Potential and Opportunities of Building Information Modeling (BIM) For Housing Maintenance

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Abstract. Building Information Modelling (BIM) represents an approach that aims to form and manage information over the building’s whole life cycle. BIM has been mainly adopted for commercial or large scales building projects while being mostly neglected by small or residential building. Therefore, the objectives of this study are to evaluate the readiness of BIM implementation for housing maintenance in Sabah, to access the types of priority maintenance in house maintenance, and to determine the potential benefits to apply BIM for housing maintenance. This research is focused on the participants of the construction industry in Sabah to obtain their opinions towards the opportunities and strategy of Building Information Modeling (BIM) adoption in housing maintenance. Two method was done which was a pilot survey that was analyse using SPSS and Revit modelling. The result shows that most of the industry sectors had a moderate knowledge about BIM but they agree that it should be implemented by the authority and the percentage of willingness to change from the conventional maintenance to BIM was high. The 3 highest ranked of priority maintenance is the pipes linkage, electrical faults and sanitary appliance failure. Furthermore, a modeling is created using Revit application and access of information which called the Level of Detail (LOD) regarding the items in houses is easily obtain using schedule list for the purpose of maintenance.

1. Introduction

One of the difficulties in projects is always the need to have sufficient information on products readily available for any maintenance operation, such as: specifications, previous maintenance work, list of specialist professionals to conduct work, etc [1].

BIM comprises ICT frameworks and tools that can support stakeholders’ collaboration over projects life-cycle. While BIM is thought to transform the way of the built environment is working, studies related to BIM have often been focusing on storing and sharing technical information. BIM capabilities can be enhanced by knowledge-based techniques, such as Case-Based Reasoning (CBR), to enable both information and knowledge-sharing that will benefit stakeholders. By incorporating Knowledge Management principles embedded in CBR systems with Information Management principles embedded in BIM systems, the transformation from ‘Building Information Modelling’ to ‘Building Knowledge Modelling’ can be better recognized [1].

On the other hand, Building Information Modelling (BIM) represents an approach that aims to form and manage information over the building’s whole life cycle [2]. BIM could potentially provide more flexible and efficient approach where customers are informed about their property during and after the delivery process [3].

The main benefit of BIM is towards facility management. Opportunities for utilising BIM for facility management have also been investigated with the focus on supporting maintenance planning and identifying useful information in a BIM model needed by facility managers [4]. This is possible with...
BIM as BIM provides a niche of software that all parties involved in the project could access and share information, amend adjustment and develop the design simultaneously within the design team [4]. Nowadays, there is a high demand of Building Information Modeling (BIM) as much international organization and government taking the steps in promoting BIM over the industry life cycle. The life cycle in BIM is primary sets it apart from preceding digital technologies, which were designed in specific phases of the building life cycle for specific sectors of the building industry, such as design, construction and Facility Management (FM) [5].

Most information created during the design and construction process that is of value to facility managers can only be found elsewhere and in scattered sources: in written construction specifications, warranty certificates and operations and maintenance manuals. However, the current practice BIM in scope of FM, stakeholders are not entirely implementing BIM in FM industry and in current FM operations that applied BIM, most functions still done manually even facility manager knowing by adopting BIM during operational building can decrease chance of errors and increase efficiency [5].

Managing facilities failure will raise the issues that occur repeatedly including assets are not registered, assets are not labelled as government asset, weaknesses on disposal and maintenance, asset does not be used or being wasted and asset misappropriation [6], [7]. Indeed, BIM has vast implications for the FM phase of buildings [5] with regard the owner and facility managers are in need of computerized supports that will improve how they operate and maintain their facility [8]. Here we can see that how important is the facilities management in construction industries especially on maintaining and operating. Based on an analysis, O&M activities can be divided into 5 groups which are maintenance and repair, energy management, emergency management, change or relocate management and securities [9].

Therefore, BIM have not been implemented in FM and have not been used for house maintenance. There is a gap of the BIM for house maintenance especially in Sabah. This is probably due to the reduction in workflow productivity of interactions between both professionals and organization, ineffective information delivery, and poor communication channels, reworks, and recurrent changes, among others [10]. The objectives of this research are to evaluate the readiness of BIM implementation for housing maintenance in Sabah. In addition, to access the types of priority maintenance in house maintenance as well as to determine the potential and opportunities to apply BIM for housing maintenance.

1.1. The Important Aspects in House Maintenance

Building Information Modeling (BIM) has constituted a technological and team coordination breakthrough in the architectural, engineering, and construction (AEC) industry, it has been mainly adopted for commercial and/or large scales building projects while being mostly neglected by small or residential building project teams [11]. The main reasons include:

- Home-builders’ unawareness of BIM, or their misunderstanding of BIM as a mere innovative and more sophisticated software producing fancy 3D models, thus ignoring the new multi-disciplinary collaboration processes among project parties for building design [12];
- The high first investment for new software, training, and/or new hires to implement BIM [13];
- Home-builders’ perception that residential projects are simple in comparison to, e.g., commercial projects, and that BIM practices significantly improve project outcomes (e.g., time, cost, and quality) only if used in complex projects [14], [15]; and
- The severe crisis in the residential building market during the last decade [16] impacting business owners’ ability to invest in innovative methods and technologies, along with the higher probability or bankruptcy of small businesses if profits are not quickly produced in such market [17].

Furthermore, BIM for residential projects is gaining popularity. The National Association of Home Builders (NAHB) conducted a survey where 15% of home-builders claimed to be very familiar with BIM, and another 30% would like to use it in the future [12]. BIM is attracting home-builders’ attention promising a great qualitative leap in residential project outcomes including time, cost, quality, and
sustainability [15], [18]. Therefore, since there are some attentions for BIM implementation in residential project, it can be said that there is a potential and opportunities for BIM to be used in house maintenance.

1.2. The potential and opportunities of BIM in House Maintenance

The advantages of BIM technology are either to reduce cost, materials usage or indirectly through efficiency gains throughout the three major phases in the building lifecycle: design, construction and management.

Moreover, BIM can provide the necessary information needed for Facilities Management (FM) that is important for maintenance and repair, management of energy, and the commissioning [19]. Burgess G, Muir K and Jones M [20] said BIM is a way that will reduce costs, save time and energy, and summarizes the main benefits of BIM as:

- Reduction of design errors, by making the errors easier to be identify before a site commencement that help in cost and time saving by eliminating work.
- Avoiding conflicts and design clashes which affect in construction changes. Therefore, this saves on construction costs and time.
- Construction of sustainable buildings, by using environment-friendly materials which reduces energy use.
- Efficiency improvements in maintenance and operation companies. Maintenance time can be saved up to 15% and the costly site visit can be removed by having the historical design data instantly available.

2. Methodology

In order to achieve the aim and objectives of the research, questionnaire was sent out to the people in the construction industry by link of Google Form via WhatsApp. This method was widely used in conducting survey because it was the most economical method which can offer relatively high validity of results. As for Modelling, an AutoCAD drawing of houses was used which was the project of SPNB terrace housing in Ranau, Sabah.

However, there is some limitation when dealing with questionnaire survey. One of which, there is no guarantee that the people who complete the survey are the right person that you stated in the questionnaire form. Other than that, respondent might answer the survey generally and also based on their knowledge or heard from others rather based on their understanding towards the current industry.

The first test was the frequency analysis is used to represent the summary of the respondent’s profile which will then be tabulated out. Basically, the respondent’s profile was from the construction industry. By knowing the distribution of the respondents’ group, the analysis can be done easily based on the ratio of it.

Next was the Crosstab or Cross Tabulation is used to aggregate and jointly display the distribution of two or more variables by tabulating their results one against the other in 2-dimensional grids. It uses a process of creating contingency tables from the multivariate frequency distribution of variables, presented in a matrix format. Crosstab is widely used in survey results to find out interrelationships and interactions between variables.

The Chi-square test is intended to test how likely it is that an observed distribution is due to chance. It is also called a "goodness of fit" statistic, because it measures how well the observed distribution of data fits with the distribution that is expected if the variables are independent. A Chi-square test is designed to analyze categorical data. That means that the data has been counted and divided into categories.

Another method that was use was creating a modelling. A modelling was created using Autodesk Revit application. A housing model was shown to have a clear picture of the benefits obtain. One of which the goal is to produce a schedule list.
In a nutshell, after the data analysis has been conducted, the feasibility of this research can be proven and the opinion towards the particular issues can be summarized out and analyzed in more details in the next chapter. As for the modelling, it will be as the supporting material for the objective number 3 which was to show the benefits of BIM.

3. Results and discussion
There are 51 sets of questionnaires answered by various profile of respondents. Based on table 1, most of the respondent are from Contractor firm (41.2%) followed by Consultancy firm (39.2%). Furthermore, most of the respondent’s profession are Civil Engineer (78.4%). Most of the questionnaire are replied by officer (60.8%). In addition, most of the respondent are less than 30 years old (88.3%) and most of them have an experience in their own profession of less than 5 years (86.3%). Additionally, their educational background are mostly Degree holders (62.7%).

From table 2, the Government (100%) had the highest percentage that willing to change from conventional to BIM in house maintenance. Then, the Consultant (75%), Contractor (38.1%), and Developer (33.3%). As an overall, most of them agreed by 60.8% and the response maybe by 37.3% and the rest answer no by 3.9%.
Table 2. Cross Tabulation of Industry Sector Organization and Agree Implement of BIM in House Maintenance by Authority

|                | Agree Implement BIM House Maintenance | Total |
|----------------|--------------------------------------|-------|
|                | yes   | maybe | no  |       |
| Consultant     | 15    | 5     | 0   | 20    |
| % within Industry Sector | 75.0% | 25.0% | 0.0% | 100.0% |
| Contractor     | 8     | 11    | 2   | 21    |
| % within Industry Sector | 38.1% | 52.4% | 9.5% | 100.0% |
| Developer      | 1     | 2     | 0   | 3     |
| % within Industry Sector | 33.3% | 66.7% | 0.0% | 100.0% |
| Government     | 7     | 0     | 0   | 7     |
| % within Industry Sector | 100.0% | 0.0% | 0.0% | 100.0% |
| Total          | 31    | 18    | 2   | 51    |
| % within Industry Sector | 60.8% | 35.3% | 3.9% | 100.0% |

A question was asked about their opinion on which part of the house they think was the priority maintenance. According to Figure 1, the top three highest percentage was the pipes linkage (80.4%), follows by electrical faults (72.5%) and sanitary appliance failure (70.6%). Figure 2 shows that most of the respondent think that BIM will benefits in improve productivity of facilities management process (74.5%). Follows by the ensure maintenance and asset performance history maintained (60.80%), save time and energy (56.90%) and reduce cost (47.10%).

4. Revit modelling
A revit is an application built for Building Information Modeling with several features. It is not a BIM, but it and other applications made for BIM help designers design, simulate, visualize and collaborate in order to capitalize on the advantages of the interconnected data within a BIM model.

Figure 1. Priority Maintenance for Housing
Figure 2. Benefits of BIM for Housing Maintenance
Figure 3. Front View of the Terrace House Model
Figure 3 shows the front view of a model of the SPNB project which is located in Taman Saujana, Ranau, Sabah, that is created in Revit. It is a terrace house project and the model consists of 5 single storey house.

![Figure 3. Model of SPNB project](image)

**Figure 3. Model of SPNB project**

Figure 4 and figure 5 shows the plumbing fixtures schedule list that shows the description which is the specific name of the items, manufacturer, the model or brand, and purchase date of an item. The information needs to only be key in once and it is automatically applied to all same items in the project. Furthermore, revit will update any changes made to the schedule. Therefore, if any problem occurs that required maintenance, this list of schedules can be refered to get extra information about the items. For instance, if the toilet bowl needed to be replaced and the owner wants the same as the old types of toilet bowl or only the manufacturer had the parts that need to be replaced, it can be easily get since the name of manufacturer is recorded. In addition, whenever a maintenance is done, the date can be updated. It is a suitable criterias and one of convenient methods for planned maintenance.

![Figure 4. Plumbing Fixture](image)

**Figure 4. Plumbing Fixture**

![Figure 5. List of Plumbing Fixture](image)

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5. Conclusion and recommendation

This research found that the industry of construction agreed with the implementation of BIM for the purpose of housing maintenance (Objective 1). In addition, there are many items that needed to be maintain in a single house and some findings related to the priority maintenance was found (Objective 2) and several potential benefits that agree by the construction industry (Objective 3).

It is crucial to identify that all industry sectors are mostly ready if the authority implemented BIM for housing maintenance and are willing to turn from the conventional method. As stated in chapter 2 that the authority plays an important role institutes a mandate for BIM implementation to be followed by its affiliated agencies. Therefore, the BIM implementation in Sabah can be achieved.

Moreover, the top three ranked priority maintenance for houses are pipes linkage it may due to leakage problem, second priority is the electrical faults which can be dangerous to maintain ourselves and last is the sanitary appliance failure which can be complicated to maintain.

Generally, the potential benefits of BIM are analyse using bar chart and the benefits stated which is improve productivity of facilities management process which is highly agree by the respondent. However, several benefits can not be neglected since there are more than half of the respondent agree to it. The rest are ensuring maintenance and asset performance history maintained, save cost and save time and energy.

As mentioned on the objectives 3 which is the benefits when apply BIM for housing maintenance. Once a building is complete, it enters into the operation and maintenance phase of its lifecycle. The Revit modelling support the statement where it can show the schedule list of items which will display the information regarding the items clicked.

The subject on Building Information Modeling (BIM) is continuously under study. Based on the study, research of an alternative based on the identified barriers in promoting adoption of BIM can be possible which beneficial to the industry. Moreover, some development on suggestion to the authority of an appropriate system can be done for BIM implementation.
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