Preventive maintenance of mechanical component development guideline on government building based work breakdown structure

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Abstract. Building is a physical form of construction work which is integrated with its domain, partly or fully on the surface and/or underneath the land and/or water, which functions as a place for people to carry out their activities. Buildings must be able to fulfill their functions. However, over the course of time and utilization, they will suffer from damage caused by various aspects, such as the mechanical components of the building. One of the efforts that can be done to reduce the damage is by doing preventive maintenance work. Preventive maintenance work includes tasks or measures taken to prevent the need for repairs. In the buildings preventive maintenance process, the scope of work can be arranged by using Work Breakdown Structure (WBS), hence a structured and activity oriented grouping can be achieved. However, in the application of government buildings there are no guidelines for WBS-based preventive maintenance work yet. Therefore, developing preventive maintenance work guidelines to improve care and maintenance performance is an important task in project management. The research methodology consisted of several stages, namely the literature study, archives analysis with data and information from previous research and related projects, case studies, and Delphi techniques through the validation of experienced experts. The result of this research was that WBS-based preventive maintenance work guidelines for mechanical components of government buildings could improve the quality of buildings and the effectiveness and efficiency of building maintenance.

1. Introduction

Building is a physical form of the result of construction work integrated with the place of domicile, partly or wholly on top and/or in land and/or water, which functions as a place for humans to carry out their activities, both for residential or residential, religious activities, activities businesses, social activities, culture, and special activities, while Green Buildings or also known as green construction and sustainable buildings that lead to structures and processes that are environmentally responsible and save resources throughout the life cycle of the building. Starting from the design, site selection, construction, operation, maintenance, renovation and allotment. This practice expands and complements classic building designs in terms of economy, utility, durability, and comfort. Green buildings are designed to reduce the environmental impact of buildings on human health and the natural environment by using energy, water and other resources efficiently, protecting the health of occupants and increasing employee productivity, as well as reducing waste, pollution and environmental degradation.

According to Law No. 28 2002, a building is a physical form of the result of construction work that is united with its domicile, partly or wholly above and/or in land and/or water, which functions as a
place for humans to carry out their activities, both for residential or residential, religious activities, business activities, social activities [1].

In building maintenance, there are four commonly used strategies, namely corrective, condition-based, prediction, and preventive [2]. Preventive maintenance work can include tasks or actions taken to prevent the need for repairs [3]. Preventive maintenance is a maintenance that is carried out on a scheduled basis, usually periodically [4]. Preventive maintenance involves maintenance activity such as periodic inspections (weekly, monthly, biennial), monitoring, cleaning, lubrication, adjustment, alignment, repair, replacement and maintenance of building components and systems before a system failure or damage occurs [5].

Mechanical components in buildings has an important role as the operational of the building. If a mechanical component building does not function, the building cannot be used properly and has an adverse effect on its users. For example, a room that has air conditioning, when the air conditioner does not function properly, then the user will feel the warm in the room. From this impact, the function of a room in the building cannot function properly. Therefore the impact that occurs on the problem of damage should be prevented before it occurs, so that users can use the room according to its function.

These problems can occur due to lack of maintenance and supervision or control of the building supervisor. From the example of the air conditioner case above, it can be caused by the cooling machine being affected internally or externally from the environment. The internal cause is sourced from these products that are already unfit for function while externally the product is exposed to leaky water, or a shorting occurs on the product cable. These causes have an impact on the function of the product which makes the product unusable, thereby reducing the ability to serve the building.

For this reason, in order to improve the building's maintenance performance, this research is to develop preventive maintenance work guidelines on mechanical components in government buildings based on work breakdown structure.

2. Literature Review

2.1. Work Breakdown structure

WBS is a method of organizing projects into hierarchical reporting structures. WBS is used to detail or solve each work process in more detail and detail. WBS is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables [6]. Activities in projects can be easily defined and will be a guidance to control project activities and its uniqueness [11].

WBS is based on the basis of learning all project documents which include contracts, drawings, and specifications. The project is then broken down into parts by following certain structural and hierarchical patterns into fairly detailed work items, called the Wok Breakdown Structure.

Mechanical components are located at level 2 in a building based on the Work Breakdown Structure (WBS) dictionary. WBS is a method of organizing projects into hierarchical reporting structures. WBS is used to detail or solve each work process in more detail.

![Figure 1. WBS Level 1 – Level 5.](image-url)
2.2. Preventive Maintenance
Based on PerMen PU No 24, 2008 preventive maintenance is an activity of maintaining the reliability of buildings and their infrastructure and facility hence that buildings are always proper to function [1]. Preventive maintenance is a strategy of proactive maintenance that keeps assets in optimal condition and reduces unscheduled repairs [7].

2.3. Mechanical Component in Government Building
Every single part/piece of machine (without circuit, digital or programmable things, etc.) that is visible and that subject to forces to run a machine is called mechanical components. (www.quora.com). In the guidelines for maintenance and maintenance of buildings according to Minister Regulation No. 24 of 2008, there are activities of mechanical components in maintenance and maintenance work of buildings, such as: Maintenance of Dirty Drains, Clean Drains, Sanitair Equipment, Water Heaters, Water Faucets, Sinks, Air Conditioning Systems, Vertical Transportation Systems, Fire Protection Systems, Plumbing Systems and Pumps.

3. Research Methodology
The research methodology strategy was chosen based on the formulation of the problem or research questions that had been previously formulated. The research strategy was used to answer or produce outputs from the formulation and objectives of this study.

This research consists of several methods, namely archive analysis and historical data, surveys, case studies, and through the validation of experts to answer all research objectives, namely (1) To define mechanical component work packages of government buildings that require preventive maintenance work on data collected from literature analysis, previous project archives, and interview experts to validate them; (2) then, to identify preventive maintenance activity and schedule for periodic inspection of mechanical component of government buildings, data collected from literature analysis, analysis of previous project archives, and interview experts to validate; (3) Finally, to develop a WBS-based preventive maintenance guideline for mechanical component of government buildings by requesting final validation to experts regarding the guidelines made. The clearer explanation can be seen in Figure 1 below.

![Figure 2. Research Methodology.](image-url)
4. Result and Discussion
From the research that has been done, the results were obtained.

4.1. Mechanical Component in Government Building based on WBS Standard Preventive Maintenance
The preventive maintenance work of mechanical components in government buildings were based on WBS, namely the primary level (from the name of the project to the work package) [8]. WBS level 4 has been validated by experts with the following results:
1. WBS Level 1 (Project Name): This level was the highest one and represents the entire project. In this study Level 1
2. WBS Level 2 (Work Section): Decomposition of project elements consisting of structural, architectural, mechanical, electrical, landscape and housekeeping elements. For this study the object of focus was the mechanical component.
3. WBS Level 3 (Sub-Work Section): This level was a further decomposition of mechanical component. This level consisted of Vertical transportation system, Plumbing, Fire protection system, and Air system
4. WBS Level 4 (Work Package): This stage was the lowest level of the WBS primary level. This level represented the decomposition of each type of work.

Part of results of the WBS decomposition of standard preventive maintenance work on mechanical components in government buildings at the primary level are presented in Figure 2. The types of work and work packages determined in the requirements of government buildings. Meanwhile, at WBS level 3, there were 4 types of work contained in the validated mechanical of government buildings. At WBS Level 3 there were 4 types of validated works. At WBS level 4 there were 55 work packages validated by experts. Meanwhile, they are illustrated in the tree diagram in Figure 2 below.

In addition to the primary level WBS, there was a complementary level WBS in the preventive maintenance work of mechanical components in government buildings, there is alternative designs or methods, activities and resources. An alternative design was a particular type of design one did for a very specific reason also the construction implementation method which was basically a combination of work procedures and implementation techniques, which were the core of all activities in the construction management system [9]. In this study, there were 29 alternative designs. Table 3 provides
an illustration of a number of preventive maintenance work packages for mechanical components of government buildings with each alternative design or method validated by the expert.

Table 1. Alternative Design in Mechanical Component.

| WBS LEVEL 3       | WBS LEVEL 4          | WBS LEVEL 4          |
|-------------------|----------------------|----------------------|
| DETAIL            | DETAIL               | Alternative Design   |
| Air System        | Unit Ac (split Duct) |                      |
|                   | Unit Ac (Wall Mounted)|                      |
|                   | Unit Ac (Ceiling Cassette) |                  |
|                   | Unit Fan (Centrifugal Fan) |                |
|                   | Unit Fan (Axial Fan)  |                      |
|                   | Chiller (Air Cooled Chiller) |            |
|                   | Compressor (Screw)   |                      |
|                   | AHU/FCU Vertical     |                      |
|                   | Pompa - Pompa (Chilled Water Pump) |   |
|                   | Grill (Exhaust Air Grill) |                  |
|                   | Grill (Intake Air Grill) |                |
|                   | Grill (Louvre Grill) |                      |
|                   | Accessories (Vibration dampers) |  |
|                   | Accessories (Sound Attenuator) |          |
|                   | Accessories (Temperature Control) | |
| Fire Protection   | Pipe Riser (wet riser) | Wet riser system    |
| System            | Dry riser system     |                      |
|                   | Jockey Pump          |                      |
|                   | Electrical Pump      |                      |
|                   | Diesel Pump          |                      |
| Valve- Valve &    | Valve- Valve &       |                      |
| Accessories       | Accessories (gate valve) |                 |
|                   | Valve- Valve &       |                      |
|                   | Accessories (check valve) |            |
|                   | Hydrant Box (Box Indoor) |            |
|                   | Hydrant Box (Box Outdoor) |          |
|                   | Fire Extinguisher (type A) - Clean Agent | 3,5 kg |
|                   | Fire Extinguisher (type B) gas Co2 6,8 kg | |
| Plumbing          | Pipa Riser (wet riser) | Pipa Riser (dry riser) |
|                   | STP (Sewage Treatment Plant) |              |
|                   | STP                   | Rotating Biological Contractor (RBC) |
|                   |                       | Bio Activator        |

After determining the design alternatives in the preventive maintenance work of mechanical components of government buildings, each alternative design had work activities. Work activity is a WBS process using decomposition taken from a work package that identifies activities needed to complete a project [6]. Work activities had the purpose of identifying specific tasks that need to be done to be able to complete the project in accordance with the target. The main input was the basic scope consisting of agreed project scope statements, WBS, and WBS dictionary. The work activities in the
preventive maintenance work of mechanical components of government buildings were inspection & repair, Replacement, Treatment, Clean-up, Lubrication, and Adjustments. With the understanding that the inspection was an activity carried out on all mechanical components which were carried out within a certain period of time in order to state the appropriateness of the building's functions [10]. Maintenance was a step taken for prevention that was carried out routinely or periodically, and Upkeep is a follow-up step of maintenance activities to maintain the condition of the building to be worthy of function. These work activities would then be used in preventive maintenance activity.

4.2. Mechanical Components in Government buildings Procedures for preventive maintenance
Based on work breakdown structure data of mechanical components, preventive maintenance procedure was obtained. For example for Chiller's activity, Chiller activity was at level 4 of the mechanical component WBS, which was a derivative of the air system.

Mechanical component work activities consisted of 6 activities; Inspection & Repair, Replacement, Treatment, Clean-up, Lubrication, and Adjustments [3]. Based on Chiller’s (air cooled) activity, inspection & repair schedule for every 3 months, with activity was “Check, test and repair or replace as necessary: all electric motors, starters, overloaded”, Replacement schedule yearly for “change oil in the gearbox, and monthly for “Change oil filter, coolant filter element” and then treatment, clean-up, and adjustments as table 2 below.

Table 2. Preventive Maintenance Periodic Schedule (Chiller-Air cooled).

| Activity    | Preventive Maintenance Activity                                                                 | Schedule       |
|-------------|-------------------------------------------------------------------------------------------------|----------------|
| Inspection & repair | Check, test and repair or replace as necessary: all Electric motors, starters, overloaded         | Every 3 months |
| Replacement | Change oil in the gear box                                                                      | Yearly         |
| Treatment   | Change oil filter, coolant filter element, oil coolant filter element                             | Monthly        |
|             | Extend the zinc anode if needed, if applicable                                                  | Every 6 months |
|             | Extend the gasket, put it back in, check and do a leak test                                     | Every 3 months |
| Clean-up    | Clean and paint all equipment                                                                   | Every 6 months |
|             | Clean: floating space, holes and filters                                                        | Monthly        |
|             | Remove the end cover from the evaporator and condenser, the Bruch wire and / or chemically clean all scales from the tube. Clean and scrape the cover and door, paint with suitable anti-corrosive paint | Monthly        |
| Lubrication | -                                                                                               | Not Applicable |
| Adjustments | Check whether the device is updated                                                              | Yearly         |

4.3. WBS-Based Preventive Maintenance Guidelines for Mechanical Components in Government Buildings
After identifying WBS, alternative designs, preventive maintenance activity for each work package activity and design, these guidelines were finished. 6 activities from preventive maintenance mechanical component, and periodic inspection schedules were written in this guide, as explained in Figure 3.
Figure 4. Preventive Maintenance Guidance.

5. Conclusion
Work packages and alternative designs in mechanical components building is defined by using WBS that requires preventive maintenance activities. There were 6 work activities preventive maintenance on mechanical components namely inspection and repair, replacement, treatment, clean-up, lubrication, and adjustment. With the Preventive Maintenance Guidance, which consisted of work activities and periodic inspection schedules to maintain, it is expected that the function and feasibility of the government building can be improved, (Especially in Mechanical Component), therefore it is in line with Indonesia regulations of Law No. 28 of 2002.

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