

THE IMPLEMENTATION OF WORK BREAKDOWN STRUCTURE IN PREVENTIVE MAINTENANCE OF TOTAL FIRE SYSTEM (PMTFS) TO IMPROVE BUILDING RELIABILITY

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ABSTRACT

This study examines the implementation of a Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) to enhance building safety and reliability. Poor maintenance practices can compromise these aspects, increasing fire risks due to inadequately maintained fire protection systems. Utilizing WBS, the study breaks down maintenance tasks into manageable components, improving clarity and effectiveness in planning, execution, and documentation. The hierarchical WBS framework, validated through expert feedback via the Delphi method, was applied in a case study at the Faculty of Computer Science building at the University of Indonesia. The case study demonstrated significant improvements in operational efficiency and compliance with fire safety regulations. WBS enhances task clarity, allows effective scheduling of maintenance activities, and establishes a reliable documentation system. Key benefits of WBS include optimized resource use, cost savings, improved team collaboration, and extended lifespan of fire safety systems. To implement WBS effectively, the study recommends comprehensive training for maintenance teams, fostering collaboration among stakeholders, and adopting continuous improvement practices. In conclusion, this study illustrates that WBS significantly enhances TFS maintenance effectiveness and can be applied across various building types, promoting structured and efficient maintenance practices to improve safety and reliability.

Keywords: Work Breakdown Structure, Preventive Maintenance, Total Fire System, Building Reliability, Fire Safety Management

INTRODUCTION

A building is considered reliable if it meets four essential aspects: safety, comfort, health, and convenience, in accordance with the minimum technical requirements stipulated in the Indonesian National Standard (SNI) (Wuryanti & Suhedi, 2016). The Indonesian government has implemented policies on the maintenance and reliability of buildings, including fire prevention systems (Law No. 28 of 2002 on Buildings, 2002). One of the regulations pertains to the installation and maintenance of fire systems in building construction to ensure legal compliance and safety measures (Yudhiarma, 2022).

The importance of maintenance management is on par with the planning and execution of construction projects (Mawardi et al., 2018). Proper maintenance ensures the reliability and safety of buildings (Anita Handayaniputri, 2020) and accurately assesses the condition of the infrastructure (Jalil et al., 2016). However, many buildings in Jakarta suffer from inadequate maintenance, leading to reduced performance (Dermawan & Wijaya, 2018). Government buildings often lack a structured approach to maintenance activities and face budget constraints (Sari et al., 2022; Widiyanto & Rahmayanti, 2022).

Building maintenance ensures the reliability and functionality of the structure and its facilities (Minister of Public Works Regulation No. 24 of 2008 on Building Maintenance and Care Guidelines, 2008). The government has laws that hold responsible parties accountable in the event of construction failures due to earthquakes or fires.

Many fires in Jakarta are caused by poor maintenance of building systems and facilities (Paulus Setyo Nugroho et al., 2022). Fire system maintenance is crucial for occupant safety and preventing major fires, as evidenced by numerous high-rise fires resulting from poor maintenance in recent years (Anita Handayaniputri, 2020). Data from the Directorate General of Human

Settlements (2019b) shows that from 2018-2019, there were 16 building fires, including 8 government buildings, indicating suboptimal building maintenance (Anita Handayaniputri, 2020).

The development of a preventive maintenance guideline for fire systems based on the Work Breakdown Structure (WBS) is an approach that can enhance building reliability and safety (Nugroho, et.al, 2021). WBS helps break down complex tasks into smaller, more manageable components, allowing for more systematic and structured maintenance. By using WBS, building owners and managers can more effectively manage and maintain their fire systems, reduce fire risks, and improve overall building safety (Pangastuti, 2021).

This study aims to develop guidelines for the preventive maintenance of the total fire system in buildings based on the Work Breakdown Structure (WBS). Additionally, this study seeks to evaluate the effectiveness of using WBS in improving the maintenance performance of the total fire system in buildings.

METHODS

This study uses a qualitative approach with literature review, case study, and expert validation methods using the Delphi method to gather in-depth data on the application of Work Breakdown Structure (WBS) in Preventive Maintenance of the Total Fire System (PMTFS). Data are collected through a literature review that examines the concepts and practices of WBS application and a case study that analyzes historical documents and empirical data from one of the lecture buildings at the University of Indonesia. Expert validation uses questionnaires based on the results of the literature review and case study, distributed to experts to obtain feedback and consensus. Data analysis is conducted qualitatively, using the Delphi method, and data triangulation to ensure accuracy and validity. Figure 1 will illustrate the methodology used in the research.

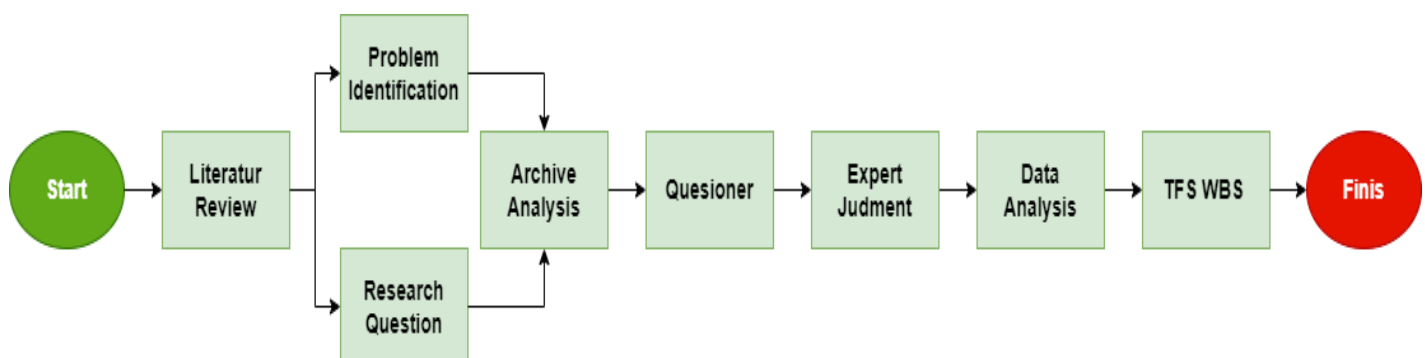


Figure 1. Research Methods

RESULT AND DISCUSSION

Identification of Components and Sub-Components of the Total Fire System

The development of the Work Breakdown Structure (WBS) for the fire system in buildings begins with identifying the main components and sub-components that make up the Total Fire System (TFS). The TFS encompasses various critical elements that work together to detect, prevent, and respond to fires, ensuring the safety of occupants and the integrity of the building.

In the first stage, three types of data are collected: work types, components, and sub-components. Before collecting primary data, secondary data is obtained through a literature review of Government Regulation No. 16 of 2021 and previous studies by Azhara Yuda Pradipta (2019) and Yusuf Djonli (2019). This data identifies the Work Breakdown Structure (WBS) for the Total Fire System in buildings. Further validation is conducted by experts across three WBS levels: level 1 (work types), level 2 (consisting of 9 components), and level 3 (consisting of 76 sub-components). The complete details of the WBS can be seen in Figure 2.

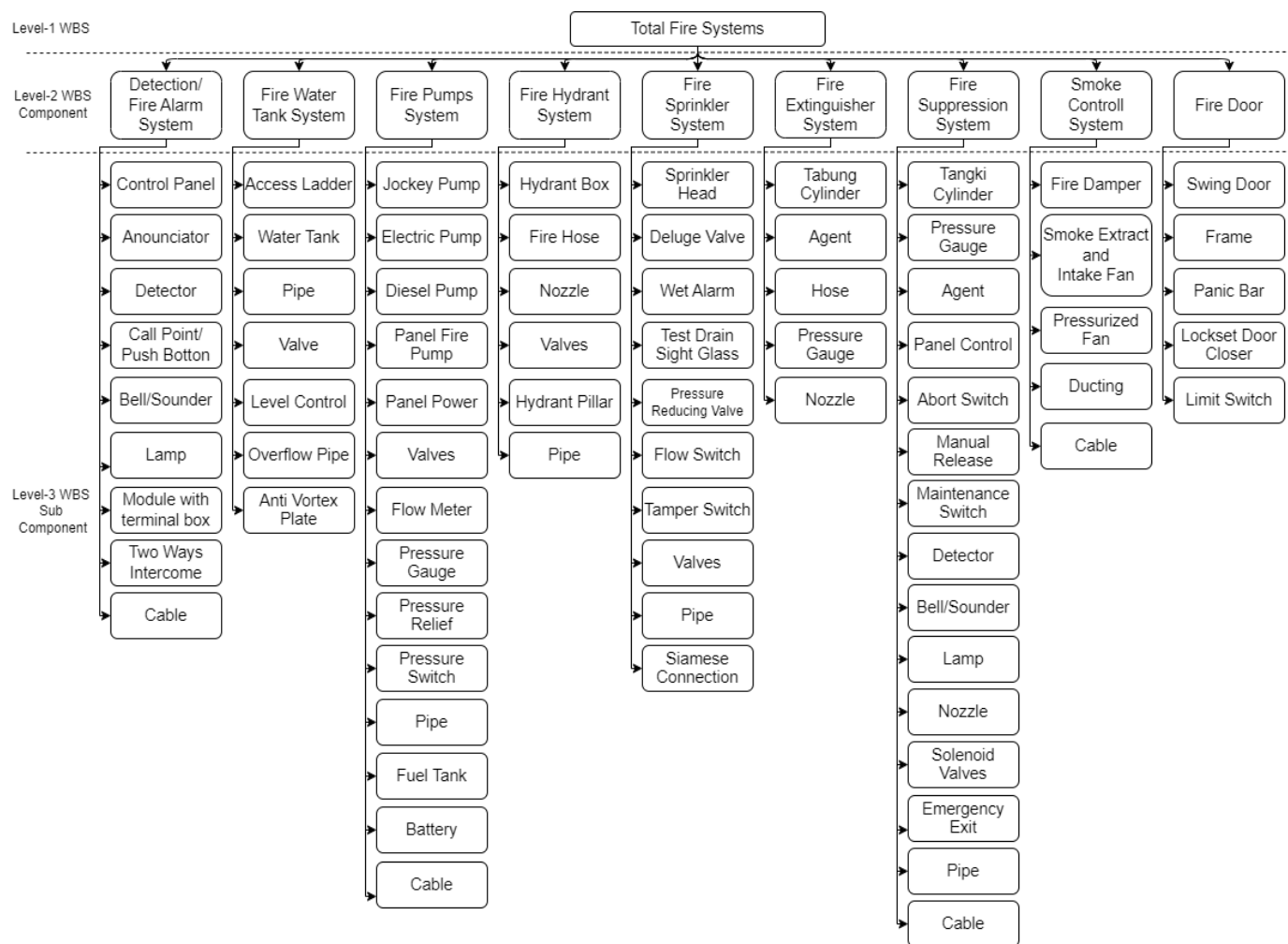


Figure 2. WBS of Total Fire System

By identifying the components and sub-components of the Total Fire System (TFS), the Work Breakdown Structure (WBS) can break down tasks into smaller, manageable units, ensuring that each TFS element can be effectively monitored, maintained, and serviced. An organized WBS structure ensures that all aspects of the fire system are addressed, maintaining the building's reliability and safety.

Implementation of WBS in Preventive Maintenance of the Total Fire System

Implementing the Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) in buildings is a strategic step to manage and maintain fire systems effectively. In the initial stage, data

is collected on the types of work, components, and sub-components of the fire system. Secondary data is obtained from literature reviews such as Government Regulation No. 16 of 2021 and previous studies (Azhara Yuda Pradipta, 2019; Yusuf Djonli, 2019). This information forms the basis for identifying the relevant WBS structure for the TFS, which is then validated by experts.

The WBS for preventive maintenance of the TFS is organized into several levels. Level 1 consists of the main work types; Level 2 consists of 9 main components, while Level 3 includes 76 more detailed sub-components. These details break down complex

tasks into smaller, manageable parts, ensuring all aspects of the TFS are addressed.

Once the WBS structure is established, preventive maintenance is implemented based on the WBS hierarchy. Each component and sub-component of the TFS is inspected and maintained regularly according to the established schedule. These periodic inspections include evaluating the reliability of the integrated components and sub-components within the TFS. The inspection results are systematically documented to ensure the building's functional feasibility and meet the requirements for the renewal of the Certificate of Building Worthiness (SLF).

The application of WBS enables more structured and systematic maintenance management, enhancing the efficiency and effectiveness of the maintenance process. With this approach, building owners and managers can ensure that all fire system components function properly, reduce fire risks, and maintain the building's safety and reliability.

Integrating WBS in the preventive maintenance of the TFS also supports the productivity enhancement of building users by providing optimal facilities. Ultimately, the use of WBS helps achieve preventive maintenance goals by ensuring that each element of the TFS is appropriately addressed and managed.

Data Analysis

The collected data were thoroughly analyzed to identify key findings related to the implementation of Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) in buildings.

First, through literature reviews and case studies, it was identified that the implementation of WBS allows the breakdown of complex tasks into smaller, manageable components. This finding indicates that using WBS enables building owners and managers to plan and execute preventive maintenance of fire systems more effectively.

Second, expert validation using the Delphi method showed that a WBS structure consisting of three levels—work types, components, and sub-components—significantly enhances orderliness and clarity in maintenance management. This finding underscores the importance of the hierarchical WBS structure in ensuring that each element of the Total Fire System receives appropriate attention.

Third, the analysis results indicate that the application of WBS in the preventive maintenance of TFS improves operational efficiency. Data grouping by variables and components ensures that all aspects of the fire system are well-monitored, reducing fire risks and enhancing building safety and reliability.

Fourth, the use of WBS allows for more systematic and organized documentation, which is crucial for meeting the requirements for renewing the Certificate of Building

Worthiness (SLF). With good documentation, the monitoring and evaluation process becomes easier, facilitating continuous improvement.

In conclusion, the findings of this study affirm that the implementation of Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) in buildings significantly contributes to enhancing the effectiveness, efficiency, and reliability of fire system maintenance. The integration of WBS helps address the complexity of maintenance tasks, ensuring occupant safety, and meeting applicable regulatory standards.

RESULT AND DISCUSSIONS

The analysis results of this study show that the implementation of the Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) provides significant benefits in managing and maintaining building fire systems. The implementation of WBS allows the breakdown of complex tasks into smaller, manageable components, thus increasing the effectiveness and efficiency of maintenance.

The hierarchical WBS structure, consisting of three levels—work types, components, and sub-components—provides an organized and clear framework for monitoring and maintaining each TFS element. Expert validation through the Delphi method confirms that this structure enhances orderliness and clarity in maintenance management, ensuring that each TFS element receives appropriate attention.

Additionally, the use of WBS supports more systematic and organized documentation, facilitating the monitoring and evaluation process. This is crucial for meeting the requirements for renewing the Certificate of Building Worthiness (SLF) and ensuring the building's reliability is maintained. These findings also show that the implementation of WBS helps reduce fire risks, increases occupant safety, and complies with applicable regulatory standards.

Overall, the findings of this study highlight the importance of implementing the Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) to achieve optimal maintenance, increase safety, and ensure the building's reliability.

Impact of WBS Implementation on Preventive Maintenance Effectiveness

The implementation of the Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) in buildings has a significant impact on the effectiveness of preventive maintenance. First, a clear and organized WBS structure helps break down complex maintenance tasks into smaller, manageable components. This enables maintenance managers to identify and address issues more quickly and efficiently, reducing the likelihood of fire system failures.

Second, WBS provides a comprehensive framework for maintenance management, ensuring that all aspects of

the fire system are inspected and maintained regularly according to the established schedule. This not only increases the reliability of the fire system but also ensures that preventive maintenance is performed consistently and on time, reducing fire risks.

Third, the implementation of WBS facilitates more systematic and organized documentation, which is crucial for meeting regulatory requirements such as the Certificate of Building Worthiness (SLF). Good documentation allows for effective monitoring and evaluation, enabling building owners and managers to easily track and address any issues that arise, ensuring the building's reliability is maintained.

Furthermore, the use of WBS in the preventive maintenance of TFS also enhances collaboration and communication between the maintenance team, project managers, and stakeholders. With a clear vision of each task and responsibility, the maintenance team can work more efficiently and cohesively, reducing errors and ensuring that every element of the fire system is addressed.

Overall, the implementation of the Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) in buildings increases preventive maintenance effectiveness by breaking down complex tasks, ensuring consistent periodic maintenance, supporting good documentation, and enhancing team collaboration. These positive impacts ensure that the fire system functions optimally, reduces fire risks, and enhances building safety and reliability.

Case Study

This case study focuses on an academic and administrative building within the campus of the University of Indonesia, Depok, West Java. This building covers an area of approximately 1,846 square meters, constructed in 2016, with dimensions of 67.10 meters in length, 29.70 meters in width, and 36.82 meters in height, consisting of 8 floors and 1 roof floor. Since its construction and use for academic and administrative activities, the maintenance and care of the building have not been maximized, particularly for the Total Fire System (TFS) in the Faculty of Computer Science building of the University of Indonesia.

The building management requires a preventive maintenance guideline for the Total Fire System (TFS) to effectively plan and execute maintenance. This is necessary to ensure the building remains fit for use and

that the five-year Building Worthiness Certificate (SLF) does not encounter issues with the Depok City Government, West Java.

The implementation of the Work Breakdown Structure (WBS) in this case study aims to enhance the effectiveness and efficiency of preventive maintenance of the Total Fire System (TFS) at the Faculty of Computer Science building, University of Indonesia, Depok. The first step in implementing WBS is to identify the relevant components and sub-components of the TFS, such as the fire alarm system, fire water tank system, fire pump system, fire hydrant system, fire sprinkler system, fire extinguisher system, fire suppression system, smoke control system, fire door system, and other components.

In the next stage, the hierarchical WBS structure is organized into three levels: level 1 (main work types), level 2 (main components), and level 3 (detailed sub-components). This structure ensures that each TFS element receives proper attention and that maintenance is carried out systematically. Expert validation is performed using the Delphi method to ensure the accuracy and completeness of the developed WBS structure.

The implementation of WBS in the preventive maintenance of TFS at the Faculty of Computer Science includes the following steps:

- Maintenance Schedule Preparation: Based on the WBS structure, a periodic maintenance schedule is prepared to ensure that each TFS component and sub-component is inspected and maintained according to the specified intervals.
- Maintenance Execution: The maintenance team carries out maintenance tasks following the WBS structure. Each task is recorded and documented for monitoring and evaluation.
- Monitoring and Evaluation: Maintenance results are documented and evaluated to ensure that all tasks have been completed properly and according to applicable standards. This process helps identify areas requiring further improvement.
- Reporting and Continuous Improvement: Findings from monitoring and evaluation are reported to the building management for corrective actions. Necessary improvements are made to ensure the reliability and performance of the TFS are maintained.

An example of WBS implementation in preventive maintenance of TFS in the case study is presented in Figure 3 below.

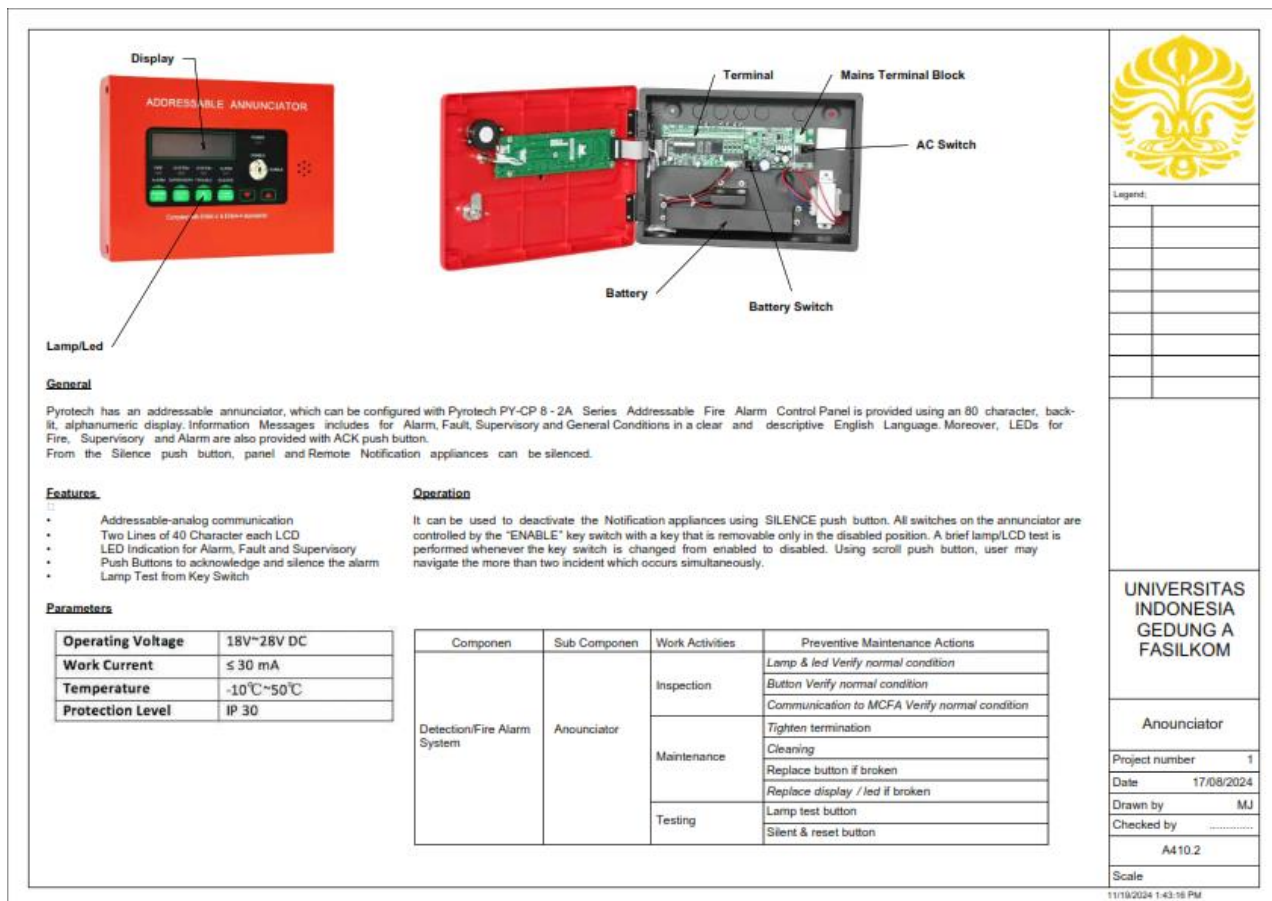


Figure 3. Example of WBS Implementation in Preventive Maintenance of TFS for Detection/Fire Alarm System Components and Sub-Components (e.g., Annunciator)

The implementation of this WBS aids in enhancing orderliness and clarity in maintenance management, ensuring that preventive maintenance of TFS is conducted consistently and on time. Consequently, building managers can ensure that all components and sub-components of the fire system function optimally, reducing fire risks and improving the building's safety and reliability.

With this structured approach, building owners and managers can maintain a high level of operational efficiency and safety, thereby safeguarding the occupants and preserving the integrity of the building.

The evaluation of the implementation of the Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) at the Faculty of Computer Science building, University of Indonesia, shows a significant increase in maintenance efficiency and effectiveness. Breaking tasks into smaller, structured components facilitates maintenance management and ensures that every TFS element is attended to.

One of the key outcomes evaluated is adherence to the maintenance schedule. With WBS, the maintenance team can perform periodic maintenance according to the schedule, which reduces fire risks and ensures the reliability of the fire system. The documentation generated is also more systematic and adequate to support the renewal of the Building Worthiness Certificate (SLF).

Lessons learned from this case study highlight the

importance of expert validation through the Delphi method. This process helps ensure that the WBS structure used meets the specific needs of the building and complies with industry standards. Additionally, integrating WBS into TFS maintenance facilitates better communication between the maintenance team and building management, enabling swift responses to identified issues.

The evaluation also indicates that the use of WBS improves collaboration among maintenance team members, ensuring that each task is efficiently and timely executed. Furthermore, more organized maintenance enhances occupant safety and extends the lifespan of TFS equipment.

In conclusion, the implementation of the Work Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) at the Faculty of Computer Science building has successfully enhanced maintenance effectiveness and efficiency, supported good documentation, and ensured the safety and reliability of the fire system. This case study provides valuable insights into the importance of an organized structure in building maintenance management and the benefits derived from this approach. These findings can serve as a basis for similar implementations in other buildings to achieve optimal results in preventive maintenance.

CONCLUSION

This study confirms that the implementation of the Work

Breakdown Structure (WBS) in the preventive maintenance of the Total Fire System (TFS) in buildings significantly enhances maintenance effectiveness and efficiency. The hierarchical WBS structure facilitates the breakdown of complex tasks into smaller, manageable parts, ensuring each TFS element is inspected and maintained regularly. The WBS implementation also supports more systematic documentation, simplifying the monitoring and evaluation process, and meeting regulatory requirements such as the Certificate of Building Worthiness (SLF). The research findings indicate that the use of WBS in TFS preventive maintenance improves occupant safety, reduces fire risks, and enhances building reliability.

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