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Reviewing the Need for Historic Building Information Modelling (HBIM) in the Conservation of Heritage Buildings in Melaka World Heritage City

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Abstract: Historic Building Information Modelling (HBIM) is an emerging technology used for documentation and management of existing historic buildings. It is a process involving data capture, modelling or simulation of building elements and subsequent communication of information to relevant stakeholders all aimed at the efficient management of a historic building. A primary factor that led to the inscription of Melaka as a World Heritage Site (WHS) is its unique heritage buildings possessing immense architectural and historical values. A striking difference between a Heritage Building (HB) and a historic building is that unlike a lot of historic buildings, all HB's are legally declared to be conserved due to such values they possess. By the use of a literature review, extracted data will be subjectively reported on the need of HBIM in the conservation of HB's in Melaka WHS. Although, HB conservation guidelines in Melaka implicitly capture the need for the adoption of technology for an efficient conservation process, studies however, reveal that the process is not efficient. Furthermore, there is scarce literature in using emerging technology such as HBIM which has the potentials to efficiently manage the conservation of HB's similar to its function of efficiently managing historic buildings. As such, this study reviews literature on the potentials and/or advantages of HBIM with a view to suggesting the need to adopt similar technologies in documenting information in the conservation of HB's in Melaka WHS.

Key words: Conservation, heritage buildings, historic building information modelling, Melaka world heritage site, Malaysia

INTRODUCTION

Buildings undisputedly forms the broadest category and are the most common form of cultural heritage (Worthing and Bond, 2008). To pass for a building of cultural heritage however, a building must fulfil all criteria for designation entailed in statutory guidelines and other statutory requirements enforced in a country (such as the National Historic Preservation Act of the United States of America, 1966 and the National Heritage Act of Malaysia). Most of these criteria are however pinned to significances possessed by a building from a point of view of architecture or history. Owning to the significances possessed by both historic buildings and HB's, systematic management processes are employed to look after them. While both historic buildings and Heritage Buildings (HB's) require systematic management due to their significances, their difference however lies in the legal protection imposed on a HB by statutes as opposed to a historic building.

Historic Building Information Modelling (HBIM) has been employed as a state of the art tool for the efficient documentation of information for historic buildings. According to Oreni *et al*. (2013), HBIM is a tool that allows data of historic buildings to be fetched using survey technologies (such as laser-scanner point clouds, digital ortho-photo monitoring data) which is subsequently used to obtain a 3D model of the historic building in the form of a geo-referenced spatial information structure. Furthermore, HBIM enables stakeholders to remotely access information on a historic building whilst having the opportunity to discuss their opinions and findings (Mahdjoubi *et al*., 2013). An interesting thing about using HBIM is its potential to making traditional management of historic buildings more efficient.

Melaka is a historic city in Malaysia possessing an array of HB's that showcase Malaysia's almost 5 centuries (1511-1957) of colonial rule by the Portuguese, Dutch and British (Sodangi *et al*., 2014). The HB's in this historic city are unique in terms of their architectural, historical, cultural, spiritual, age and rarity and group-value among other significances. This ultimately enabled Melaka to be listed as a World Heritage Site (WHS) by United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 2008.

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According to Forster (2010), a HB must be legally declared to be protected under the approval of a government. This protection is referred to as conservation. Article 1.4 of the Burra Charter (hereinafter referred to as France, 1999) defines conservation as all processes of looking after a place (buildings and monuments among others) aimed at retaining its cultural heritage. As is obtained in National Heritage Act of Malaysia (hereinafter referred to Act 645, 2005) conservation of HB's may according to circumstances be in either of the following forms: maintenance; restoration; reconstruction; adaptation and stabilisation. Whichever form of conservation of HB's is adopted however, its sole aim is to protect the building with as little change as possible thus prolonging its lifespan.

Mansir and Kasim reported that conservation in Melaka has accorded several benefits (particularly after inscribing Melaka as a WHS) which have pulled tens of millions of tourists and generated revenues of tens of billions of Malaysian Ringgit. This has yielded significant impacts not only to Melaka but to Malaysia at large. While applauding such literature however reports that conservation of HB's in Malaysia is faced by several shortcomings regarding efficiency in documenting information which HBIM has addressed for historic buildings. For instance, Woon and Yoke (2010) report that information and documents pertaining to conservation work in Melaka and other parts of Malaysia is still lacking and as such, leads to difficulty in preparing complete working documents for the conservation works. They further report that the normal practice is that conservation professionals essentially modifies or adapts information or standards from new construction works to be used for conservation works. Although, this method is not totally incorrect, the problem with it lies in the fact that there is high risk of missing out important data which ultimately deviates from best practices obtainable using tools such as HBIM. As such this study seeks to review literature on the potentials and/or advantages of HBIM with a view to suggesting the need to adopt similar technologies in documenting information in the conservation of HB's in Melaka World Heritage Site.

Heritage buildings and their conservation in melaka: Most of this feat that enabled Melaka to achieve WHS acclaim can be attributed to Outstanding Universal Value (OUV) of its cultural heritage particularly its HB's. The HB's possessing these OUV's are located in the Core and Buffer Zone of Melaka WHS. In an attempt to safeguard the OUV of these HB's, conservation is a process that has been applied to achieve such. The subsequent sub-sections will provide a glimpse of topical issues in the conservation of HB's and how each issue is contextualised in Melaka.

Definition of heritage buildings: Act 645 (2005) defines a HB as "a building or group of separate or connected buildings listed in the heritage register which because of their architecture, their homogeneity or their place in the landscape, possess Outstanding Universal Value (OUV) that are striking from the point of view of history, art or science thus subject to legal protection". In another definition by Harun (2011), a HB is "a listed building built in the past which have high historical and architectural values and require continuous care and protection to preserve their aesthetic, archaeological, spiritual, social, political economic values". It can be noted from these definitions that in order to qualify for a HB, a building must not only be associated with some unique values but also must be subject to some degree of legal protection.

Classification of heritage buildings: Melaka has an array of HB's that have been around for centuries and showcase its diverse history. Table 1 depicts some among other HB's in Melaka that are still standing.

Some significance of these HB's in Melaka WHS that significantly enabled the achievement of global acclaim of the city as outlined in Malaysia (2007) are: cultural significance; historic significance; architectural significance; close historical association; significance of setting; group value; age and rarity value and physical features of the building. Relying on these significances, Malaysia categorises HB's into:

- Category 1: buildings registered as national heritage and gazetted under Act 645
- Category 2A: buildings of exceptional interest related to or associated with Category 1buildings
- Category 2B: buildings of special interest that warrant conservation

Table 1: Classification of heritage buildings in Melaka

Type of building	Building	Year built
Administrative	Stadthuys building	1650's
	Melaka Architecture Museum	1750's
	Melaka Stamp Museum	1750's
	Melaka Islamic Museum	1850's
Religious	St. Pauls Church	1512
	Cheng Hooon Teng Chinese Temple	1645
	Sri Poyyatha Indian Temple	1710
	Kampong Hulu Mosque	1726
	Christ Church	1753
	Kampong Keling Mosque	1748
	St Francis Xavier Church	1849
Institutional	St. Francis Institution Melaka	1906
Residential	Dutch style terraced houses	1700's
	Early shop-houses	1800's
	Munshi Abdullah Residence	1850's
Others	Porte de Santiago (A Famosa)	1548
	Dutch Cemetery	1750's

According to Malaysia, some of the HB's that fall within these categories in Melaka date back to the Portuguese colonisation period (1511-1641: 130 years), others since the Dutch colonisation period (1641-1795 and 1818-1824) and some since the British colonisation period (1795-1818; 1824-1957). It must be noted that the categorisation of a HB (sometimes referred to as classification or grading) is inspired by several factors which according to researches by Yaacob and that of Yvonne include: architectural interest; historical association; social value; group value and age and rarity among others.

Conservation of heritage buildings: Historically, conservation is traced to be practiced since the 17th century. However, events from the mid-20th and early 21st century (such as the two World Wars, civil unrests, global, environmental and economic challenges among others) have awakened modern conservation movements. In Malaysia in general and Melaka in particular, there has been a flourish in conservation especially with the advent of Melaka being listed as a World Heritage Site (WHS) by United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 2008.

The Burra Charter for Places of Cultural Significance (hereinafter referred to France) which is a comprehensive global guideline on HB conservation defines conservation as all processes of looking after a place (buildings and monuments among others) aimed at retaining its cultural heritage. Similarly, Randle defines conservation as the accepted term to describe actions regarding protecting buildings for future use. The Standards and Guide lines for the conservation of historic places in Canada (hereinafter referred to as Canada, 2010) also defines conservation as the process of looking after a building so that the functionality and significance is retained. In yet another definition, Zambri defines conservation as all actions aimed at safeguarding the character that define the elements of a building to retain its heritage value and extend its physical life.

In Malaysia, the highest epoch of statutory document that regulates conservation is Act 645. The interpretation of conservation in Act 645 (Section 2; 1) is: conservation includes maintenance, preservation, restoration, reconstruction, rehabilitation and adaptation or any combination. This interpretation is in line with how conservation is interpreted by Page and captured in several international conservation guidelines (such as France and Appleton Charter hereinafter referred to as France) among others. Within the context of HB's, irrespective of the type and interpretation of conservation, the process usually focuses on prevention of decay and management and documentation of dynamic change of a building for the future.

MATERIALS AND METHODS

Method of data collection and analysis: Data used in this study basically consists of secondary data sourced from textbooks, articles, thesis and policy documents. According to Ramele *et al.* (2010), in order to get basic knowledge about conservation in Melaka, statutory documents can be studied. As such, the statutory documents used for this research include: Charters of International Council on Monuments and Sites (ICOMOS); Guidelines for the conservation of HB's; and Archives from the World Heritage Office, Melaka. It must be emphasised here that the method adopted for data collection in this study is a literature review. Upon extracting data from the review, inferences will be drawn on HBIM and its need in the conservation of HB's in Melaka WHS. Subsequently, the inferences will be subjectively reported.

Historic building information modelling: The custodians of historic building are continually faced with the challenge of improving and standardising the effectiveness of conventional documentation of information. To address such challenge, HBIM is an emerging technology poised to offer reliable and effective solutions to such by way of digitising the information management process of a historic building. According to Murphy *et al.* (2013), HBIM is a novel solution process whereby interactive parametric objects representing historic building elements are architecturally constructed from historic data by accurately mapping out these elements onto a point cloud or image-based survey using advanced scientific rules for the production of architectural elements which support the design of parametric models. In another definition, HBIM is a recent solution for 3D parametric representation which enables the user to draw models and manage data of historic building elements within a common software environment (Oreni *et al.*, 2013). In yet another definition, HBIM is a tool that allows the combination of content information of historic buildings whose data is fetched using survey technologies (such as laser-scanner point clouds, digital orthophoto monitoring data). The data fetched for HBIM using survey technologies is further used to obtain a 3D model in the form of a geo-referenced spatial information structure (Pauwels *et al.*, 2008; Oreni *et al.*, 2013). These definitions clearly reveal that as is obtainable in to the

delivery of new building projects, emerging technologies can indeed be adopted and applied to historic buildings. Such paradigm shift brought about by HBIM has proved its ability to seamlessly facilitate the utilisation and sharing of information within stakeholders for an efficient management of a historic building.

Historic building information modelling process: Several authors have presented literature on the process of HBIM. According to Murphy *et al*. (2009), HBIM is a reverse engineering process consisting of the following stages:

- Remote collection of survey data using a terrestrial laser scanner combined with digital photo modelling
- Design and construction of a parametric library of objects
- Exchange of data through plug-ins within appropriate software platforms using Geometric Descriptive Language (GDL)
- Plotting of parametric objects onto the laser scan surveys as building components to create or form the entire 3D building model including detail behind the object's surface concerning its methods of construction and material make-up

In an improved study by Murphy *et al*. (2013), they proposed a new methodology for HBIM process which involves the following stages: collection and processing of laser/image survey data; identifying historic detail from architectural pattern books; building of parametric historic components/objects; correlation and mapping of parametric objects onto scan data and the final production of engineering survey drawings and documentation. Furthermore, as presented by Rua and Gil (2014), the HBIM process can be split into five sequential phases which are: data collection; architectural survey; data processing; digital modelling; and virtual modelling. Still yet, according to Barazzetti *et al*. (2015), HBIM consists of: brief site description and historical information;laser scanning data acquisition and processing; historic BIM generation from laser point clouds; finite element design; structural simulation. Similarly, Hong *et al*. (2015) reports that HBIM process entails four main sequential tasks which are: spatial measurement and acquisition of necessary data; geometric modelling; object recognition; and relationship modelling. All these HBIM processes presented basically fall into: data and information collection; modelling (design and simulation) and data communication. This is presented in Fig. 1.

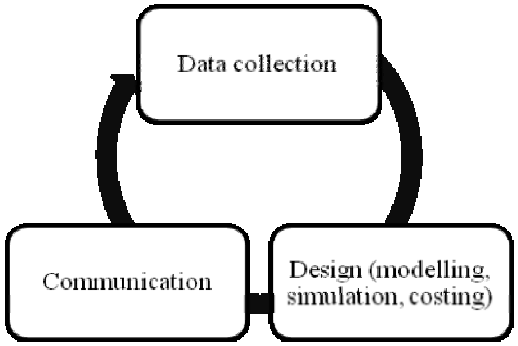

Fig. 1: Historic building information modelling process

Advantages of HBIM

Data and information collection: Heritage Buildings have a very complex geometry thus 3D documentation will be most appropriate to capture every detail. Documentation output is flexible. Imprecisions of existing drawings can be overcome. Establishing a digital archive involving different types of information, graphical and alphanumeric in the same database. End result provides automated documentation for precise conservation of architectural heritage. Integral digital representation of building information for different phases of the building lifecycle in the form of a data repository. Accelerate the data acquisition process and improve the accuracy of spatial measurements.

Design: Simulations can be performed quickly and performance benchmarked, enabling improved and innovative solutions. Environmental performance is more predictable; lifecycle costs are understood. Simulation capabilities for finite element analysis of large and complex structures. It performs advanced static and dynamic calculations including earthquake analysis. Structural anomalies are included in the simulation exhaustive description of the complex shape that characterises load-bearing elements. The ability to model different scenarios for the same space, representing distinct epochs, allows establishing a sequence of temporal evolution. Allow the addition of components based on the information of the construction process, which results in the creation of libraries of parametric objects. Whenever one component is modified, all others automatically adapt and conform to the new shape and/or position without having to remake the entire virtual model from the beginning (automatic updating). Growing number of techniques and algorithms that aim at handling unlimited, massive 3D point clouds. Enhance understanding of complex spatial and functional relationships in a historic city.

Communication: Information is more easily shared and can be value added and reused. Stakeholders have a common data protocol over any or all lifecycle phasesof a building's development. Opens up more opportunities for detailed information about buildings. The needs of different stakeholders can be met by the ability to combine easily and effectively visual information and/or its associated descriptive text at various levels of detail and length thereby generating a coherent overview of a HB which ultimately aids understanding of the whole conservation process.

From Fig. 1 data collection for HBIM is fetched using multiple sources like laser/image survey using laser point clouds, digital maps historic map data. Subsequently, elements or objects are designed and simulated from information obtained in data collection using 3D digital modelling software's. Furthermore, among other inputs, schedules are also designed and costs estimated. Finally, HBIM enables seamless communication through utilisation and sharing of information among numerous stakeholders.

Potentials of historic building information modelling: The adoption and application of HBIM in managing historic buildings has in it enormous potentials. For instance, Mahdjoubi *et al.* (2013) posits that emerging technologies have offered new possibilities for capturing, mapping and the analysis of multiple dimensions of building information used for efficient management of historic buildings. They further posit that the potentials of HBIM lies in its detailed scrutiny of historic buildings from several perspectives thereby adding a dimension to existing planning tools and traditional management processes.

As such, HBIM's potentials permit the co-relationship of data and information at many different levels of detail because possessing accurate records serves as a key potential for the efficient management of a historic building. The potentials of HBIM has revealed several advantages established in numerous works such as (Murphy *et al.*, 2013; Mahdjoubi *et al.*, 2013; Rua and Gil, 2014; Barazzetti *et al.*, 2015). These collective advantages are grouped according to the stages constituting the HBIM process earlier presented in Fig. 1.

RESULTS AND DISCUSSION

The need for historic building information modelling in conservation of heritage buildings: To qualify for a HB, a building must be statutorily subject to legal protection. In some cases however, historic buildings are not necessarily subjected to any legal protection. By inference, this might mean that HB's are considered more valuable than historic buildings. Sadly however, most researches on emerging technologies (such as HBIM) used for the efficient management of existing valuable buildings focus more on historic buildings than on HB's.

In the research of Mansir and Kasim, they report that conservation of HB's in Melaka has not only generated revenues of tens of billions of Malaysian Ringgit but also serves as a source of pulling tens of millions of tourists. Furthermore, they presented the benefits accrued from conservation of HB's in Melaka where they grouped them into:

- Employment benefits
- Heritage tourism benefits
- Property value benefits
- Small business incubation benefits
- Socio-cultural benefits
- Environmental benefits
- Non-priced benefits

In an effort to imbibe emerging technologies that will make conservation of HB's in Melaka more efficient, Malaysia reports that there is need to make full use of modern information and communication technology in conservation of HB's to ensure an appropriate and comprehensive use and implementation of a Conservation Plan. In yet another source, Malaysia stipulates that:

> "…with modern technology, digitalisation of conservation of HB's will be useful for dissemination of information of heritage. Digitalisation will also help to preserve knowledge that has been recorded through particular heritage elements. Existing HB's should be digitalised and conserved in such a way that allows information to be retrieved by different user's criteria"

On a guideline level, there seem to be the representation on the need to adopt emerging technologies (such as HBIM) for more efficient conservation of HB's in Melaka. However, Malaysia further reports that there is only very limited use at present of information and communication technology to store and use records relating to Melaka World Heritage Site. Similarly, going through literature, there exist scarce researches on the need to implement emerging technologies (such as HBIM) for the conservation of HB's in Malaysia generally and in Melaka in particular. This is evident from the assertion of Mohd Isa that

conservation in Malaysia is not being deemed as holistic. To address such statement as such using effective management tools (such as HBIM) will make the conservation of HB's in Malaysia in general and Melaka in particular more efficient. Considering the enormous benefits of HB conservation in Melaka on one hand and the potentials and advantages of reaped from the HBIM process on another (all presented against the backdrop), there is thus an immense need for adopting and implementing emerging technologies (such as HBIM) for more efficient conservation of HB's in Melaka.

CONCLUSION

This study initially presented literature ON HB's and their conservation in Melaka WHS. Subsequently, it reviewed Historic Building Information Modelling (HBIM) process and the potentials reaped from implementing it. Afterwards, while presenting the benefits reaped from the conservation of HB's in Melaka, the authors established the need for adopting HBIM technologies for a more efficient conservation of HB's in Melaka particularly due to its WHS status.

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