Information system development for maintenance work of green buildings in Indonesia

A Zahrin*, Y Latief and R A Machfudiyanto
Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Depok, Indonesia

*amalia.zachrin16@gmail.com

Abstract. Building maintenance is an activity of maintaining the reliability of buildings, infrastructure and facilities to have the proper functions and are not damaged quickly. The main goal is to manage a building and its grounds, as well as customize needs for the facility and achieve the reliability requirements of building (comfort, safety, health and convenience). The problem is that the current condition of building maintenance is generally still conventional. As a result, the building maintenance process tends to be slow, often neglected, and can often result in insignificant additional costs. For example, the condition of a tempered glass was dirty and dusty conditions, then this will disrupt the lighting in the room, so that electricity will increase while the functional value of green buildings decreases. This certainly contradicts to the principle of green building that carries Energy Efficiency & Conservation / EEC, which is caused by non-maximization of one green building’s components especially in architecture components. The purpose of this research is to improve the performance of maintenance work to green buildings in state’s buildings for architecture components. The research methods used are literature study, data analysis and case studies of information systems development. Minister of Public work regulation 24/2008 are used as a Guidelines for Building Maintenance which are then integrated into the Information System-WEB. By developing an information system for maintenance, the performance of Architecture Components in green building will be achieved 4 points from building requirements and reduce the possibilities damage in future especially for plafond and tempered glass damage. The results of this studies is a web-shaped information system that is useful for state agencies and others in carrying out the work of maintaining a green buildings, especially in the architecture component.

1. Introduction
The Building has a very important role as a place where humans carry out their daily activities [1]. A decent maintenance system is a vital component of all buildings [2]. The organizing of building was needed to be regulated and managed according to regulations for the continuity and improving the quality of building’s life, as well as the realization of functional building, self-identity, legal certainty, balanced, harmonious and in line with the surrounding environment [1]. Therefore, Based on UU No. 28/2002 in section 3 that said to realize the functional and appropriate of buildings needed to ensure the reability of safety, health, comfort, and convenience [3].

Though many theories and hypotheses are postulated daily on building issues and especially on building maintainability, maintenance problems remain adamantly unyielding and unresolved [4]. This can be clearly seen from the existing condition of most buildings which have been operating for some
time [5]. Maintenance is still considered a less important and costly task, and as such, its priority is often not prioritized by many of the organizations involved [5]. The behavior of the community as building users also seemed to be less concerned about the importance of good physical conditions for the common good [5].

For Architecture in case, the problems are some components were found to be damaged, such as lack of plafond, defective of façade, broken and dirty of Tempered glass, etc. Whereas the Tempered Glass can reduce and saving the electricity, especially for the lighting aspects [6]. This shows when the damage of the components happened, then one of the functions of the green building is not achieved.

The building maintenance phase is one of the project life cycles with a relatively long time span compared to other phases. The operation and maintenance phase requires the longest and most expensive period in determining the life cycle [7]. About 75–80% of the total Life Cycle Cost of buildings is spent during the Operation and Maintenance phase [8]. In this phase, maintenance and maintenance activities include several multidisciplinary work activities. No doubt during the maintenance phase the owner needs to build data and information [7]. Building data and information that is formed in an information system is proven to be able to remind effectiveness in tracking and managing information. This is proven because the problem is not well managed by the building because of poor information management system maintenance and maintenance of buildings cannot be accessed easily [9].

In order to facilitate access to building maintenance and maintenance systems an effective software system is needed which includes operation, maintenance, and modification for decision making purposes [10]. The New Concept of Architecture maintenance in Building shown in Figure 1.

The purpose of this research is to improve the performance of maintenance work especially for architectural components of green buildings in to achieve the reliability requirements of building (comfort, safety, health and convenience) in order to make more efficient of the information.

2. Literature study

2.1. Architecture components at green building

Green architecture is certainly more than just planting grass or adding more plants in a building, but also wider than that, for example empowering architecture or buildings to be more beneficial to the environment, creating new public spaces, creating tools for community empowerment, and so on. Green architecture defines an understanding of environment-friendly architecture under all classifications, and contains some universal consent, It may have many of these characteristics: (a) Ventilation systems designed for efficient heating and cooling, (b) Energy-efficient lighting and appliances, (c) Water-saving plumbing fixtures, (d) Landscapes planned to maximize passive solar energy, (e)Minimal harm to the natural habitat, (f) Alternate power sources such as solar power or wind power, (g) Non-synthetic, non-
toxic materials, (h) Locally-obtained woods and stone, (i) Responsibly-harvested woods, (j) Adaptive reuse of older buildings, (k) Use of recycled architectural salvage, (l) Efficient use of space [11].

2.2. Damage category and the causative factor
The intensity of building damage can be classified into three levels of damage, namely: (a) Light damage is damage mainly to non-structural components, such as roof coverings, ceilings, floor coverings, and wall fillers; (b) Medium damage is damage to some non-structural components, and or structural components such as roof structures, floors, etc.; (c) Heavy damage is damage to most building components, either structural and non-structural which if after being repaired can still be functioning properly as it should [12].

2.3. Minister of Public Work Regulation 24/2008
Building maintenance is the activity of maintaining the reliability of buildings and their infrastructure and facilities so that buildings are always functional (preventive maintenance) [13]. In this regulation also stated that the maintenance of a building must include requirements related to the safety, health, comfort and convenience of buildings. Therefore, all forms of building maintenance and maintenance activities have been regulated in Permen PU No.24 of 2008 and this regulation must be a guideline [12].

2.4. Integrated between maintenance building with information system into a WEB based
Building completion system, which is a module coordination system that can save time, money, building materials and labour. This system manages all building components related to one another in measurements based on modules or unit dimensions [14].

3. Research methods
The questionnaire survey approach was used to collect primary data. A cover letter and the questionnaire were specifically addressed to the ‘expert of green building and building maintenance’ in Indonesia. A set of questionnaires with the letter is posted to all respondents on the same day. An email addressed, prepaid envelope was provided to facilitate return of that questionnaire. Before the primary data collection, a pre-tested study was conducted to test the wording, ambiguities and ease of understanding of the questions. Interviews and surveys of several buildings were also conducted to obtain data and support this research. This include The validation of Architecture’s work package, component damage with damage category, causative of damage, maintenance activities until the information system.

The data collection started on August 2019 and lasted through to November 2019. The survey was initially intended to last for 2 months. But by the cut-off date, only 3 of the 10 experts had returned their completed questionnaires. So the time is extended to obtain the result of all questioner as expected result. The Figure 2 below shows a flowchart of the steps taken to carry out this research.
4. Results and discussion

Results from the research and validation of building maintenance checks can be summarized as follows: Architectural components included in the green building include 12 items, there are: Exit way, Tempered Glass, Ceramic Walls / Mosaics, Plywood Wall, etc. Form that work package than obtained each cause of damage and future maintenance activities for prevention. The result as seen on Table 1.

Table 1. List of architecture components, damages and causes in green building.

| Components | Component Damages | Damages Category | Cause of Damages | Maintenance Activities | Maintenance Schedule |
|------------|-------------------|------------------|-----------------|------------------------|-----------------------|
| Exit Way   | Mossy             | Light            | Nature Factor   | Perform routine cleaning and checking | Every 3 Month         |
|            | Cracked           | Medium           | Age Plan, Overcapacity | Perform cleaning and checking of EKSIT marks |                      |
|            | Dirty and Dusty   | Light            | Lack Of Maintenance | Clean the glass with detergent also cleans with a rubber brush. Do not use cleaning agents that contain thinner or benzene because it will damage the elasticity of the rubber or sealent |                      |
| Tempered Glass | Sealant Leakage | Medium           | Lack Of Maintenance | Clean the corners of Glass, routine checking and cleaning, do with soft brush | Weekly               |
|            | Broken            | Heavy            | Human Error, Natural Disaster | Brush the ceramic surface with a soft plastic brush and rinse with clean water | Monthly               |
| Ceramic Walls / Mosaics | Dirty and Dusty | Light            | Lack Of Maintenance | Brush the ceramic surface with a soft plastic brush and rinse with clean water | Monthly               |
|            | Peeled Off        | Medium           | Age Plan | Clean by using materials that do not damage the ceramic binding cement | Monthly               |
|            | Dirty             | Light            | Lack Of Maintenance | Clean by using materials that do not damage the Marmer binding cement | Monthly               |
| Marmer Wall | Scratches         | Medium           | Lack Of Maintenance | Brush the Marmer surface with a soft plastic brush and rinse with clean water | Monthly               |
|            | Dirty             | Medium           | Lack Of Maintenance, Human Error | Check sealants and backups on component connections, if there are peeling parts repairing with the same sealant | Monthly               |
| Wall with Cladding Alluminium Composit cover | Scratches | Light            | Human Error | Clean the Marmer and Sealtants with the agents that do not damage such as ingredients containing thinner / benzene, hard water and strong acids | Every 3 Month         |
|            | Leakage           | Medium           | Overload, Less Checking | Perform an inspection every 6 (six) months | Every 6 Month         |
| Acoustic Plafond | Leakage       | Light            | Human Error | Spray the enzyme / detergent formula onto the surface of the acoustic Plafond, then Clean it | Monthly               |
|            | Broken            | Heavy            | Nature, Less Checking | Perform an Inspection Every 3 (three) Month | Every 3 Month         |
| Gypsum Plafond | Dirty             | Light            | Lack Of Maintenance | Clean by closing with gypsum powder (gypsum powder) that has been stirred with water | Once a year           |
|            | Broken            | Heavy            | Overload, Age Plan | Perfoarm an inspection Every 3 (three) Month | Every 3 Month         |
| Wooden Plafond | Dirty and Dusty  | Light            | Hama, Lack Of Maintenance | Clean the surface of the wood using a brush or broom or other similar tool, from the dirt attached | Monthly               |
Table 1. Cont.

| Components                      | Damages       | Cause of Damages                  | Maintenance Activities                                      | Maintenance Schedule |
|---------------------------------|---------------|-----------------------------------|------------------------------------------------------------|----------------------|
| Sliding door, rolling door, folding door | Broken Heavy, Stuck Light | Human Error, Less Greasing, Lack of Checklist | Check the state of keys, latches and hinges on high-level use doors, such as exits, room doors and so on. Lubricate moving parts with lubricant, while removing rust formed by dirt and weather / dust. | Daily Weekly |
| Aluminum Frame                  | Broken Medium, Scratches Light | Human Error | Clean the wooden frame from dust that sticks every day | Weekly Every 3 Month |
| Wooden Frame                    | Dirty Light, Termite Medium | Lack Of Maintenance, Less Checking, Hama | Clean the wooden frame from dust that sticks every day | Daily Every 3 Month |
| Door Closer                     | Stuck Light | Less Greasing, Lack of Checklist | Open the door closer, refill the oil in it | Weekly |

According to experts, wooden plafond is included in the work package of the green building architecture component of the state building. In line with the statement that said the use of wood products can also improve air quality by absorbing or releasing water vapor in the air for moderate humidity [6].

This table shows, most of the building components are not running in good condition, especially at the point of comfort and safety. While Layout inside, must consider the function of space, building architecture, and reliability building [1]. The final results of this study will be in the form of a web-shaped information system to maintenance the building. Part of Interface Website and the steps to use be like Figure 3.

**Figure 3.** Maintenance Web interface.

**Figure 3** show the information information regarding maintenance activities and schedule for each of green building architecture components. This system also functioning as a reporting system to report any damages occurred in green building so that the building management and user can monitor the periodic maintenance together.

The web of maintenance work will be functioned with the information process scheme as below;
This flow shows the activity of proposed maintenance in a more efficient way.

5. Conclusion

- There are 12 variables that highly associated with Architecture components in green building maintenance performance especially for wood Plafond and Tempered Glass
- Web information systems do facilitate the process of building maintenance, this process can be maximized by identifying damage to the maintenance, and most of cause that damage is because lack of maintenance also human error
- Maintenance based on Minister of helps provide solutions and preventive maintenance that will be needed in the architecture maintenance process. The combination of the two information system based on Minister Regulation No. 24 /2008 will minimize the damage that occurs because information can be better integrated.

Acknowledgement
This paper was supported by an amazing counsellor, Mr. Yusuf Latief and Mr. Rossy Armyn who provided expertise that greatly assisted to this research. Also many thanks to all of the experts who support and give the useful discussion for this research.

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