid advancement of technology has significantly influenced building maintenance management, enabling organizations to adapt to evolving operational demands and customer expectations. Technology serves as a key enabler for maintenance personnel, enhancing efficiency, accuracy, and response times in maintenance operations [28]. By integrating technological solutions, maintenance teams can streamline workflows, automate routine tasks, and improve decision-making processes.

### **Digital**

The adoption of digital technologies has transformed maintenance management, enabling organizations to enhance efficiency, accuracy, and decision-making processes. Digital tools, such as Computerized Maintenance Management Systems (CMMS) and Internet of Things (IoT)-enabled sensors, to streamline maintenance planning, tracking, and execution by automating workflows, optimizing schedules, and centralizing maintenance-related data [27]. These technologies facilitate real-time monitoring, allowing maintenance teams to detect issues proactively and implement predictive maintenance strategies.

The integration of digital solutions into maintenance operations can significantly improve efficiency, minimize downtime, and enhance asset lifecycle management. By leveraging data analytics, cloud-based platforms, and automated reporting systems, organizations can streamline maintenance processes, optimize resource allocation, and ensure data-driven decision-making. As a result, digital transformation plays a pivotal role in modern maintenance management, improving organizational productivity, cost-effectiveness, and long-term infrastructure sustainability [28].

### **Building Information Modelling (BIM)**

Building Information Modelling (BIM) is a digital representation of a building's physical and functional characteristics, providing a comprehensive platform for managing building information throughout its lifecycle. BIM integrates 3D modelling, data analytics, and collaborative tools to enhance planning, design, construction, and maintenance processes [29]. In the context of maintenance management, BIM enables real-time access to asset information, allowing maintenance teams to track building components, predict failures, and optimize maintenance activities.

The adoption of BIM in building maintenance improves efficiency, accuracy, and cost-effectiveness by enabling data-driven decision-making and proactive maintenance strategies. By integrating BIM with other digital technologies, such as Computerized Maintenance Management Systems (CMMS) and the Internet of Things (IoT), organizations can enhance predictive maintenance, automate fault detection, and streamline facility management operations. Ultimately, BIM plays a crucial role in modern maintenance strategies, ensuring better resource utilization, extended asset lifespan, and overall infrastructure sustainability.

### **Artificial Intelligence (AI)**

Artificial Intelligence (AI) has emerged as a transformative technology in building maintenance management, enabling automated decision-making, predictive analytics, and process optimization. AI-driven systems leverage machine learning algorithms, real-time data processing, and IoT integration to enhance fault detection, predictive maintenance, and resource allocation [29]. By analyzing historical maintenance data, AI can identify patterns, forecast potential failures, and recommend proactive maintenance actions, reducing unexpected breakdowns and minimizing downtime.

The integration of AI into maintenance operations significantly improves efficiency, cost-effectiveness, and service reliability. AI-powered chatbots and automated reporting systems streamline maintenance requests and response times, while computer vision technologies assist in inspections and defect detection. Furthermore, AI enhances energy efficiency and sustainability by optimizing building performance and resource consumption. As AI technologies continue to evolve, their role in automated diagnostics, intelligent asset management, and predictive maintenance strategies will further revolutionize maintenance management practices [28].

## **Conclusion**

Effective building maintenance management requires careful consideration of various interrelated factors. This study highlights four key determinant groups, namely organizational factors, human factors, technological factors, and process-related factors, which have all been extensively examined in previous research. The integration of these factors is essential in ensuring an effective maintenance management framework, particularly within Malaysian polytechnics.

As a result, the preliminary conceptual model developed in this study provides insights into how these factors contribute to maintenance effectiveness. The findings of this Systematic Literature Review (SLR) serve as a foundation for future research, specifically in identifying the dependent variable (DV) and developing a comprehensive model for effective building maintenance management. This conceptual model will guide empirical studies, enabling further validation and refinement to enhance maintenance strategies and institutional asset sustainability.

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