Information system development using BIM on wall work packages of government green building to improve the convenience of maintenance performance

Y S Pratiwi* and Y Latief and R A Machfudiyanto
Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI Depok, Jawa Barat 16424, Indonesia

*yusti.sekar@gmail.com

Abstract. Comfort is one indicator in the performance of building maintenance. This performance can be achieved by carrying out maintenance work on the building architecture components. The maintenance of government green buildings in Indonesia has not been done in an optimum manner due to constraints in maintenance work to government green buildings such as non-digitized data, poorly documented data, substandard maintenance work, and poor or slow identification of damages. Impacts resulted from the poorly maintained building are the increasing operational cost and ineffective maintenance work done to the building. The aim of this study is to increase the comfort of maintenance performance of the architectural component of government green building, especially the wall work package. The case study taken is the Ministry of Public Works and Public Housing Building which is considered as a representation of government green building in Indonesia. The method used are literature research, case study, and survey. The result of this research is the information system development using Building Information Modelling (BIM) integrated into building maintenance systems such as Work Breakdown Structure (WBS), SOP, and building maintenance guidelines for architectural components.

1. Introduction
The longest and costliest phase in a building's life cycle is the operational management implementation phase [1]. The financing for the maintenance of domestic state buildings in Indonesia has been regulated in Minister of Finance Regulation No. 33 of 2016 concerning the Input Cost Standard for the 2017 Budget Year. worth trillions of rupiah [2]. A building consists of five main components, namely architectural, structural, mechanical, electrical, landscape and grammar components [3]. This research will be limited to building wall work package of architecture components.

The study case of this research is the Ministry of Public Works and Public Housing Building which is considered as a government green building. In Indonesia, green building is one of the building requirements regulated by Minister of Public Works and Public Housing Regulation No 02 / PRT / M / 2015 and DKI Jakarta Governor Regulation No 38/2012.

Ironically there are many cases where the architectural components of Indonesia Government Buildings are damaged. An example of the damaged architectural in buildings include cracks in walls. The occurrence of building management that causes damage is caused by several factors. First, failure to implement preventive maintenance plans due to poor information management and impact on
maintenance systems and buildings that are difficult to access [4]. Second, there are no guidelines or manuals for building maintenance and maintenance [5]. Third, the implementation of building maintenance works that still using the conventional systems so that data related to the complexity of building development over time is not recorded and not integrated [6].

The solution offered to solve the problem is by utilizing the Information System and Building Information Modelling (BIM) in the implementation of maintenance and maintenance of government green buildings. A software system is considered as an effective tool for easy access to building maintenance and maintenance systems, which includes operation, maintenance, and modification for the purpose of decision making [7]. Whereas BIM is considered as a very useful tool for project actors to coordinate during the construction work cycle [8]. The information entered can be automatically updated at BIM as a centre for data storage and retrieval [9]. The purpose of this study is to develop an information system using BIM in the maintenance of green building architecture components of government buildings in the hope that the performance of building maintenance can be achieved.

2. Methods
This study uses the literature review method to collect variables of the green building maintenance work packages of government buildings architecture components that can improve the maintenance and maintenance performance of green buildings in government buildings which will then be validated by experts. Then multiple regression analysis is used as a development model of the relationship between variables X1, X2 and Y to get final validation and approval from experts on the model of the relationship between the green building system of government buildings on the maintenance and maintenance performance of architectural building components.

![Figure 1. Operation research models.](image)

3. Results and discussion

3.1. Alternative design identification
Based on the literature review, there are 4 alternative designs which are the result of decomposition of the wall work package on the government green building architecture component maintenance. After going through the validation stage with the experts, an analysis result was obtained that all 4 alternative designs were validated or accepted as alternative designs of wall work package on the government green building architecture component.
Table 1. Wall Work Package Design Alternative Validation Results.

| Variables | Wall Work Package Design Alternative | Respondents' Number | Results |
|-----------|--------------------------------------|---------------------|---------|
| X.1.1     | Exposed Brick Wall                   | ✓ ✓ ✓ ✓ ✓            | Accepted |
| X.1.2     | Veneer Brick Wall                    | X ✓ ✓ ✓ ✓            | Accepted |
| X.1.3     | Precast Concrete Wall                | ✓ ✓ ✓ ✓ ✓            | Accepted |
| X.1.4     | Tempered Glass Wall                  | X ✓ ✓ ✓ X            | Accepted |

3.2. BIM and web development on government green building maintenance system
After determining the alternative design of the wall package in the maintenance work of green building components of the Government building as the object of study, a 3D Building Information Modelling (BIM) model was created which was included in a web information system. On the website called sipenjau.com, information about WBS, SOP, and guidelines for maintaining the green building architecture components of government buildings will be included.

Figure 2. 3D model of the ministry of public works and public housing building using BIM.

Figure 3. Home page website of sipenjau.com.
3.3. Variables’ regression on government green building maintenance system

3.3.1. Data sufficiency test. A test of the adequacy of the data is needed to ensure that what has been collected and presented in the weighing report is objectively sufficient based on the following formula:

\[
N' = \left( \frac{k / s (N \Sigma x^2 - (\Sigma x)^2)^{1/2}}{\Sigma x} \right)^2
\]

(1)

The number of observational data (N) is 41 data, with confidence level (K) 1.65, and degree of accuracy (s) 0.1. If N' \leq N then the data is considered sufficient, but if N'> N the data is not enough (less) and need to add data. The highest N' value is 33.92, so it can be concluded that N' \leq N then the data is considered sufficient.

3.3.2. Normality test (Shapiro-Wilk). Normality tests are used to determine if a data set is well-modeled by a normal distribution and to compute how likely it is for a random variable underlying the data set to be normally distributed. The method chosen for this study is the Shapiro-Wilk test. The requirements of the Shapiro-Wilk test are interval or ratio scale data (quantitative), single or unclassified data in the frequency distribution table, and random sample-derived data. Significance compared to Shapiro Wilk's table. The significance of the test value of T3 compared with the value of the Shapiro W table, to see the position of the probability value (p). If the value of p <5%, then Ho is accepted. Conversely, if the value of p <5%, then Ho is rejected. Minitab software was used for this test, and the results were obtained that all variables were declared normal because the p value was >5%.

3.3.3. Validity test (Pearson's correlation coefficient). Validity Test is a test of the accuracy of a measuring instrument in measuring what is being measured. The calculated r value is obtained by the Pearson's correlation coefficient formula which will then be compared with the value of r table. If r value \geq r tables, the instrument or question items correlate significantly to the total score (declared valid). From a total of 9 variables tested, all were declared valid.

3.3.4. Reliability test (Cronbach-Alpha). The reliability test refers to an understanding that the instruments used in research to obtain the information used can be trusted as a data collection tool and are able to reveal the real information in the field. If alpha > 0.90 then reliability is perfect. If alpha is between 0.70 - 0.90 then reliability is high. If alpha is 0.50 - 0.70, the reliability is moderate. If alpha <0.50, reliability is low. If alpha is low, chances are one or more items are not reliable. In testing the reliability of this study utilizing Minitab software, and obtained an alpha value of 0.999 which means perfect reliability.

3.3.5. Multicollinearity test. Multicollinearity test is a test conducted to ascertain whether in a regression model there are intercorrelations between independent variables. One way to detect the presence of multicollinearity is to look at the value of the Variance Inflating Factor (VIF) in the regression model. If the VIF value > 10 can be indicated the existence of multicollinearity. If the VIF value <10 can be indicated the absence of multicollinearity. In the dependent variable to the Y variable (convenience) multicollinearity was tested using minitab software and among the 8 independent variables had a VIF value <10, so it can be concluded that there was no multicollinearity.

Table 2. Multicollinearity test based on VIF value result.

| Var. | X.1 | X.1.1 | X.1.2 | X.1.3 | X.1.4 | X.2 | X.2.1 | X.2.1.1 | X.2.1.2 | X.2.1.3 | X.2.2 | X.2.2.1 |
|------|-----|-------|-------|-------|-------|-----|-------|---------|---------|---------|-----|--------|
| VIF  | 2.506 | 3.035 | 3.687 | 2.303 | 1.63  | 1.835| 1.542 | 1.328 |
3.3.6. **Multiple regression analysis.** Multiple regression analysis is a linear relationship between two or more independent variables \((X_1, X_2, ..., X_n)\) with the dependent variable \((Y)\). This analysis is to determine the direction of the relationship between the independent variable with the dependent variable whether each independent variable is positively or negatively related and to predict the value of the dependent variable if the value of the independent variable has increased or decreased. The data used is usually interval or ratio scale. The multiple regression equation is as follows:

\[
Y = a + b_1X_1 + b_2X_2 + \cdots + b_nX_n \tag{2}
\]

In this study there are 8 independent variables \((X)\) that will be tested against the dependent variable \((Y)\). A regression equation is obtained as follows:

\[
Y = 0.518 + (-0.137)X.1.1 + (0.061)X.1.2 + (-0.015)X.1.3 + (-0.020)X.1.4 + (0.186)X.2.1.1 + (0.096)X.2.1.2 + (0.342)X.2.1.3 + (0.385)X.2.2.1 \tag{3}
\]

In addition, several other values were also obtained, such as the Adjusted R Square value of 0.5359, which means that 53.59% of the \(Y\) variable was influenced by 8 independent variables in the regression equation, and the remaining 46.41% was influenced by other factors. The \(F\) value in this equation is 6.774, greater than 1.829 in the form of the \(F\) table value. If \(F\) value> from \(F\) table then the model is significant.

4. **Conclusion**

There are 4 alternative designs that have been validated by experts in the wall work package maintenance of government green building architecture components. In addition, information systems consisting of information technology and Building Information Modelling (BIM) are factors that have an impact on improving comfort in building maintenance performance. The results of the analysis using multiple regression stated that all the independent variables had an impact of 53.59% on comfort in the maintenance performance of green buildings of government buildings. Utilization of information systems contribute greatly to the impact given.

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