

Development of Preventive Maintenance Guidelines for Architectural Components on Government Building Based on Work Breakdown Structure

Luki Wijaya*, Yusuf Latief, Rossy Armyn Machfudiyanto

Faculty of Engineering, Universitas Indonesia (UI), Depok, Indonesia

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Abstract To reduce the occurrence of damage to government buildings, the efforts for preventive maintenance work must be made. In a building's preventive maintenance work process, the scope of work can be arranged using Work Breakdown Structure (WBS), so that it becomes structured and activity-oriented. However, in the application of government buildings, there are no guidelines for preventive maintenance work that is standardized by WBS. Therefore, developing guidelines for preventive maintenance work is important to improve maintenance and upkeep on a work package. The purpose of this research is to develop the guidelines for preventive maintenance work based on Work Breakdown Structure (WBS) on the architectural components of government buildings. The research methodology comprises several steps, named the literature study, analysis of archives with data and information from previously related research and projects, case studies, as well as through the validation of experts. The results of this study are WBS-based preventive maintenance work guidelines for architectural components of government buildings that can improve the quality of buildings and the effectiveness and efficiency of building maintenance and upkeep.

Keywords Government Building, Guideline, Preventive Maintenance, Work Breakdown Structure

1. Introduction

According to Indonesian Law No. 28/2002 concerning Buildings, a building is a physical form of the result of construction work which is integrated with its footgord, partly or wholly above and/or in land and/or water, which gives the function as a place for humans to carry out their activities, whether it is for residential, religious, business, social, cultural, as well as special activities.

Referring to Regulation of the Ministry of Public Works No. 45/PRT/ M/2007, one of the type is state buildings that is used for official purposes and constitute as a state property. Facilities and infrastructure contained in the building in the form of important components are interrelated with one another in order to achieve the function of the building to provide comfort and safety for its users (Assafat & Prasetyo, 2011).

Basically, the buildings that are used for a long time will suffer damage to various aspects, one of which is the architectural component of the building, this condition will result in a decline in quality and ultimately can cause the building to collapse (Sing, Chan, & Leung, 2015). Referring to Regulation of the Ministry of Public Works No. 24/PRT/M/2008, government buildings are buildings that function as centers of government activity and buildings for official purposes owned by government and managed funds come from the state budget and other legal benefits, aimed at achieving national welfare. Therefore, government buildings are suitable to represent their goals maintenance management. The multitude of damage experienced is caused by the lack of maintenances on government buildings (Suffian, 2011). Lack of attention to the maintenance and upkeep of architectural components can reduce the level of satisfaction of building occupants (Au-Yong, Ali, & Ahmad, 2014). Building maintenance aims to minimize the cost of repairs, minimize the cost of energy use, increase user satisfaction, increase the efficiency of activities, and minimize potential safety problems.

In building maintenance and upkeep, there are four commonly used strategies, named corrective, condition-based, prediction, and preventive strategy (Kim, 2018). Preventive maintenance work can include tasks or actions taken to prevent the need for repairs (Ebell, 1997). Preventive maintenance is an upkeep activity carried out on a scheduled basis, usually done periodically (Assauri, 2008). Preventive maintenance involves upkeep

work such as periodic inspections (weekly, monthly, biennially), monitoring, cleaning, maintenance, lubrication, adjustment, alignment, repair and replacement of building components and systems before a system failure or damage occurs (Moghaddam & Usher, 2010). Furthermore, preventive maintenance is based on characteristics of component reliability and aims to reduce the possibility of failure of a component in buildings (Fouladgar, Yazdani-Chamzini, & Lashgari, 2012). To prevent the failures, preventive maintenance can indicate the right time to carry out maintenance or upkeep work that needs to be done (Yang, 2004).

In the process of preventive maintenance work of a building, the scope of work can be arranged using the Work Breakdown Structure (WBS). WBS is a process of breaking down from project work into smaller and more manageable components (PMBOK, 2017). WBS is a structured grouping and oriented on the activities and work contained in the project that defines the overall scope of the project (Hans, 2013). WBS is a tool for project management because it provides a basis for planning, scheduling, controlling, assignment of responsibilities and information management thus WBS can be used in any way including care and maintenance (Ibrahim, 2009) (Park & Cai, 2017). Accordingly, WBS plays an important role in sharing information about buildings and can help in developing preventive maintenance guidelines. Therefore, it is necessary to develop the guidelines for WBS-based preventive maintenance work for architectural work in government buildings.

2. Research Objective

The objectives of this research are:

1. To identify the architectural component work packages in government buildings that are required for preventive maintenance work.
2. To identify the current procedures and guidelines used in the preventive maintenance work of architectural components in government buildings.
3. To create the preventive maintenance work guidelines on architectural components in government buildings based on WBS.

3. Literature Review

Work Breakdown Structure (WBS)

Work breakdown structure (WBS) forms the basis of most projects. WBS is an activity that describes the components of the entire scope of works in a project. WBS

is a hierarchical decomposition of work oriented to the total deliverables to be carried out by the project team in order to achieve the project objectives and produce the required deliverables (PMBOK, 2017). WBS is a breakdown of deliverables and project work into smaller components that can be better managed the project work (Farizi & Latief, 2018). WBS is a dynamic document used to manage the scope of work as a whole. WBS has several levels consisting of two main levels, named the primary level (from the name of the project to the work package) and the complementary level (activities and resources) (Rianty, Latief, & Riantini, 2018). Specifically, in the case of building maintenance and upkeep, WBS structures were introduced by the development of guidelines for building maintenance based on WBS increase building performance (Aryaningrum, Latief, & Riantini, 2018). The structure of WBS is further defined in **Table 1** below.

Preventive Maintenance

Obviously, the objective of building management is to maintain the value of the building and is responsible for maintenance functions of building as it is designed purpose (A. Crespo Marquez, Gomez Fernandez, Parra Marquez, & Gonzalez, 2009) (Lam, 2010). The building maintenance is an effort to avoid the damage of building components due to obsolescence of buildings before the age is over (Latief, Armyn Machfudiyanto, Susilo Soepandji, Khairina, & Aldesty, 2018). The maintenance works of implementation is categorized into four activities: planning, implementation, maintenance, and maintenance supervision (Armyn Machfudiyanto, Latief, Susilo Soepandji, & Anggia Putri, 2018). Referring to Regulation of the Ministry of Public Works No. 24/PRT/M/2008, the preventive maintenance is an activity of maintaining the reliability of buildings and their infrastructure and facilities so that buildings are always worth for the function. Preventive maintenance is maintenance/upkeep activity that is carried out on a scheduled basis, generally on a periodic basis, in which a set of maintenance tasks such as inspection and repair, replacement, cleaning, lubrication, adjustment, and equalization (Ebellling, 1997) (Assauri, 2008) (Moghaddam & Usher, 2010). Preventive maintenance is usually performed periodically on the critical components/elements to keep the components/elements performance function as it is designed (Basri, 2017). Preventive maintenance is an effective approach to improve the reliability and quality of a system and its components in a building. To prevent failure, preventive maintenance can indicate the right time to carry out maintenance/upkeep work that needs to be done (Yang, 2004).

Table 1. Structure WBS of Buildings

WBS Level 1:	WBS Level 2:	WBS Level 3:	WBS Level 4:	WBS Level 5:	WBS Level 6:	WBS Level 7:
Project Name	Primary Elements of Construction / Works Cluster	Locations	Sub Elements / Job Type	Work Package	Activities	Resources

Guideline for Preventive Maintenance Work in Buildings

According to Regulation of the Ministry of Public Works No. 29/PRT/M/2006, the guideline is intended as a reference in meeting the technical requirements of buildings. Guidelines for maintenance and upkeep of buildings that are used as a reference in the framework of activities regulating and controlling the organization of buildings are needed for the process of building utilization. Referring to Regulation of the Ministry of Public Works No. 24/PRT/M/2008, this guideline aims to realize the use of buildings that meet the safety, health, comfort and convenience requirements as well as efficiency, harmony and in tune with the environment.

4. Research Methodology

The research methodology comprises several steps, named the study of literature, analysis of archives with data and information from previously research related and projects, case studies, and through the validation of experts to answer all research objectives, as follows: (1) identifying the architectural component work packages of government buildings that require preventive maintenance work on data collected from literature analysis, analysis of previous project archives, and asking experts to validate

them; (2) furthermore, identifying preventive maintenance measures and schedules for periodic inspection of architectural components of government buildings, data collected from literature analysis, analysis of previous project archives, and ask experts to validate; (3) next, creating a WBS-based preventive maintenance guideline for architectural components of government buildings by requesting final validation by experts regarding the guidelines made. The explanations related to the flow of this research more clearly can be seen in **Figure 1** below.

In this research, a case study is conducted on one of the government buildings in Indonesia and refers to Regulation of the Ministry of Public Works No. 24/PRT/M/2008, concerning the guidelines for building maintenance and upkeep and referring to Regulation of the Ministry of Public Works No. 16/PRT/M/2010, about the technical guidelines for periodic inspection of buildings. Regarding the schedule of periodic inspections on preventive maintenance work on the building's component of government buildings based on preventive maintenance in the work activities of each work package or alternative design, this periodic inspection schedule is validated by experts who are then developed to serve as guidelines for preventive maintenance work on architectural components in government buildings.

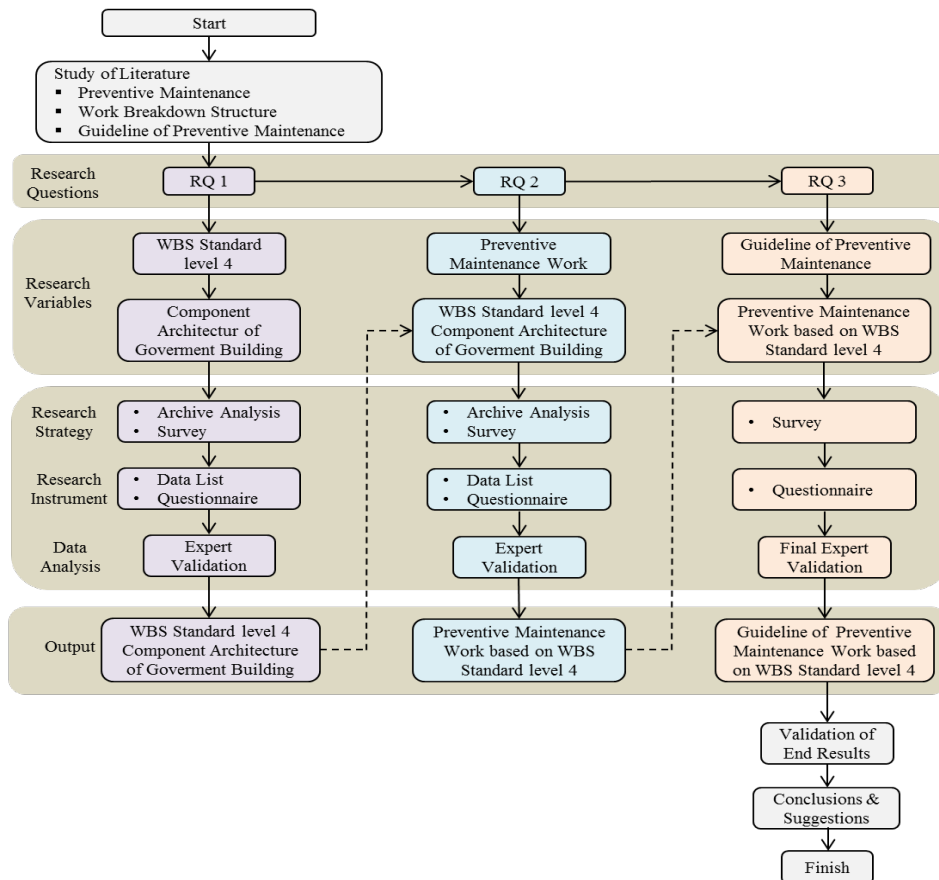


Figure 1. The Research Flow Diagram

5. Result and Discussion

Based on conducted research, the following results are obtained.

1. WBS standard of preventive maintenance work of architectural components in government buildings

In the preventive maintenance work of architectural components in government buildings that are based on WBS, named the primary level (from the name of the project to the work package) (Rianty et al., 2018). WBS level 4 has been validated by experts with the following results:

- a. WBS Level 1 (Project Name): This level is the highest and represents the entire project. In this study, level 1 is preventive maintenance of government buildings.
- b. WBS Level 2 (Work Section): This level is the decomposition of project elements consisting of structural, architectural, mechanical, electrical, landscape, and housekeeping elements. In this study, the object of research is the architectural element.

- c. WBS Level 3 (Sub-Work Section): This level is a further decomposition of architectural elements. This level consists of parking and pedestrian facilities, smoking facilities, exit facilities, floor work, wall work, ceiling work, door and window work, hardware work, sanitation work, facade work, roofing work and other works.

- d. WBS Level 4 (Work Package): This level is the lowest level of the WBS primary level. This level represents the decomposition of each type of work.

Some of the results from the WBS decomposition of standard preventive maintenance work at the primary level are presented in **Figure 2**. The types of work and work packages determine the findings in the requirements of government buildings. Meanwhile, at WBS level 3, there are 12 types of work contained in the validated architecture of government buildings. At WBS Level 3, there are 12 types of validated works. At WBS level 4, there are 41 work packages validated by experts. Meanwhile, some of them are illustrated in the tree diagram in **Figure 2** below.

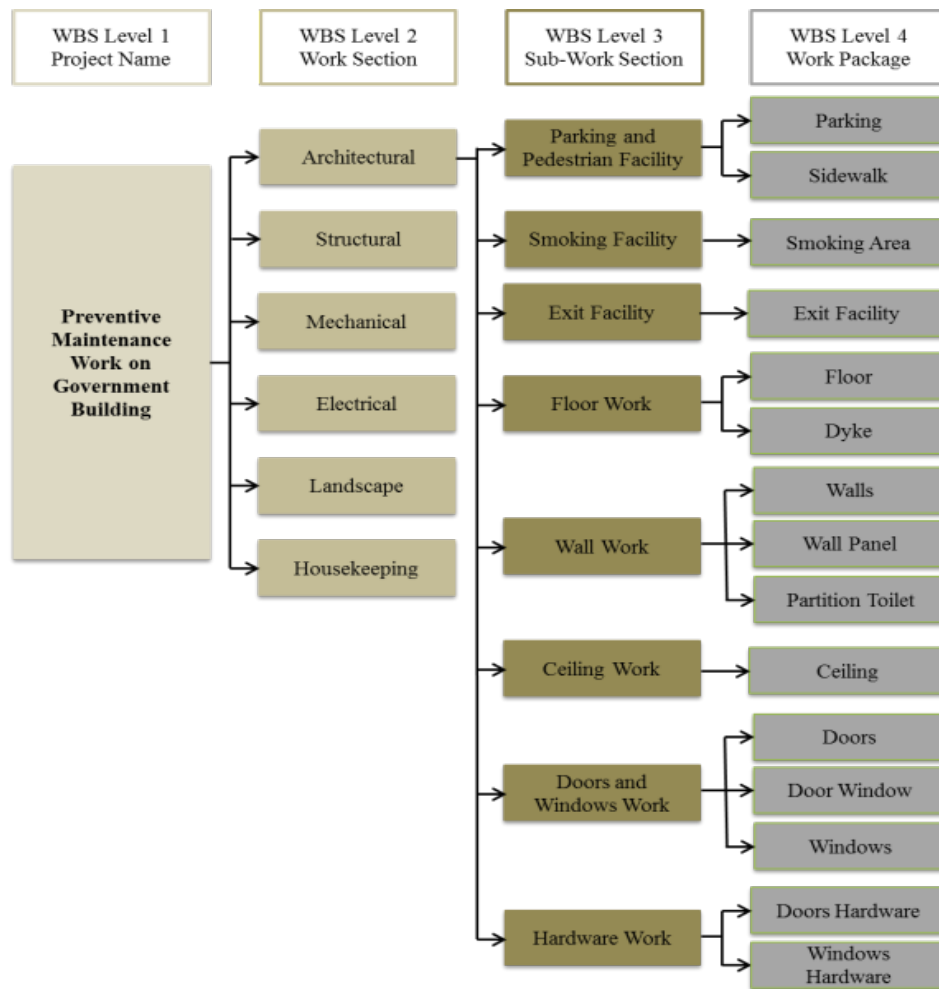


Figure 2. WBS Standard Component Architecture of Government Building

In addition to the primary level WBS, there is a complementary level WBS in the preventive maintenance work of architectural components in government buildings, named alternative designs or methods, activities and resources. Alternative design or method is the construction implementation method which is basically a combination of work procedures and implementation techniques, which

are the core of all activities in the construction management system (Jawat, 2015). In this study, there are 75 alternative designs. **Table 2** provides an illustration of a number of preventive maintenance work packages for architectural components of government buildings with each alternative design or method validated by the expert.

Table 2. Alternative Design Preventive Maintenance Work Component Architectural Government Building

WBS Level 3		WBS Level 4		Alternative Design			
KODE	DETAIL	KODE	DETAIL	KODE	DETAIL		
X3.1	Parking and pedestrian Facility	X4.1	Parking	X4.1.1	Bicycle Parking		
				X4.1.2	Motorized Parking		
X3.4	Floor Work	X4.5	Floor	X4.5.1	Floor Hardener		
				X4.5.2	Corridor Area Ceramic Floor		
				X4.5.3	Dry Area Ceramic Floor		
				X4.5.4	Wet Area Ceramic Floor		
				X4.5.5	Fire Stair Ceramic Floor		
				X4.5.6	Waterproof Concrete Coating Floor		
				X4.5.7	Waterproof Concrete Membrane Flooring		
				X4.5.8	Screed Floor		
				X4.5.9	Wooden Deck Floor		
				X4.6	Dyke	X4.6.1	Brick Dyke
X4.6.2	Concrete Dyke						
X3.5	Wall Work	X4.7	Wall	X4.7.1	Wet Area Ceramic Walls		
				X4.7.2	Parapet Brick Wall		
				X4.7.3	Fire Rated Wall		
				X4.7.4	Tempered glass Wall		
				X4.7.5	Mozaik		
				X4.7.6	Marble Layer Walls		
				X4.7.7	Cladding Aluminium Composite Cover Wall		
				X4.7.8	Gypsum Partition Walls		
				X4.7.9	Drywall		
				X4.7.10	Fiber Cement Board		
X4.8	Wall Panel	X4.8.1	Plywood Finish Hpl				
		X4.10.1	Acoustic Ceiling				
X3.6	Ceiling Work	X4.10	Ceiling	X4.10.2	Gypsum Ceiling		
				X4.10.3	Water Resistant Gypsum Ceiling		
				X4.11.1	Wood Door		
X3.7	Doors and Windows Work	X4.11	Doors	X4.11.2	Toilet Door		
				X4.11.3	Aluminum Glass Door		
				X4.11.4	Iron Door with Panel Iron Frame		
				X4.11.5	Fire Ladder Door		
				X4.11.6	Frameless Glass Door		
				X4.11.7	Iron Plate Shaft Door		
				X4.11.8	Plywood Panel Door with Aluminum Frame		
				X4.11.9	Sliding door, Rolling Door, Folding door		
				X4.12	Door Window	X4.12.1	Aluminum Glass Door Window Frame
						X4.12.2	Entrance Glass Door Window
X4.13	Window	X4.13.1	Aluminum Glass Window Frame				
		X4.13.2	Bovenlicht Aluminum Glass Window Frame				
X3.8	Hardware Work	X4.14	Door Hardware	X4.14.1	Single Swing Door		
				X4.14.2	Double Swing Door		
				X4.14.3	Urinoir		
				X4.14.4	Automatic Door		
				X4.14.5	Fire Ladder Door		
				X4.14.6	Keys, Latches, and Hinges		
				X4.14.7	Door Closer		
				X4.14.8	Accessories Door Stopper		
X3.9	Sanitary Work	X4.15	Toilet	X4.15.1	Toilet Seat		
				X4.15.2	Toilet Squat		
		X4.21	Tap	X4.21.1	Wall Tap		

X3.10	Facade Work	X4.27	Wall	X4.21.2	Table Tap
				X4.27.1	Sticky Brick Wall
				X4.27.2	Curtain Wall
				X4.27.3	Sunscreen grille
				X4.27.4	Alumunium Extruded
X3.11	Roof Work	X4.28	Roof Insulation	X4.28.1	Alumunium Foil Insulation
				X4.29.1	Waterprof Concrete Membrane Roof
		X4.29	Roof Coating	X4.29.2	Waterprof Concrete Coating Roof
				X4.29.3	Waterprof Concrete Integral Roof
				X4.29..4	Fiberglass Roof
				X4.29.5	Polycarbonate Roof
				X4.29..6	Glass Roof
				X4.30	Railing
		X4.32	Wheel Stopper	X4.32.1	Wheel Stopper Concrete
		X4.34	Convex mirror	X4.34.1	Convex Mirror Pole
X4.35	Signpost	X4.35.1	Pole Signs		
X4.37	Gutter	X4.37.1	Open Gutter with Grill		
X3.12	Other Work	X4.38	Cover Column	X4.118	Panel Plywood Finish HPL
				X4.119	Panel ACP
		X4.40	Canopy	X4.40.1	ACP Canopy
				X4.41.2	Glass Canopy
				X4.41.3	Tempered Glass Canopy
		X4.41	Grill	X4.41.1	Grill Alumunium
				X4.41.2	Grill Steel

Table 3. Model of WBS Preventive Maintenance Work on Government Building

WBS Level 1 Project Name	WBS Level 2 Work Section	WBS Level 3 Sub-Work Section	WBS Level 4 Work Package	Alternative Design/Method
Preventive Maintenance Work on Government Building	Architectural	Ceiling Work	Ceiling	Acoustic Ceiling
				Gypsum Ceiling
				Water Resistant Gypsum Ceiling

After determining the design alternatives in the preventive maintenance work on architectural components of government buildings, each alternative design has their own work activities. Work activity is a WBS process using decomposition taken from a work package that identifies activities needed to complete a project (PMBOK, 2017). Work activities have the purpose of identifying specific tasks that need to be done for completing the project in accordance with the target. The main input is the basic scope consisting of agreed project scope statements, WBS, and WBS dictionary. The work activities in the preventive maintenance work on architectural components of government buildings are inspection, maintenance, and upkeep. According to Regulation of the Ministry of Public Works No. 16/PRT/M/2010, the inspection is an activity taken on all architectural components which are carried out within a certain period of time in order to state the appropriateness of the building's functions. Maintenance is a step taken for prevention that is carried out periodically. Upkeep is a follow-up step of maintenance activities to maintain the condition of the building to be function-worthy. These work activities will be used in the preventive maintenance work actions. The **Table 3** is a WBS model of preventive maintenance work on architectural components in government buildings.

2. Procedures for preventive maintenance work on Architectural Components of Government buildings

Based on the standard WBS, the preventive maintenance measures are reviewed from each work activity on a work package or an alternative design from the architecture component of a government building. In the parking and pedestrian facilities work, the preventive measures are checking the surface of the road around the facility every month, carrying out cleaning of dirt, grass, dead bushes every 3 months, and painting the facilities annually. In floor work, the preventive maintenance measures taken are checking the condition of the floor every month, cleaning and vacuuming the floor every day. In wall work, the preventive maintenance measures are carried out by inspecting the walls for cracks and deformations every 3 months and cleaning the walls from dirt every week. In ceiling work, the preventive maintenance measures are carried out by checking the ceiling protectors, cleaning the dust and dirt every month, and repainting the ceiling every 6 months. In door and window work, the preventive maintenance measures taken are checking the operation and locking for 3 months, lubricating the hinges, opening the door and keyhole every 3 months. In roof work, the preventive maintenance measures taken are checking the roof for cracks and damage every 3 months, cleaning the

surface of the roof from dirt that is stuck every 3 months, and giving a leak-proof coating every 6 months. In railing work, the preventive maintenance measures are carried out by cleaning and wiping the railing against the dirt and stains every week, and replacing damaged layers with new ones each year. In canopy work, the preventive maintenance measures are carried out by tightening the bolts in the canopy every 6 months, painting the canopy annually, and replacing or repairing sealants that are contained in the canopy every year. The following of **Table 4** is the illustration of the preventive maintenance procedure.

Table 4. The Preventive Maintenance Procedure

Standard Procedure Preventive Maintenance – Gypsum Ceiling	
Activities	Periodic Inspection Schedule
Inspection	
• Make sure the ceiling remains dry	• Every 3 month
• Check the ceiling protection devices	• Every 3 month
• Check for damage and cracks in the ceiling	• Every 3 month
Maintenance	
• Clean the dust regularly or clean it with a damp cloth	• Every month
• Make sure the surface is always dry	• Every month
• Seal cracks and joints	• Every month
Upkeep	
• Do a ceiling repaint	• Every 6 month
• Apply preservatives, or other suitable protective sealants	• Every 6 month

3. WBS-Based Preventive Maintenance Guidelines for Architectural Components in Government Buildings

After defining the WBS, the alternative designs, the preventive maintenance measures for each work package activity and design, these alternative guidelines are built. The important work, the preventive maintenance, and the periodic inspection schedules are stated in this guide, as described in **Figure 3**.

6. Conclusions

In answering the objectives of this study, the following conclusions can be drawn:

- WBS level 4 Work Package: At WBS level 4, there are 41 work packages and 75 alternative designs that are used in preventive maintenance work on architectural components of government buildings.
- There are several preventive maintenance measures for each work activity in the form of inspection and maintenance on the work package, along with a regular inspection schedule for each action.
- The result of this study is an implementation guidance document containing the identification of WBS from level 1 to level 4 including the alternative designs, work activities, preventive maintenance measures and periodic inspection schedules.

PREVENTIVE MAINTENANCE WORK GUIDELINES FOR GOVERNMENT BUILDING		
CODE WBS	DESCRIPTION	
WBS Level 2	WORK SECTION	Architecture
WBS Level 3	SUB-WORK SECTION	Ceiling Work
WBS Level 4	WORK PACKAGE	Ceiling
	ALTERNATIVE DESIGN	Ceilin Gypsum
Activities	Preventive Maintenance Procedures	Periodic Inspection Schedule
Inspection	• Make sure the ceiling remains dry	• Every 3 month
	• Check the ceiling protection devices	• Every 3 month
	• Check for damage and cracks in the ceiling	• Every 3 month
Maintenance	• Clean the dust regularly or clean it with a damp cloth.	• Every month
	• Make sure the surface is always dry	• Every month
	• Seal cracks and joints	• Every month
Upkeep	• Do a ceiling repaint	• Every 6 month
	• Apply preservatives, or other suitable protective sealants	• Every 6 month

Figure 3. The Guideline for Preventive Maintenance Work

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