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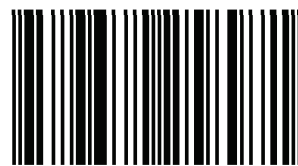
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STUDY ON THE EFFECTIVENESS OF PLAN PREVENTIVE MAINTENANCE IN HVAC BY FACILITIES MANAGEMENT

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ABSTRACT

Effective maintenance can help to minimize the effects of failure and extend the system's life. Preventative maintenance (PM) was developed in the 1950s and is an alternative to corrective maintenance (CM). Facilities management (FM) an essential strategy to operating, maintaining, improving, and adapting an organization's buildings. Maintenance activities can predict the amount of damage to facilities and infrastructure. Poor heating ventilation air conditioning (HVAC) system operation or failure can result in insufficient ventilation, which can contribute to Sick Building Syndrome (SBS). The main objective of this study is to identify the factors requisite for the implementation of plan preventive maintenance (PPM) in HVAC. This research study will be use the abductive (mixed method) in the form of qualitative approach and supported with qualitative approach. The instruments also will use in this study questionnaire and semi-structured interviews for data collection. Thus, the findings have found that the factors that affecting the effectiveness of PPM in HVAC by FM depends on skilled labour, spare part and material, maintenance and failure downtime, maintenance performance and predetermined intervals maintenance.

Keywords: Preventive maintenance, HVAC, Facilities Management

1. INTRODUCTION

In general, maintenance entails sustaining, keeping, maintaining, or preserving a building or structure to an acceptable standard. Preventative maintenance is cost-effective because it can decrease or eliminate necessity, and scope of major repair operations. Effective maintenance can help to minimize the effects of failure and

extend the system's life. Preventative maintenance (PM) was developed in the 1950s and is an alternative to corrective maintenance (CM). Predictive maintenance (PdM), on the other hand, involves condition-monitoring systems. Tasks are scheduled during machine stoppages or shutdowns to replace components before they fail.

Preventive maintenance refers to a compilation of frequent inspections, regular service, and part replacements for all systems. The goal of preventative maintenance is to keep a facility in the maximum possible operating and functioning condition. Preventive maintenance is performed at predetermined intervals or in accordance with specific standards. A building's heating, ventilation, and air conditioning (HVAC) system ensures optimum ventilation and air circulation. In large buildings, such as office buildings, commercial buildings, and shopping malls, a central HVAC system is commonly used. This is owing to the system's advantages. Major components can be divided in a mechanical room according to the central HVAC system. Facilities management is an integrated strategy to operating, maintaining, improving, and adapting an organization's structures and facilities. Managers are involved in maintenance planning, implementation, monitoring, and evaluation. Facilities managers typically have a wide range of responsibilities, ranging from administrative to technical.

Plan Preventive Maintenance enables to significantly reduce reactive maintenance while maintaining the quality of company buildings and assets. Condition monitored maintenance refers to assets that can communicate their current status in real time to a maintenance system (IWMS, CAFM, CMMS). Just-in-time maintenance is enabled by this monitoring, which lowers costs and eliminates asset failure and the reactive maintenance that occurs with it. A maintenance measure will be effective when technicians have the proper skills, expertise, and training to properly implement it. Planning the work that has to be done to keep the building in great condition needs a high level of expertise. Maintenance feedback should be a continuous process for improving the design and maintenance stages. The HVAC system is of limited utility regardless of the preventive maintenance if it is not regularly and adequately maintained (Hassan et al., 2017). Facilities management (FM) an essential strategy to operating, maintaining, improving, and adapting an organization's buildings. As a result, assessing the level of management service delivery is quite important. Previous studies have indicated that Malaysians are concerned about service quality, which has been noted both in the perspective of shifting customer expectations and the problems associated with globalization. The effectiveness of plan preventive maintenance would be questioned if the assessment was completed and the facilities' performance

remained poor. As a result, the purpose of this study is to show the effectiveness of plan preventive maintenance in HVAC by facilities management. This is crucial for the facilities management to make operational recommendations.

Plan preventive maintenance will ensure that all necessary assets are available on time, in the right amount and quality, and at a reasonable cost. Maintenance activities can predict the amount of damage to facilities and infrastructure. In addition, maintenance planning benefits health, safety, and the environment. Poor HVAC system operation or failure can result in insufficient ventilation, which can contribute to Sick Building Syndrome (SBS). Preventive maintenance is a crucial aspect of any asset management strategy, since it leads to longer facility lifespans, less unscheduled downtime, and, eventually, lower long-term maintenance costs. Preventive maintenance entails inspecting an object on a regular basis and servicing or replacing it when a specific condition is discovered. Eye, nose, and throat irritation; skin allergies; mental fatigue; headache; and difficulty concentrating are all symptoms of SBS. (Mentese et al., 2020).

The primary goal of this study is to achieve the research purpose, and the objective of the research is to identify the factors requisite for the implementation, current condition the implementation and appropriate improvements of plan preventive maintenance in HVAC. This study can be used as a guide to the facilities management company for plan preventative maintenance in HVAC. So that the life cycle of HVAC asset will be last longer and the cost repair for the machinery will not expensive. In addition, it is hoped that the findings of this research can be used as a reference to employers and employees.

2. LITERATURE REVIEW

A literature search was conducted to identify the studies that related to plan preventive maintenance in HVAC by Facilities management. The review process involved searching for published studies from google scholar, scienceDirect, and Emerald using the keywords plan preventive maintenance, HVAC and facilities management. The study focused on studies on maintenance, HVAC and facilities management that was published between 2014 and 2022.

The goal of maintenance is to provide the most efficient and cost-effective means of keeping the facility and its services fully operational. Building maintenance in Malaysia

is conditionally driven, and it is often carried out only when funds are available in the budget. Maintenance managers are still implementing ineffective methods in the field of maintenance management, with little regard for the satisfaction of customers and users, as well as the overall performance of the building.

Plan Preventive Maintenance (PPM) is referred to instances in which repair or replacement is performed without the presence of a specific defect. The goal of scheduled maintenance is to create and maintain the most optimal equipment and process conditions possible. It is critical to the survival of any structure, whether historic or not, to perform regular maintenance on it. A preventive maintenance (PM) is a set of plans and recommendations for carrying out additional operations required by a system or a particular system, such as repair and repainting workstations, that are carried out by an organisation's own staff over a period of time.

A central HVAC system may be used to cool or heat one or more areas of a building. It enables significant components to be isolated in a mechanical room for maintenance and repair. The isolation also contributes to the reduction of noise and the enhancement of the aesthetic value. Improper operation and maintenance of the HVAC system can result in energy waste, customer complaints, poor indoor air quality, and even environmental harm. Maintenance should concentrate on these critical components in order to improve system performance and cost effectiveness. (Srinivasan et al., 2017).

Facilities management is an essential strategy to operating, maintaining, improving, and adapting an organization's buildings. With little or no knowledge or skills linked to building maintenance, clients and organisations rely heavily on the facilities manager to maintain their buildings. The importance of facilities managers cannot be overstated.

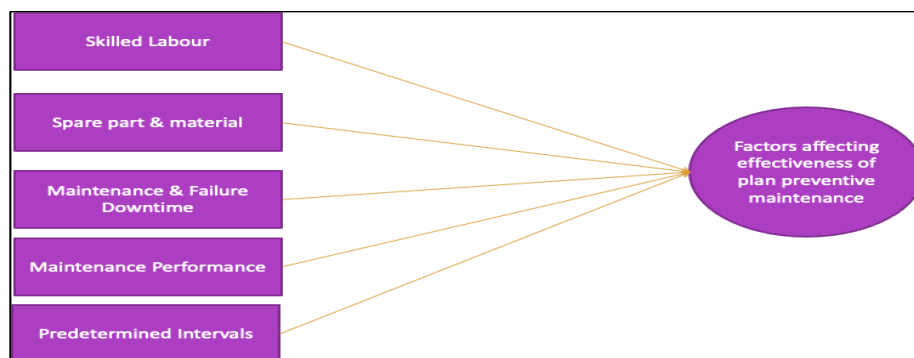


Figure 1 shows Conceptual Framework

2.1 Skilled Labour

The quality of the maintenance team's work has a significant impact on the project's overall success. Maintenance workers who do not perform above the acceptable level of maintenance on HVAC systems might have an adverse effect on the everyday activities of building occupants and visitors. It is generally accepted that an individual's salary is directly proportional to his or her level of skill and knowledge. The basis for prioritisation should be a balance between the finalisation of maintenance jobs and the needs of the client (Chua et al., 2018). It is critical that the resident committee or client agree with and support the maintenance priority that has been determined by the maintenance staff or experts. Maintenance management performance in buildings is influenced by a number of factors, including a lack of skilled labor to maintain works in facilities built and designed by expatriates, and the lack of willingness of some establishments to support innovation. As a result, it is critical that the resident committee or client agree with and support the maintenance priority that has been determined by the maintenance staff or experts.

2.2 Spare Part and Material

The satisfaction of tenants is inversely proportional to the quality of spare parts and materials used in their construction. The use of high-quality spare parts ensures that building systems run efficiently and without interfering with occupants' activities. Poor quality spare parts, on the other hand, will result in more flaws and a rise in the frequency of breakdowns and failures. (Au-Yong et al., 2014a). The availability of spare parts has an impact on the official release of assembly plants.

Spare parts supply is an activity that increases inventory costs, and decision makers seek to keep total cost to a bare minimum. The result is that technicians are idle when they should be working, and the ability of an organization in order to meet customer demands is reduced. Most of the time, the importance is put on management and employee problems rather than equipment-related constraints. Advance demand information (ADI) is info on demand, whether perfect or imperfect, that is made available prior to the occurrence of the actual demand situation. Forecasting spare parts demand is critical for maintaining control over spare parts stocks and avoiding shortages of critical spare parts. This concept was widely adopted in a variety of other

industrial settings, such as demand forecasting in e-commerce, customised products, and the construction industry.

2.3 Maintenance & Failure Downtime

The downtime and cost allocation for maintenance and failure should be taken into account when planning the maintenance method, because scheduled maintenance is unable to eliminate the possibility of failure. Failure of a system can sometimes result in collateral harm to other systems in the surrounding area (Franky & Joseph, 2019). Because the failures happened prior to the specified maintenance time, there would be additional downtime and costs paid as a result. Failure and downtime have an impact on the system's overall quality, including its impact on human health, safety, and the environment. Maintenance downtime must be meticulously managed in order to avoid wasting money on unneeded expenses.

In order to effectively manage maintenance and downtime, maintenance work must be incorporated into an organization's overall maintenance strategy. Lack of maintenance management has resulted in significant financial losses for several organisations as a result of production interruptions and injury to humans, the environment, and physical assets. In order to minimise the problem, we must develop an effective maintenance management system. It is necessary to evaluate the old method that was previously employed in order to improve the maintenance performance.

2.4 Maintenance Performance

Monitoring and evaluating maintenance performance is a process that assists in identifying the advantages and disadvantages of various maintenance procedures and activities. As a result, management is in a better position to plan for and make appropriate decisions regarding future maintenance strategies. The level of success or failure in terms of schedule, cost, and functionality can be used to determine the level of performance achieved or achieved by a project. Main problem with building maintenance management is that it has been applied in an unprofessional manner by the facilities managers. Poor performance of building services and facilities has the potential to cause harm to building users in the areas of health, safety, and comfortability, among other things.

Success of maintenance performance is dependent on the skill and knowledge of maintenance personnel. Organizations can use maintenance performance measurement to understand the value created by maintenance, to re-evaluate and reconsider their maintenance policies and techniques, and to modify resource allocations. It is necessary to measure maintenance performance in order to evaluate the effectiveness and efficiency of the preventive maintenance. Effective maintenance minimises the negative impact of declining equipment performance, while efficient maintenance reduces the amount of money spent on maintenance.

2.5 Predetermined Intervals

The interval between maintenance activities has a significant impact on the outcome of the maintenance. If a maintenance task is not completed on time or is delayed, it may result in further damage to the components of the system. As a result, it is necessary to determine and implement an appropriate maintenance interval. Maintenance schedule works are done at fixed intervals, regardless of whether or not other information is available, in order to ensure the proper functioning of building systems. Preventive maintenance (PM) was first implemented in the 1950s, following the realisation of the importance of preventing failure.

PM systems are based on the principle that they involve predetermined scheduled maintenance that are inferred from machine capabilities and component lifetimes. PM planning is also a component of the managerial point of view, and it necessitates consideration of objectives, planning, and methods prior to the execution of PM on a system. A balance must be struck to avoid the problems associated with under- or over-maintaining of systems. Maintenance intervals must be determined in order to achieve the desired performance level. For maintenance to be beneficial, the equipment must exhibit relatively predictable pattern of failure. Because of the complexity of equipment and specialized equipment, it has become more difficult to identify sequential patterns of breakdown.

3. RESEARCH METHODOLOGY

This study is considered to be the central point, and in other words, the five components of the objective, the conceptual framework, and the research questions

for the research are considered to be the central points. As previously stated, this component has a relationship with both the conceptual framework and study method because the goal of this study will result in the creation of a conceptual framework, while at the same time determining the appropriate method selection for the study information and the answering of the study's questions. The validity of a study is determined by the relationship between the goals, the conceptual framework, the methods, and the study's question.

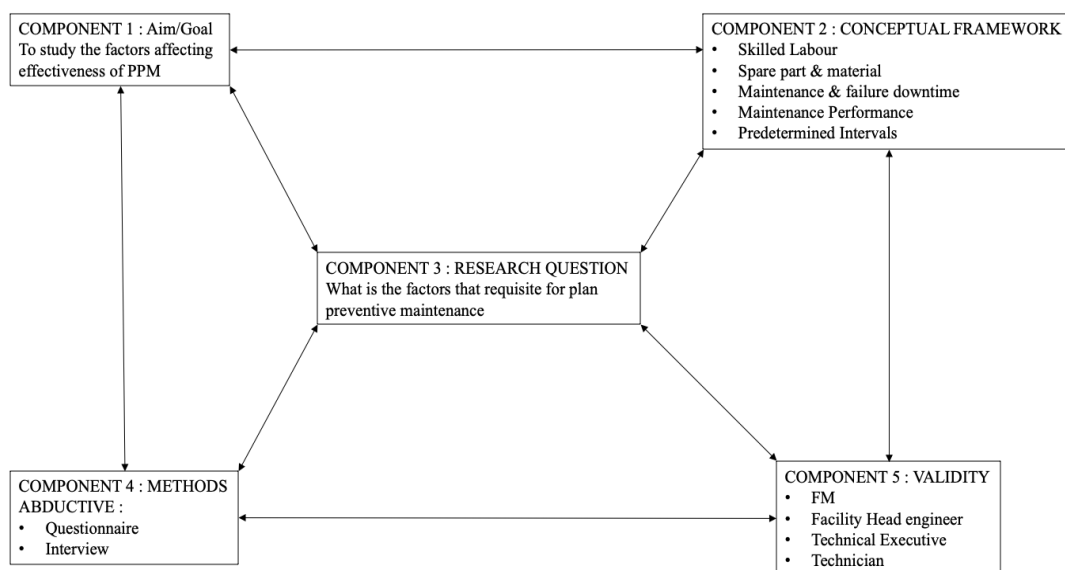


Figure 2 shows Research Design

The research design of the study is a combination of the purpose, objectives and the whole of the subjects being studied in the above chapter. The aim of this study is to study the factors affecting effectiveness of plan preventive maintenance in heating ventilation air conditioning system (HVAC) by facilities management. The conceptual framework has five contracts, which represent the factors that influence the effectiveness of plan preventive maintenance in heating ventilation air conditioning system by facilities management. When it comes to conducting a study, the research question is one of the most important aspects to consider because it is one of the most important factors in developing research objectives, developing conceptual frameworks, selecting appropriate methods for gathering information, and validating the study's findings. According to (Kothari, 2004) The validity of a study is a criterion that indicates how sound the research was conducted. More specifically, validity can be applied to both the research design and the research methods. Validity in data

collection refers to the extent to which the findings accurately represent the phenomenon that is claimed to exist. In this study, the researcher uses the abductive approach to analyse data for aspects that can further improve of the effectiveness of plan preventive maintenance in heating ventilation air conditioning system by facilities management. Depending on the questions, both quantitative and qualitative methods on questionnaires can be classified as follows as a side from that, answers obtained through closed-ended questions with multiple choice answer options are analyse using quantitative methods, which may include pie charts, bar charts, and percentages, among other things. The interviews use in this study were semi-structured types of interviews in which only the main questions were provided and then the follow-up questions based on respondents' responses were questioned, as in the case of this study. This is due to the fact that the researcher believes that the face-to-face method is more appropriate because researchers are more likely to interact with respondents in order to obtain research information

4. CONCLUSIONS

The literature review identified the important aspects that affecting the effectiveness of plan preventive maintenance in HVAC. Plan preventive maintenance is important for the operation of a building mostly in HVAC system because HVAC is one of the systems that make working environment comfortable. In all of building asset, HVAC asset is the most expensive machinery when it related to repair work because sometime the spare parts are from oversea. Furthermore, the implementation of plan preventive maintenance in HVAC is important for a facility manager. Besides, the problem statement that was stated by the past researcher mention that the occupant satisfaction, maintenance planning and comfortable of working environment is related to HVAC system. After that, from the problem statement the research objective was created to fulfil this research and the scope of this research will involve the facilities management company in Malaysia only. Lastly, was explained that the significant of the research as a guidelines and reference to employer and employee.

Specifically, the effectiveness of planned preventive maintenance in HVAC systems by facilities management was the focus of this study. The factors that influence the effectiveness of plan preventive maintenance in HVAC by facilities management are skilled labour factor, spare part and material factor, maintenance and failure downtime factor, maintenance performance and predetermined intervals. In accordance with the findings of the previous research, these elements can be defined as the primary factors that contributed to the efficiency of planned preventive maintenance in HVAC by facility management. Therefore without a proper plan preventive maintenance

aspects the facilities management cannot provide or unable to support the intended function and retain the value of HVAC system machinery or asset. Thus, the findings of this research reflected the concerns of the aspects that will affecting the effectiveness of plan preventive maintenance which can ensure the machinery of HVAC can work in optimum demand and also can ensure the customer or client will satisfying the service that have been delivered by facilities management team. Based on the findings, a future research to study the benefits of plan preventive maintenance to facilities management.

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