



Implementation of Building Information Modeling (BIM) for Social Heritage Buildings in Kuala Lumpur

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Abstract: Heritage buildings offer a sense of identity in every country. Preserving heritage buildings is important to ensure that *bona fide* aesthetic values are well maintained. However, the conservation and preservation of heritage buildings during operation and maintenance (O&M) has been taken lightly which can cause buildings to be abandoned due to the tedious work involved for the Facility Managers. Therefore, a need for advanced technology, such as Historic Building Information Modeling (HBIM), is important to enhance the efficiency of O&M for heritage buildings in Malaysia. Even though BIM has many benefits, yet it is not widely adopted in Malaysia especially for heritage buildings. Therefore, this research highlights the awareness of BIM for social heritage buildings in Kuala Lumpur. Semi-structured interviews were conducted with various construction professionals that have experience in BIM projects and managing heritage buildings. These interviews prove that the current facility management practices for heritage buildings do not use advanced technology for upkeep and maintenance, particularly when producing dilapidation reports and measured drawings. Findings also show the challenges that restrict the implementation of BIM in heritage buildings and how to overcome the problems which have been categorized into three (3) elements: people, process, and technology. This research is expected to fill the gap in the implementation of BIM by supporting the initiatives by the Malaysian government for increasing productivity in construction projects through the adoption of new technology, like BIM, especially for heritage buildings.

Keywords: Heritage buildings, Operation and Maintenance (O&M), Building Information Modeling (BIM), facility management, Malaysia

1. Introduction

A heritage building is one which possesses architectural, aesthetic, historic, or cultural values. Eventually, after 50 years or more, a building can be considered as a heritage where pieces of political, military, cultural or social history have been preserved due to their heritage value (Roper, 2015). According to Ali *et al.* (2017), there are a total of 183 buildings have been gazetted as national heritage by Jabatan Warisan Negara (JWN) because they preserve material related to the heritage of Malaysia. Many heritage buildings deteriorate day by day which threatens the cultural values of the country. This deterioration of the heritage buildings that needs to be preserved reflects the inadequate maintenance of relevant documents (Ali *et al.*, 2017). Therefore, with the advances in new technology, the preservation and conservation of heritage buildings can be achieved by using Building Information Modeling (BIM).

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BIM is an approach for improving the efficiency of building processes and potentially providing the main data set acquired by facilities managers to operate buildings more effectively (Fadeyi, 2017). While BIM's design and construction phase is advanced, the facility management or post-construction phase is not as sophisticated as planned. Although attempts have previously been made to establish similar facility management models, they have failed due to the complexity of the data analysis and the inadequacies of the available computational technologies (Carbonari, 2014).

Today, HBIM is widely recognized and implemented worldwide. However, although BIM has been used in Malaysia for more than 10 years (since 2007), yet it is not widely applied in the construction industry, particularly in heritage buildings. This is because Historic Building Information Modeling (HBIM) needs more technical input to obtain all the data regarding the construction of heritage buildings. The implementation of HBIM within the Malaysian construction industry is however low and slow as it demands new skill sets, such as understanding the approach, professional 3D modelers, and comprehensive cooperation since it requires industry players to relate to each other differently (Ali *et al.*, 2018). Therefore, it is crucial to take care of heritage buildings as the number is limited.

According to Ali (2018), a loss of information, inadequate documentation, a lack of maintenance, and the lack of technological adaptation and reliable reports are among the common problems faced by the construction industry. Facilities Management (FM) typically involves tedious and difficult work with the staff involved which usually using paper information systems to document their work. Nonetheless, it is not easy for facility staff to refer to information in conventional drawings, plans, and illustrations to perform facility maintenance (Su, Lee, & Lin, 2017). Moreover, the repetition of information records for the same facilities maintenance information causes inconvenience for facility management staff.

The BIM concept is then utilised and the information of the building is developed as 3D models to assist in managing and maintaining the facilities (Carbonari, 2014). Consequently, the integration of the BIM model with relevant facilities maintenance information, thus helps facilities managers improve the efficiency of facilities maintenance work during the O&M phase.

Hence, this paper aims to propose the adoption of BIM, specifically HBIM, for facility managers and staff in maintaining heritage buildings. Finally, this paper will present the benefits, limitations and conclusions on BIM application in facilities management of heritage buildings.

2. Literature Review on BIM as applied to Heritage Buildings

Building Information Modeling (BIM) is a recent approach implemented in construction projects to digitally manage building design and project data throughout the life cycle of a building, a method that provides information sharing and interoperability among stakeholders. (Othman, Al-Ashmori, Rahmawati, Mugahed Amran, & Al-Bared, 2020). According to Brahim (2018), BIM has been defined into 5 perspectives: design, technology, process, performance, and productivity. BIM as defined by Bilal Succar (2009) and cited by Raza (2017), is "an emerging technological and procedural shift within the Architecture, Engineering, Construction and Operations (AECO) industry". This helps to understand that BIM is not just the name of a technology but more a process of change within the construction industry. BIM is used as a collaborative tool by the Architectural, Engineering and Construction (AEC) industry to improve the visualization and constructability of designs, reduce time, cost and conflict among construction professionals (Latiffi-*et al.*, 2016).

In today's construction industry, the BIM model has become a necessity in terms of providing integration between project stakeholders and providing the ability to process and store project data at a common point (Namlı, Işıkdag, & Kocakaya, 2019). BIM has been commonly used in the construction industry to generate data-rich models of buildings and structures. BIM can be described as a project and process simulation to the extent that the realization of BIM is very similar to the planning and actual construction of projects (Latiffi *et al.*, 2016). Therefore, BIM cannot be viewed as a software tool, it must impact on all the processes during the entire construction project. In addition to that, BIM helps by having project simulations in which construction players can monitor the actual performance that happens in every phase of a construction project, which makes BIM an efficient and effective tool in construction projects. With an accurate building model developed, BIM allows an efficient and better-planned construction process that helps to reduce any errors and conflicts occurred (Latiffi *et al.*, 2016).

BIM is a mechanism for developing and managing information on a construction project throughout the lifecycle of project (Latiffi *et al.*, 2016). Latiffi *et al.* (2016) also added one of the key outputs of the BIM process is the digital description of every aspect of the built asset. This model is developed based on information that is collaboratively collected and revised at key stages of a project. The development of a digital BIM model helps those who communicate with the buildings to automate their action, which results higher value for the asset.

BIM adoptions in construction projects offer many benefits to construction players such as improving coordination between them and encouraging faster design decisions (Latiffi *et al.*, 2016). In addition, one of the advantages of BIM is the ease of use of its tools; thus, the use of BIM will minimize the time spent in the design as well as the cost and duration to complete the project. BIM may be extended to all project phases of construction: pre-construction, construction, and post-construction (operation).

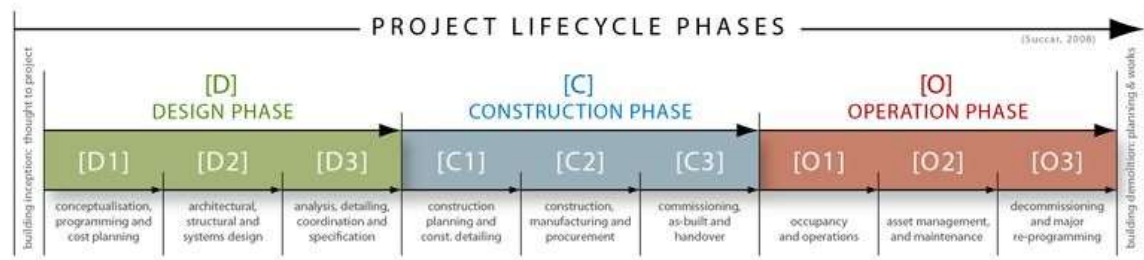


Fig. 1 - BIM in the project lifecycle phases (Succar, 2009)

2.1 Current Implementation of BIM in the Malaysia Construction Industry

In spite of all the advances in technology around the world, Malaysia's construction industry should not forget to implement BIM even though it is still relatively new. According to a research study conducted by Latiffi *et al.* (2016), as cited by Brahim (2018), the purpose of BIM implementation in Malaysia is for 3D visualization, clash analysis, design review, cost estimation and the operation and maintenance of a building. Thus, the implementation of BIM in Malaysia can be assumed mostly at the design phase with some limited use in the operation phase.

According to Haron (2013), as cited by Harris *et al.* (2014), fragmentation, low productivity and time and cost overruns due to variation orders, inadequate drawings and specifications, consultants' late issuance of construction drawings, and the interrelated issues of coordination between consultants are among the factors that require BIM to be implemented effectively. Therefore, BIM is considered to be a solution to many significant problems that occur rapidly evolving across construction industry in Malaysia.

In the meantime, the Malaysia's Government has initiated BIM started with the first project: The National Cancer Institute (NCI) located in Putrajaya which was officially announced in 2010 (Harris *et al.*, 2014). BIM implemented demonstrates the efficiency and advancement of technology where the NCI project was completed three (3) weeks earlier than the planned completion date. NCI was the pilot project of the Government that proved the benefits of using BIM as it shortened the construction period and facilitated problem-solving at the early phase of the project lifecycle (Harris *et al.*, 2014). Since then, the Malaysian Public Work Department (PWD) has accepted BIM by striving for BIM to be introduced on 10% of public projects above RM 50 million under latest Rancangan Malaysia ke-11 (RMK11). Conversely, in the beginning of 2018, BIM is compulsory for every public project budgeted at or above RM100 million (Harian Metro, 2015). Roslan *et al.* (2019) added that by 2020, players in the construction sector who are engaged in government projects worth over 100 million will be expected to reach a minimum Stage 2 BIM maturity execution rate of 40 percent. Under the 2016 to 2020 Construction Industry Transformation Program (CITP), BIM continues to flourish within the Malaysian construction industry. Currently, the Malaysian Ministry, through the Strategic Plan 2021-2025 of the PWD, has scheduled the mechanism's adoption to hit 50 percent next year and 80 percent by 2025 (MyBIM, 2020). According to MyBIM (2020), there are total of 34 projects where 7 has been completed, 8 are still in construction, and 19 under design stage.

2.2 Definition of a Heritage Building

Heritage is the history of a country that has been preserved for future generations to inherit. Heritage itself is conceptualized as the meanings attached to the past in the present and is regarded as information established within a framework of society, politics and culture (Harun 2011). Conservation of heritage buildings is an important tool in the development of a city. This can be seen in cities worldwide, such as in the United Kingdom, Turkey, and others. It plays a vital role in defining landmarks within a heritage area as well as generating an economic return and supporting the tourism industry. Harun (2011) also stressed that conservation of heritage buildings is very important as it offers sign of belonging and continuity in a fast-changing environment for future generations.

The distribution of historic buildings in Malaysia shows that more than 20,000 buildings are considered historical and worthy of conservation. According to Harun (2011) there are many building in Malaysia that are classified as historic buildings such as mosques, residential dwellings, schools, railway stations, hotels, churches, palaces, clock towers, prisons, government offices, forts, monuments, institutions and commercial sites.

Ali (2018) added that it is crucial to preserve the elements and structures of heritage buildings. Guidelines for the conservation of heritage buildings are among the measures suggested for their protection. The lack of these guidelines contributes to the mismanagement and deterioration of heritage buildings. Therefore, conservation guidelines must be produced and established to ensure that any substantial improvement during conservation work on heritage buildings are undertaken in ways that are most compliant with the preservation of the heritage structure's historic character and features.

2.3 Historic Building Information Modeling (HBIM)

According to Ali (2018), Historic Building Information Modeling (HBIM) is a study where BIM concept is adopted and use for historic buildings. Heritage buildings conservation can be achieved through the implementation of BIM, especially in terms of the facility management of the building itself. Many of the BIM practices applied to newly constructed buildings can also be applied to heritage buildings. Despite the absence of BIM implementation for heritage buildings in Malaysia compared to other advanced technology countries such as the United States (Ali, 2017), narrowing the gap is not impossible.

Implementing BIM for heritage buildings will enable the facilities management to store information about the building's components in a clear and reliable visual display, classify the building's components into their elements, and automate the results for documentation and reference (Ali, 2018). Therefore, HBIM offers benefits that allow documentation, the simulation of planning, and also communication.

There are differences when implementing BIM for an existing building, including obtaining the information for the building e.g. the specifications, types of materials used, and other construction parameters. However, with a well-trained BIM knowledge as well as concept and processes, these BIM-implementation problems in heritage buildings can be overcome.

2.4 Benefits of HBIM

HBIM can be a benefit for both new and existing buildings, including heritage buildings. According to Ali (2018), the benefits of HBIM are varied depends on the scope and purpose of a project, with the following considerations:

2.4.1 Documentation

Most historic buildings have complex designs in terms of their geometry, ornamentation, and also carvings. Therefore, the ability of BIM to produce 3D documentation is needed to capture and store every detail of the building elements (Quattrini, Malinverni, Clini, Nespeca, & Orlietti, 2015). The documentation is stored in digital archives to enable the collection of historical data, information, and different types of design in the form of automated documentation which reveals the precise preservation and conservation requirements for the heritage building (Baik *et al.*, 2013).

2.4.2 Simulation for Planning

For the simulation of a design, such as a sun path, structural reliability and other tests can be performed within short time and provide reference benchmarks for planning (Antonoupoulou, 2017). Therefore, the simulation can allow both time- and cost-saving methods in order to keep track of the environmental performance of the historic building. According to Khodeir *et al.* (2013), as cited by Ali (2018), other available simulation abilities and benefits include the analysis of energy efficiency, the structure, and the scenario. Scenario analysis is where the ability of the HBIM model to represent distinct periods enables the sequence of the building's evolution and condition to be established.

2.4.3 Communication

According to Continenza *et al.* (2018) and Ali *et al.* (2017), as cited by Ali (2018), the implementation of HBIM allows the communication between stakeholders to become simpler, faster and easier thereby providing time savings. The HBIM model can be a 'live update' platform if there are any modifications or changes to the model. These can be instantly shared and the data used by relevant parties such as the Facility Managers.

2.5 Processes Involved in HBIM

According to Ali (2018), there are two (2) stages for the process involved in HBIM: the Data Collection phase and the Processing phase. During the data collection phase, all data and information regarding the heritage building are collected to identify the type of material used in every element of the heritage building. In order to do the collection of data, especially in a heritage building, it is vital to have as much knowledge regarding the building as possible (Baik, 2017).

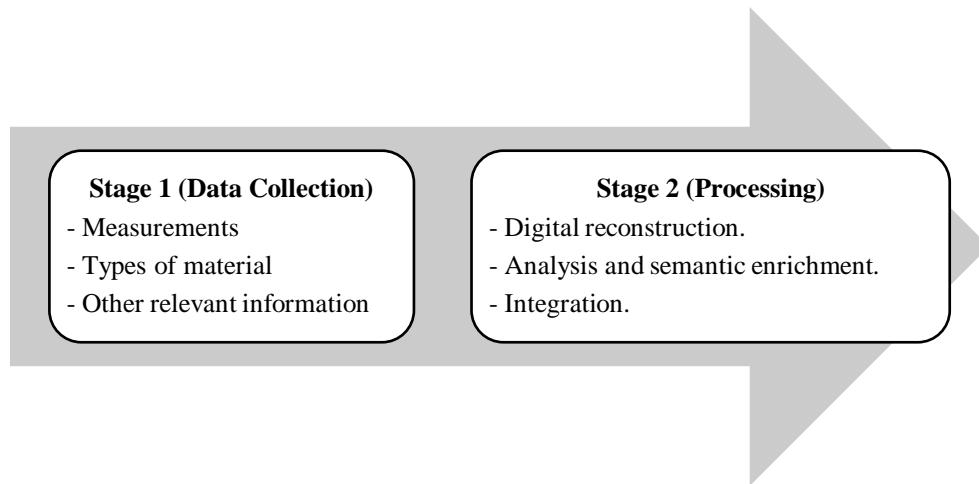


Fig. 2 - Processes involved in HBIM

Figure 2 shows the processes involved in HBIM as stated by Ali (2018) where stage 1 is gathering tangible data on the heritage building such as measurements, types of material and other relevant information. All the information gathered is then used in stage 2 where all the dimensions obtained from the data collection stage are then transferred into a digital reconstruction or modeling. After the digital reconstruction is completed, an analysis and semantic enrichment will take over. This is crucial since much tedious work is involved in order to organize these data and metadata in this phase. Lastly, the integration of the HBIM project is produced for the client who is the owner of the building. For the integration process, the delivery requirements vary based on the clients' need. It can be concluded that the processing stage is mainly to store and to utilize the information gathered by implementation of BIM.

1.6 Issues of Implementation of HBIM

It is proven that implementing BIM for heritage buildings gives many benefits. However, there are five challenges to ensure that the benefits of HBIM are able to be delivered and implemented effectively. According to Dore & Murphy (2017) and Antonopoulou (2017), as cited by Ali (2018), these challenges are insufficient experts to execute the process, expensive tools and training, stakeholders' low commitment and awareness of the need to invest in historic buildings, documenting the building in terms of BIM features can be difficult due to much information about historic buildings becoming lost and sometimes irretrievable, thus creating data void problems, low and slow demand for new skill sets, such as expert 3D modelers; the need to understand the approach; and the requirement for extensive collaboration force industry players to relate in ways not widely found in Malaysia.

In addition, local acceptance of BIM technology and the appropriate software for generating 3D as-built plans is not widespread. According to S.A. Shukor (2015), developed countries in North America and Europe are widely adapting the technology; however, Malaysian construction players are still skeptical about the product produced by the HBIM tools/technology such as Terrestrial Laser Scanner (TLS).

3. Methodology

All data and information for this paper has been obtained by means of a literature review and semi-structured interviews. A literature review is a process of understanding the existing sources of knowledge which is vital in doing a research study. For this paper, the literature review provides the initial analysis of the main drivers towards BIM in heritage buildings along with its importance as well as the tools, the challenges, and the solutions to overcome the challenges of HBIM. The literature review also helped in producing the sets of semi-structured interview questions to be given to the respondents to enable the data collection.

The main selection method for respondents was primarily by a direct approach to the various parties in the construction industry who were involved both in BIM projects and managing heritage buildings, especially the Facility Managers and Conservators. These professionals were chosen to be the respondents because of their perspective in terms of involvement and their vast experience of BIM in the construction industry and of heritage buildings in Malaysia. All data sought from the interviews were recorded, transcribed, analyzed, and represented using text, tables, and figures in order to provide a clear understanding.

Table 1 - Interview questions

Section	Purpose
Section 1: Respondents' Background.	To identify respondents' designation and current involvement in projects using BIM and heritage buildings.
Section 2: Current practices of BIM implementation.	To study the current facility management practices in heritage buildings.
Section 3: Challenges in BIM implementation.	To identify the challenges that restrict the implementation of BIM for heritage buildings.
Section 4: Solution to the best practices in BIM implementation.	To identify the solution for the implementation of BIM for heritage buildings.

For the semi-structured interview data, content analysis was used as it is relevant for analyzing unstructured information such as interview transcriptions, hence, for this research, Transcribe software was used for the transcription and analysis of the data from the interviews conducted.

4. Results and Findings

This section consisted the data obtained from the semi-structured interviews conducted with construction players, namely, facility managers, conservators, and an architect. There are six (6) parts in this section as follows:

4.1 Respondents' Designation

The purpose of identifying a respondent's designation is to investigate their involvement with BIM projects and heritage buildings. There were five (5) respondents with various designations involved with the interviews. Table 2 shows their designations.

Respondent	Designation
R1	Facility Manager
R2	Facility Manager
R3	Architect
R4	Conservator
R5	Conservator

From the table, there are two (2) Facility Managers, one (1) Architect, and two (2) Conservators who were involved in both BIM projects and heritage buildings.




1.2 Respondents' Background

The purpose of this section is to identify respondents' designation in their current project using BIM. There were five (5) respondents involved in the semi-structured interviews. Table 3 shows the respondents' background information:

Table 3 - Respondents' Background

RESPONDENTS	YEAR																			CONSTRUCTION INDUSTRY	BIM PROJECTS	HERITAGE BUILDINGS
	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19				
R1																				17	1	2
R2																				9	4	0
R3																				13	0	3
R4																				13	0	3
R5																				10	1	12

LEGEND:

-  Construction Industry
-  BIM Projects
-  Heritage Buildings

The indicator is used to represent respondents' years of experience in the construction industry, BIM projects and heritage buildings. The purpose of Table 3 is to identify each of respondent's experience with BIM and the inception of BIM in heritage buildings in Malaysia. From the Table 3, majority of the respondents have more than 10 years' experience in the construction industry. However, there are three (3) of the respondents (R1, R2, and R5) are familiar with BIM projects due to the lower levels of BIM usage in Malaysia as it is newly introduced and not yet widely adopted. Furthermore, there are four (4) respondents (R1, R3, R4, and R5) involved in managing heritage buildings. Apart from that, only two (2) respondents (R1 and R5) have experience in both BIM projects and heritage buildings. Based on the respondents' experience in Table 3, it can be deduced that most of the respondents are lacking involvement in BIM projects.

1.3 Understanding the definition of BIM

The purpose of this section is to study the current facility management practices for heritage buildings. Respondents' roles that involved BIM projects and heritage buildings have been identified. From the interviews, the respondents were asked their point of view in understanding BIM. Table 4 shows the responses.

Table 4 - Understanding the Definition of BIM

Respondent	Annotation
	Process
R1	<i>"BIM is ... making the process of work easier."</i>
	Technology
R2	<i>"BIM is where you can make 3D modeling and clash analysis."</i>
R3	<i>"BIM basically is a tool, how you want to produce the drawing."</i>
R4	<i>"BIM is a very good technology tool that could manage project information from design to operation and maintenance of the building...It will make the process of work easier."</i>
R5	<i>"BIM is actually system and technology changes in terms of process of work. If in construction, it is advancement of technology where technology and software are used for the execution of a project.[sic.]"</i>

The answers given by the respondents showed a revision of their existing understanding of the BIM definition. As a result, two (2) perspectives of the BIM definition have been identified: process, and technology. Based on the table, R1 defined BIM as a process where BIM can make the process of work easier. R1 further explained that with the adoption of BIM, especially for new buildings, the sequence of work in the construction phases: pre-construction, construction, and post-construction is efficiently delivered without clashes of information.

Meanwhile, four (4) respondents defined BIM as technology that use to helps the construction professionals, especially during design. According to R2, 3D modelling and clash analysis can take place with the adoption of BIM especially during pre- and post-construction. It is also agreed by R4 and R5 that BIM is a system and good advancement of technology that can make the execution of projects easier, especially in managing project information from the design stage until the O&M of the building. Apart from that, R3 understood BIM as a tool which helps to produce the drawings. Therefore, it can be concluded that BIM has great advantages for the construction industry in Malaysia mostly in terms of work process due to the advancement of technology in managing the lifecycle of a building in relation to Industrial Revolution (IR) 4.0.

From the literature review, the understanding of BIM as mentioned by Brahim (2018) has been categorized into five (5) perspectives: design, process, technology, performance, and productivity. Nevertheless, the data has proven that the understanding of BIM among Malaysian construction professionals specifically involved in managing heritage building are limited to only two (2) perspectives mainly process and technology. Not only that, this has proven that their awareness on the use of BIM also at low pace.

4.4 Current Processes Involved in Managing Heritage Building

The discussion of the process is mainly the sequence of managing heritage based on the construction professionals' roles and responsibilities. The discussion of the heritage building maintenance work process is required in order to understand how the current practices involved in managing heritage ensure that the heritage building is well maintained and conserved during the operation and maintenance of the building without the adoption of BIM. Based on the semi-structured interviews with five (5) respondents, the information regarding the current process involved in managing heritage buildings has been analyzed and plotted as follows:

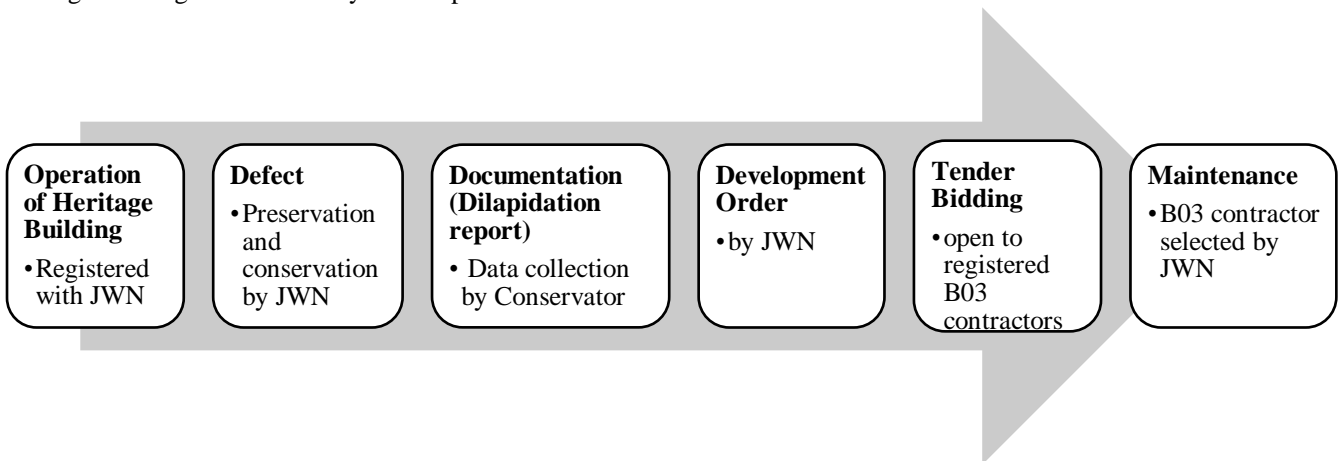


Fig. 3 - Current process of managing heritage buildings

Figure 3 above shows the current process of managing heritage buildings during the O&M phase starting from the activities performed to reach objectives during the operation of the heritage building itself. In order for the building to be categorized as a heritage building, the owner of the building needs to be registered with JWN and qualified according to the requirements stated in the National Heritage Act 2005. When the building has been registered, JWN is responsible for preserving and conserving it, including the minor defects, to maintain the originality of the building. Specialists are then appointed, generally a Conservator, to produce documentation namely the dilapidation report for the JWN review. Once the dilapidation report has been reviewed, a Development Order from JWN is undertaken for the conservation/preservation work and tender bidding starts where only B03-registered contractors are eligible to bid. Maintenance work starts when the contractor has been selected under the supervision of JWN.

		tiang keluli, keluda rasuk keluli, tiang keluli, seperti bumbung keluli dan portal frame.	pengurusan
B03	Pemulihan dan pemuliharaan	Kerja-kerja Pemulihan dan pemuliharaan bangunan Warisan / monumen bersejarah	Surat Tawaran Kerja dan Bukti Siap Kerja
B04	Kerja-kerja Pembinaan bangunan	Kerja-kerja Pembinaan apa-apa	Pengalaman / Personel Teknikal / Buks. Insanior. A1 /

Fig. 4 - B03 contractor scope of work

Source: Construction Industry Development Board of Malaysia (CIDB)

From the semi-structured interview conducted regarding current process of managing heritage buildings, the current process of managing heritage buildings is more detailed which consisted six (6) stages compared to literature review as Ali (2008) which involved only two (2) stages; data collection and processing. It can be concluded that HBIM process is tedious especially in terms of data collection where all respondents and Ali (2018) mentioned in order to organize data retrieved.

4.5 Challenges that Restrict the Implementation of BIM in Heritage Buildings

This section discusses the three (3) main challenges and barriers that occur in implementing BIM in heritage buildings in terms of **people**, **process**, and **technology**.

Table 5 - Challenges that restrict the implementation of BIM in heritage buildings

Challenge	Details	Respondents
People	Lack of knowledge and expertise.	R1, R2, R3, R4
	Paranoid and rigid attitude to new technology.	R5
Process	Documentation.	R1, R2, R3, R4
	Dragging-out time.	R5
Technology	Cost.	R1, R2, R3, R4, R5

Table 5 shows the challenges that restricted the implementation of BIM in heritage buildings for every category in terms of people, process, and technology. They have been summarized according to respondents' statements from the interviews. In terms of people, a majority of the respondents (R1, R2, R3, and R4) agreed that lack of knowledge and expertise are the main challenges that restrict BIM implementation. This can be noticed where the adoption of BIM for the construction industry in Malaysia is relatively low, unlike neighboring countries like Singapore. Meanwhile, R5 stated that paranoid and rigid attitudes to new technology is a challenge because people have adopted conventional methods and are not willing to change the process of work to one that is more advanced.

R5 further explained that the paranoid and rigid situation is the same one to be seen back in the late 1980s when AutoCAD was introduced in Malaysia and construction players still tended to produce drawings manually instead of using AutoCAD as they were paranoid about the advancement of technology and rigidly applied traditional methods, which took time. This is agreed by S.A. Shukor (2015) where developed countries such as the United States and in Europe are willingly adopting the technology; however, locals are still skeptical about the product of the tools/technology used in HBIM. Hence, the acceptance of new technology takes time, especially for senior staff who have become used to current manual practices.

The second challenge is the process where most of the respondents (R1, R2, R3, and R4) agreed that documentation is the main challenge, especially during the collection of the data to be keyed into the system. Since the heritage building was constructed at least 50 years ago, it is hard to determine and identify the types of material used for the building. Since the process of adopting BIM for heritage buildings is complicated and needs tedious work, it will drag out the time involved as noted by R5.

The third challenge is technology where all respondents (R1, R2, R3, R4, and R5) agreed that lack of funding to provide BIM facilities, such as servers, software and tools, is a significant problem. R1 further explained that the cost of the software itself is expensive especially since the software license needs to be renewed every year. Therefore, many organizations use alternative 'pirate software' to reduce the cost but later-on this will cause problems. The statement agreed by R4 notes the situation where an organization cannot provide a large number of BIM software seats as they are expensive.

All challenges that restricted the implementation of HBIM mentioned by respondents are agreed by Dore & Murphy (2017) and Antonopoulou (2017) in terms expertise and knowledge, documentation, and high cost for the tools and training itself. Therefore, it is crucial for Government and NGOs to take action in order to increase BIM awareness in Malaysian construction industry.

4.6 Solutions for the Implementation of BIM for Heritage Buildings

The purpose of this section is to identify the solution for the implementation of BIM for heritage buildings. From the challenges and barriers to this implementation, it is important to identify the activities that could improve BIM implementation among construction professionals, especially those involved with heritage buildings. Therefore, this section discusses the potential improvement that could be used to overcome these challenges and produce a strategy which can enhance and widen the usage of BIM, especially for heritage buildings.

Table 6 - Solutions for the implementation of BIM for Heritage Buildings

	Details	Respondents
1	Increase the awareness of BIM in Malaysia.	R1, R2, R3, R4
2	Provide sufficient funding for the facilities.	R1, R2, R4, R5
3	Collaboration with educational institutes.	R2
4	Strengthen the enforcement of BIM adoption.	R2, R5
5	Provide training for all generations in the construction industry.	R2, R5

Table 6 shows five (5) solutions for the implementation of BIM for heritage buildings as suggested by the respondents. Four (4) respondents (R1, R2, R3, and R4) stated that in order to cope with the challenges, the awareness of BIM concept needs to be increased so that construction professionals and the public are aware of the benefits of BIM for both new and existed buildings, including heritage buildings. This can be done, for example, by conducting seminars, media advertisements and other communication events.

The next solution is to provide sufficient funding for the facilities as agreed by the majority of the respondents (R1, R2, R4, and R5). R1 stated that BIM can bring lots of benefits for Malaysia's construction industry development but it is very expensive. On the other hand, Government has taken initiatives such as allocating grant to undergraduates by Multimedia Super Corridor (MSC), and Construction Industry Development Board of Malaysia (CIDB) collaboration with myBIM centre that provides BIM facilities and training which is called as Affordable BIM Training (ABT) in order to in line with CITP.

The third solution is collaboration with educational institutes due to the lack of exposure of construction-related undergraduates to BIM. R2 claimed that, in order to cope with the challenges of implementing BIM in terms of people, technology, and process, JKR has taken the initiative and drawn up a Memorandum of Understanding (MOU) with universities. With this initiative, undergraduates' exposure to, and knowledge of, BIM is paid for by their undergraduate fees. According to Kusin (2020), there are currently nine (9) public universities has signed MOU and collaborated with PWD: UMP, Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM), Universiti Teknologi MARA (UiTM), Universiti Malaysia Perlis (UniMAP), Universiti Tun Hussein Onn (UTHM), Universiti Malaya (UM), Universiti Teknologi Malaysia (UTM) and Universiti Kebangsaan Malaysia (UKM). From the collaboration, it may help PWD's initiative to bring BIM forward which has been recognize as one of the strategies to boost the productivity of Malaysian construction sector. This will reduce the cost when the undergraduates enter the construction industry by providing incentives for training.

Although JKR commercialised BIM in Malaysia in 2007, due to the lack of enforcement, the implementation is not advanced and the use of BIM is not widespread. Two respondents (R2 and R5) agreed that the regulated enforcement of BIM implementation for all projects, including heritage buildings, will overcome the challenges, especially in terms of people. Without the enforcement, construction players will not prioritize BIM so that BIM-uptake will be slow.

The next solution to overcoming the challenges of BIM implementation for heritage buildings is to provide training for both undergraduates and construction industry employees. Two respondents (R2 and R5) agreed that providing training will be eye-opening for the construction industry about the benefits of BIM. Thus, the training should not only be provided for the new generation, but also to senior staff. Therefore, both generations can work together to ensure that projects can be efficiently delivered.

In order to cope with the challenges BIM implementation of heritage building, various workshops, seminars and conferences spearheaded by CIDB since 2013 was one of the government's efforts to promote BIM technology to the AEC (Rosli et al., 2016). According to Brahim (2018), there are five (5) government-related bodies mandated in promoting the use of BIM among professionals: PWD, CIDB, PR1MA Corporation Malaysia (PR1MA), Multimedia Super Corridor (MSC) and the Construction Research Institute of Malaysia (CREAM). Therefore, it is crucial for these

government-related bodies to take action in order to increase awareness of BIM especially HBIM in Malaysian higher education and construction industry.

5. Conclusion and Further Works

From the findings from the interviews, it can be concluded that Malaysia is still lagging behind in terms of the use of BIM, especially its adoption for heritage buildings. Furthermore, the objectives for this research are achieved and it has shown that the success of BIM implementation for heritage buildings depends on the cost, which is initially high in order to provide training and improve the current facilities for BIM especially in the Malaysian construction industry. When construction players are well-trained and BIM facilities improved, it is not impossible for the BIM implementation for heritage buildings to accelerate in the near future. Further work will be carried out on the construction players' current practices in projects using BIM in the management of heritage buildings.

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