

Utilizing Building Information Modeling and Radio Frequency Identification in Recording and Preserving Historic Buildings

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Abstract

Preserving irreplaceable historic structures is an important factor in architecture design studies. The environmental, cultural and economic benefits cannot be overemphasized. We have an obligation to record and preserve the history of each generation because the buildings change with us. Historic buildings are not too complex to benefit from the advantages of building information modelling (BIM). BIM and RFID (Radio Frequency Identification) integration serve as a powerful tool useful across the lifespan of a building. RFID tag is a memory storage device for storing a certain amount of data—highly effective in decentralizing information management of historic buildings. The tags are attached to different components of the building that are of historic relevance. This information are accessible wirelessly providing the ability to process large volumes of multiple data sets simultaneously. Historically, buildings have been better and more accurately described in drawings rather than words and BIM is an extension of that process, particularly for existing infrastructure. Where 2D CAD improved on paper drawings by adding the ability to describe a building in layers, BIM and RFID allows the process to be taken further by increasing the efficiency of facility inspection, maintenance and data collection. Rudimentarily, BIM models are used to document historic buildings prior to any development, stabilization or investigative work are conducted in order to record crucial material evidence. Understanding how a building has changed over time is helpful in determining the level of deterioration. Data gained from investigations of a historic building are well documented and fed into RFID tags. In this study, options and decisions

necessary to establish a BIM and RFID for recording and preserving historic buildings are discussed along with a case study of Bopiliao Historic Block in Wanhua District, Taipei. As foreign students, when we discovered the physical, political and social threats on Bopiliao Historic Block, it is evident that it needs saving from various threats because it holds so much of historic value to the community and the country at large. A comprehensive data analysis was conducted to assimilate the current method used in preserving the historic structures.

Keywords –

BIM, historic buildings, preservation, RFID, Bopiliao Historic

1 Introduction

Historic preservation is the process of maintaining and managing change to a heritage asset in a way that sustains and where appropriate enhances its significance [1]. Heritage sites are living monuments & record of certain happenings and this is our real connection to our past. It proves the existence of our ancestors [2]. For years, historic preservationists have faced challenges in conserving some important historic structures. Governments, public and preservationists face dilemmas of conflicting interests that endangered many historic buildings. It is rare to have a single right answer, so adopting a consistent, rigorous process and adequate information are crucial to reaching publicly-justifiable decisions. This topic triggers series of factors to be considered howbeit, these does not change the importance of protecting historic elements. Preservation of historic buildings is a one-way street. There is no chance to renovate or to save a historic site once it's gone.

This reality brings to light the importance of locating and saving buildings of historic significance—because once a piece of history is destroyed, it is lost forever:

- People value this historic environments as part of their cultural and natural heritage. It reflects the knowledge, beliefs and traditions of diverse communities.
- It gives distinctiveness, meaning and quality to the places in which we live, providing a sense of continuity and a source of identity.
- It is a social and economic asset and a resource for learning and enjoyment. Each generation should therefore shape and sustain the historic environment in ways that allow people to use, enjoy and benefit from it, without compromising the ability of future generations to do the same. [3].

Building information modeling and radio frequency identification (BIM and RFID) seeks to integrate processes in preservation of historic buildings. The focus is to create and reuse consistent data storage and digital information by the stakeholders and transferring this information from generation to generation. According to UK conservation principles 2015, conservation involves people managing change to a significant place in its setting, in ways that sustain, reveal or reinforce its cultural and natural heritage values [3]. Is critical to the realization of preserving important historic buildings by utilizing this proposed conceptual approach to track changes by using a multi-disciplinary building information modeling and radio frequency identification. This will enhance the efficiency of historic building preservation and the authenticity of historic documentation.

2 Background

In order to limit the broad scope, this paper focused on documenting and management, maintaining/preserving historic buildings. Interoperability of BIM in different building life cycle (LC) stages and functionalities still is limited but studies have shown that it could fit perfectly with RFID in constant coordination in providing information especially in preservation of historic monuments. BIM functionalities require a certain accuracy, information richness and actuality of the underlying data to fulfill their purposes A frequently mentioned concept to describe information richness of BIM objects is 'Level of Detail' or also referred to as 'Level of Development' [4]. The scope and potential of BIM is ever-increasing as a result of new and IT-enabled approaches to facilitate design integrity, virtual prototyping, simulations, distributed access, retrieval, and maintenance of project data

between multiple disciplines. An important aspect of historic buildings that makes them important is how the elements emanate to be historic [the story] and that makes them worth preserving. Therefore, systematic and consistent information management—detailing the existence of a historic monument through times is a cardinal factor inspiring technology intervention to amplify the efficiency.

3 Problem Statement and Research Gaps

Several researches in the use of BIM concentrates in new architectures and rarely about preserving and maintaining historic architectures. A connection between historic preservation and BIM&RFID integration is important in both history and historic building preservation. Application of such technology in preserving historic building is very fundamental in preservation process. This study focuses on creating a rigid system that uses consistent data storage and retrieval in a form of digital information sharing with different stakeholders in historic building preservation— through a rigorous literature reviews, there is indication that this system has not been considered in (HBP).

In our previous research where an analyst of other systems of historic building preservation was done, there are some inconsistencies and inefficiencies in the way they operate especially data management, interoperability and ease of use. BIM and RFID integration is deemed to be of high efficiency in building information management throughout the life of the building. Due to a mainly interactive and time-consuming data capturing, processing and creation process, BIM modeling effort is high and thus BIM is often not applied in existing buildings yet, but the worth of preserving historic structures over shadows the complex nature of the system.

4 Research methodology

A theoretical review and analysis from previous literatures on existing building was used along with a case study of Bopiliao Historic Block in Wanhua District, Taipei to provide options and decisions necessary to establish a BIM and RFID for recording and preserving historic buildings. Several visits to the block was done to collect some information and an interview with the director of Center for Heritage and Culture Education have been conducted to document the state of the historic block, to understand what

methods have been used in recording, documenting and preserving the block.

4.1 Understanding BIM&RFID

What is building information modeling (BIM) and Radio frequency identification (RFID)? Building Information Modelling is emerging as a method for creating, sharing, exchanging and managing the information throughout the lifecycle of buildings. Radio Frequency Identification (RFID), on the other hand, has emerged as an automatic data collection technology, and has been used in different applications for the lifecycle management of facilities [5]. BIM and RFID integration functions as a central data depository for storing and recalling scores of information about buildings by creating an intelligent 3D model with data. BIM is not just utilized for 3D visualization but also imparts incredible intelligent functions. RFID is proposed to be used to store lifecycle and context aware information taken from a BIM during the lifecycle as a distributed database. RFID tags forms a loop between building components and BIM Data.

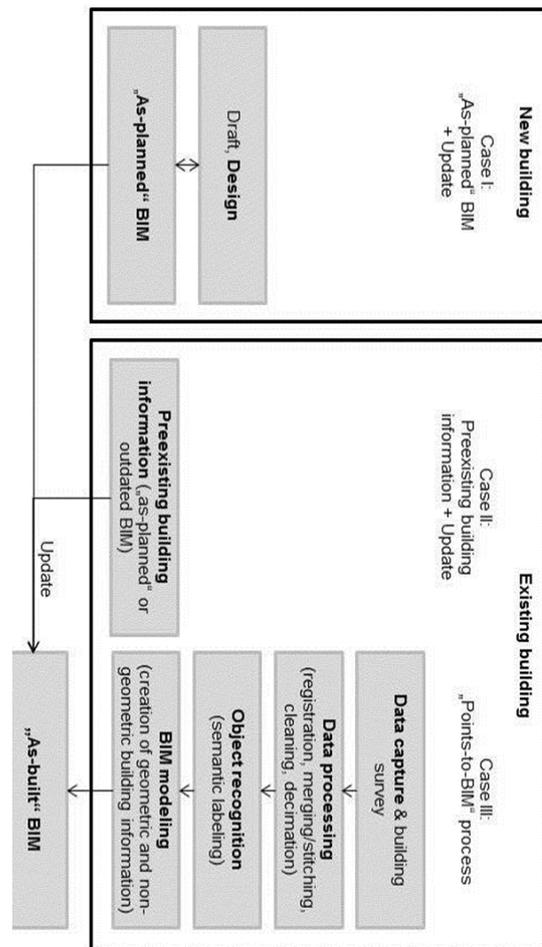
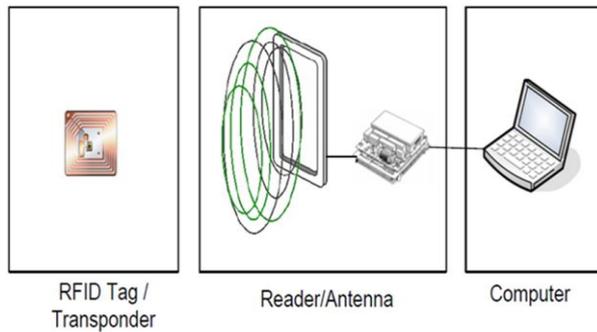


Figure 1. BIM creation processes for new and existing buildings, partly from Huber [6].

An RFID system consists of a transponder (tag), transceiver and antenna or coil. The tag is composed of a computer chip with an internal memory in which a limited amount of information can be stored. The set of transceiver and antenna is called reader and it can read and may write data from and on the tag holding information about the object attached to it by generating an electromagnetic field. This technology aims to decentralize objects' information by making it available wherever the component exists [7].

Figure 2. *RFID system* [8].

4.2 Informational issues and interoperability

Expert functionalities are linked with a BIM model through Information Delivery Manual (IDM) frameworks and Model View Definitions (MDV) providing relevant information, facilitating data exchange and avoiding ambiguities [9]. BIM process is used for new building rather than for existing building. This is related to the fact that existing buildings have many constraints to respect, considering the will to preserve the correspondence between the parametric model and the existing structure. Adding to this is the interoperability [10]. Existing buildings have a number of major difficulties than new buildings, but the use of new technologies mentioned above gives the opportunity for professionals to manage data, querying the 3D model through an iterative and interactive steps that characterize the BIM process.

This system will assist BIM and RFID integration in monitoring and recording details changes of historic buildings thereby maintaining their originality. In his deductions, Becerik-Gerber, recent technological advancements in field data acquisition technologies such as 3D Laser Scanning, Photogrammetry, Sensors, Radio Frequency Identification (RFID), and Tablet PCs have offered opportunities to address some of the disadvantages of current data collection practices. Data collected through such methods are stored in RFID tags on either buildings or specified historic components. Also, an interface is created that support information transmission and availability to different stake holders either encrypted or in open access format. The stored data can be as simple as an ID number or can be more complex.

4.3 Technical Issues

Geometrical and topological information of historic sites has to be gathered, modeled and complemented by semantic property/attribute

information manually. If a reliable data capture technique could provide an as-built BIM at reasonable time and cost, existing buildings could benefit from BIM usage e.g. regarding documentation, visualization or facility management to gather and model actual building conditions.....To create an as-built BIM. Building from scratch detailing every aspect of a historic element. Materials used, design aesthetics, façade types and every fabric of a historic edifice that has historic importance are simulated and incorporated into historic data. A comprehensive 3D, 2D CAD files with corresponding materials evidence of changes on historic buildings are captured, attached to a timeline and fed in to respective RFID tag.

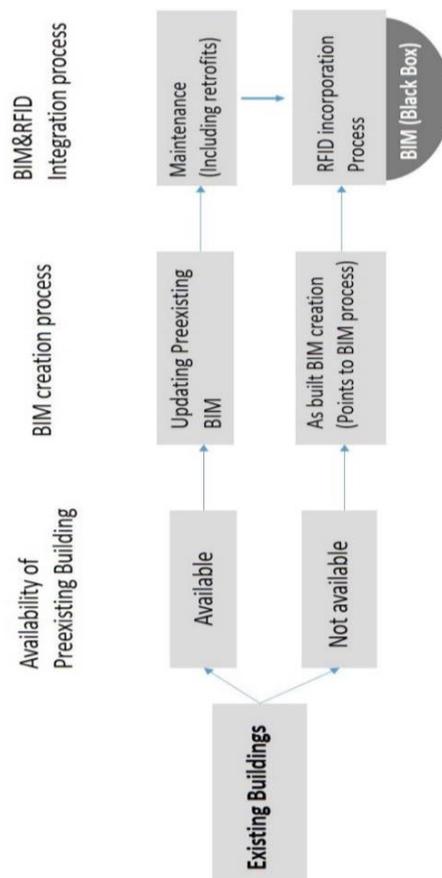


Figure 3. *BIM&RFID model creation processes in existing buildings depending on BIM availability.*

4.4 Case study

The need for utilizing BIM&RFID technology in (HBP) cannot be over emphasized. Preserving historic structures is very vital to modern day architects, researchers, historic preservationists and the future generation. As a result, a system like BIM&RFID integration that safeguard historic

buildings, data authenticity is highly encouraged to be employed. One of the factors influencing the value proposition of BIM in industry is the efficiency of interoperability solutions that provide flawless and streamlined information flow between different disciplines in a project, [9]. Historic data about Bopiliao Historic Block are mostly 2D cad drawings, word files, 2D images, deteriorating hard copy images.

4.4.1 Case Study, Bopiliao Historic Block

Bopiliao Historic Block is one of the key attractions of Wanhua District that portrays some of the oldest and most historical architectures in the modern city life of Taipei. With a long history dating back to 1799 when it was first known as

“Fupiliao” (福皮寮街), this street has been revamped, and officially opened to the public in 2009 again with a new appearance. Today, it serves not only as a preserved attraction popular among tourists but also a site that reminds and educates the locals of their traditional culture and history. This includes a wide range of traditional shop houses from the Qing dynasty (1683 - 1895) to buildings constructed during the Japanese occupation, (1895–1945) till early post war periods. [11].

According an interview with the officials on the site, the director of Center for Heritage and Culture Education, Mr. Chang reiterate that the management of the historic block took two forms i.e. preservation and rehabilitation.

- a) Preservation focuses on the maintenance stabilization, and repair of existing historic materials and retention of a property's form as it has evolved over time. Preservation only concentrates on
- b) Rehabilitation acknowledges the need to alter or add to a historic property to meet continuing or changing uses while retaining the properties of historic character.

Bopiliao historic block is a multicultural environment that upholds vital Taiwanese history in different periods making it a critical historic monument. The government diversified the use of the space for art exhibitions, shooting movies, wedding pictures and even advertisement videos; as a result boomed tourism in the area. Different opinions and demands impacted the evolution of the historic block.

Before adding a timeline to the historic block for preservation purposes, you must understand different period on the timeline and finally make conclusion base on reasons. Mr. Huang, restoring the block will depicts its characteristics at a particular period of time in history while removing evidence of other periods. This made restoration work tedious and

sometimes impossible to undertake. Some of the varieties of wall-types used over the life of the buildings includes, bamboo net walls plastered with hay-treated mud shown in figure.6a, to-ga (adobe), which is a mixture of rice straw as in figure.6b bricks and concrete. At a communal level and without the intervention of well-seasoned, skilled historic restoration experts, preserving the structure can get quite unwieldy. The preservation work today involves some uncanny methods like steel encasement as in figure.5b or adding extra layers of concrete as in figure.5c.

A closer look at the buildings on the block, it is evident that there are different material types used. Due to different rehabilitated phases or remodeling, different materials are been used on the facades. E.g. Cement, facial washed terrazzo, face bricks etc. —the combo material used depicts the evolution of the historic block over time. Some walls are made of wood, others of stone brick, and some are made of to-ga (adobe), which is a mixture of rice straw, lime, clay, and shredded old hemp sacks. The historic Block displays a lot of traditional architecture from Qing Dynasty includes wall engravings, clay embellishments, etc., Japanese colonial era onwards and has been preserved to this day (figure 4).



Figure 4. clay embellishments dated back since Ching dynasty



Figure 5. Samples of bricks and stones that were used on the block over centuries are still kept.

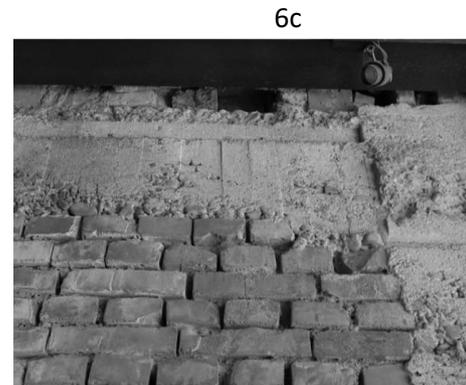


Figure 5. wall variety used over the life of the building includes, bamboo net walls plastered with hay-treated mud, adobe walls, bricks and concrete.

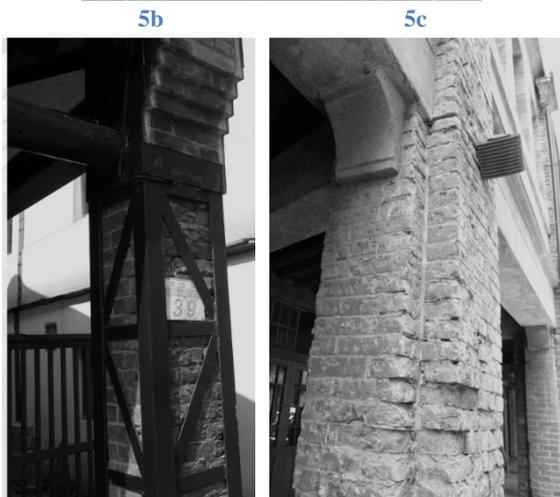
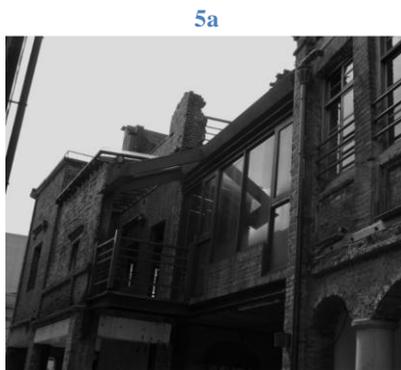


Figure 4. mixed of materials used on the historic building on different stages of renovation, steel frames were used to support the structure

Restoring the block to fit the current need or preserved to its original state is always a challenge and hard to come to a consensus among government, public and experts. One of the most important challenge is to get the required experts to restore the historic blocks to original form. Poor data management and record keeping has made this task very difficult. Mr. Chang, sometimes some parts of the buildings sustain damages inside, only when under renovation we could detect it. There is always going to be a problem if the damage needs expert to resolve the issue. Oftentimes, the maintenance is hard to be undertaken due to budget restriction. In most cases, we modify that part of the building despite clear restrictions of historic preservation. He added that it's really a good idea to have an efficient system, a technology that could make preservation and data management work easier. Once I faced a plumbing problem, I asked for a detail drawing of the utilities. But were very misleading and inaccurate, stopped me from fixing

it because I fear making mistakes and end up destroying important parts of the structure.

BIM technology could be used to virtually document the transition of this historic block through all phases of rehabilitation and obtained captured data are then transmitted to RFID tags for easy retrieval and usage. Utilizing BIM to virtually remodel the block according different time lines by collected data either through laser scanning, 3D integrated survey, hard copy images, old building models, descriptive text files, etc. Updating building systems in historic structures requires striking a balance between retaining original building features and accommodating new technologies and equipment. Building system updates require creativity to respect the original design and materials while meeting applicable codes and user needs. The system is could be used as an approach to track changes within a multi-disciplinary building information modeling environment could save the historic structures and a 400 years historic data that is on hand. Understanding what is at stake, the case study could be conclude that the local government is still learning and adopting new methods and technologies to enhance public infrastructure development in Taiwan and there is still a room for incorporating BIM&RFID technology in historic building preservation.

5 Conclusion

Although there must be a balance of consideration between the old and the new, historic structures with clear modern application through adaptive reuse resulting in cultural enlightenment of a community should be maintained, restored, and rehabilitated as part of historic preservation. From the case study and literature reviews, it is evident that there is a need to apply BIM&RFID framework in pursuit of augmenting historic building preservation process. The case study data shows that the methods adopted in preserving Bopiliao historic block is neither effectual nor constructive. The record keeping system could be updated to accommodate an efficient data collection and preservation system. BIM&RFID integration if utilized could revitalize historic data management, keep tabs on deteriorating old infrastructure. According our findings, the management faces financial challenges in adopting new methodologies. Understanding what is at stake, the government and stake holders should assist in providing support because;

- a. Preserving historic buildings plays a great role in cultural education. It teaches history that happened before we were born and promotes the

knowledge of those who lived in different times and different societies. Architectural monuments cultivates pride of our past and heritage making a community unique in the world. Historic buildings gives character and certain charm to a neighborhood that people live in.

- b. Economic factor could serve an important merit for keeping the old. Architectural monuments are great attractors of tourists. Everyone likes to experience the “spirit” of a place, which most often is represented through architecture and history behind it. Tourism provides jobs to locals with could earn them extra income. Restoring and preserving locally important historical structures generates workplaces for both local people, researchers, student and international experts. Preserving historic buildings require more skills and knowledge than simple building and thus result in higher salaries and also contribute to boosting the economy.

The challenges faced in maintaining and preserving historic monuments could be revolutionized by adding cutting-edge technology that minimizes or erase human defects and errors. Integration of RFID and BIM could create a chance to salvage our about-to-be-lost historic masterpieces by effective and efficient data management technology.

6 Acknowledgement

We would also like to thank the following experts who were involved in compiling data for this research project: Urban Planning Commissioner, Po-Wen Huang of Taiwan Urban Planning and Construction Agency, Ministry of Interior and Mr. Chin-Peng Chang Director of Heritage and Culture Education Center of Taipei City. Without their passionate participation and input, the data collection and interviews could not have been successfully conducted.

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