Available online at 2019.creative-construction-conference.com/proceedings/

CCC 2019

Proceedings of the Creative Construction Conference (2019) 123

Edited by: Miroslaw J. Skibniewski & Miklos Hajdu

https://doi.org/10.3311/CCC2019-123

Creative Construction Conference 2019, CCC 2019, 29 June - 2 July 2019, Budapest, Hungary

# Rethinking the Complex Refurbishment Project Attributes for Building Information Modelling (BIM) Adoption

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**Abstract**

*Uptake of Building Information Modelling (BIM) for complex refurbishment projects is foreseen as an essential resolution which will possibly increase the BIM adoption rate and eventually play a major role in transforming the construction industry. This anticipation is primarily based on the success of BIM with regards to complex construction operations, management, performance and productivity improvement. Various architecture, engineering and construction (AEC) key players have promoted the adoption of BIM and highlighted its significance in enhancing project delivery. Despite the envisaged benefits and feasibility of BIM adoption for complex refurbishment projects, many small and medium enterprises (SME) are still reluctant towards BIM. Though the incorporation of BIM in the New Zealand context is also similarly expected to move the construction industry forward, little has been reported in the literature to address the impact of refurbishment project attributes towards BIM adoption. A case study of tertiary education multipurpose facility project is adopted. Semi-structured interviews were conducted with informed project stakeholders and BIM experts outside the project based in New Zealand with the aim to identify refurbishment projects attribute and how it contributes to BIM adoption barriers for refurbishment project stakeholders in the construction industry in New Zealand. The benefit of this study is that it leverages the traditional refurbishment practice towards being BIM capable, and thus enable BIM uptake for refurbishment project stakeholders at the pre-maturity stage in New Zealand tertiary institutions.*



Peer-review under responsibility of the scientific committee of the Creative Construction Conference 2019.

*Keywords: Building Information Modelling (BIM); Refurbishment project attribute; Project stakeholders; BIM adoption barriers;*

## 1. Introduction

Building Information Modelling (BIM) is an emerging technology and its implementation is expected to lead to improved performance in construction processes throughout the life cycle of an existing building facility. Despite BIM benefits to construction projects [1], its delivery and uptake has been reported to be slow for existing building projects [2]. Anecdotal evidence reveal that the decline in uptake is due to project fragmentation [3], isolation, lack of collaboration and information sharing within the construction firms [4, 5]. Besides, the refurbishment projects are of risky essence [6], and very complex in nature [2, 4]. In addition, the U.K government, as part of enhancing adoption of BIM in the public sector earlier in 2016, targeted minimizing life cycle cost by 20% and 80% reduction in carbon by 2050 [7]. Similarly in Netherlands, BIM is now a mandatory requirement for governmental projects towards energy refurbishment, while in Denmark, the government requirement for BIM implementation since 2007 has influenced its use for energy efficiency target [8]. Considering New Zealand construction environment, a previous survey regarding BIM adoption affirmed that within construction organizations, 38 % used BIM for most projects, 20 % used BIM for

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few projects, while 42 % of organizations did not respond indicating low level of engagement in projects models among project stakeholders [9]. Although the need to investigate BIM relationships with attributes of projects to enhance BIM adoption potentials has been highlighted by [10-14], significantly, the project attributes can have different potentials to different organizations, projects or individuals [15]. In addition, the project attributes can give different results in different construction environment[16]. Hence, as BIM tool is generic [14, 16, 17], this means that these project attributes can be influenced by culture and collaborative environment for effective BIM adoption [14]. Therefore, the current authors believe that identifying the refurbishment project attributes in a given environment can be useful to understanding how to motivate adoption of BIM. Hence, this portrays the need to investigate refurbishment projects attributes to maximise BIM adoption [18]. Hence, the study aims at identifying the refurbishment project attributes for client-organisations such as tertiary institutions to address the potentials of BIM adoption for the multipurpose existing buildings in New Zealand. To achieve these objectives, this study starts with literature review of existing studies on BIM adoption for refurbishment projects and the discussion about project attributes and perceptions of refurbishment stakeholders in the New Zealand construction environment. Therefore, a descriptive interpretative research was conducted by using semi-structured interviews. This approach is suitable to allow the investigator to disallow presuppositions regarding the phenomenon in search of the true meanings and to have deeper understanding of the phenomenon as experienced by the experts.

## 2. Research Background

The potentials of BIM adoption is to improve the refurbishment work flows so as to mitigate cost overrun, critical decision and save time by project stakeholders [2]. There are authors that have contributed to BIM adoption study for refurbishment project. Volk, Stengel [19] focused on the technical problems related to BIM implementation. This includes updating and handling of uncertainty of data information of BIM in existing buildings. Also, a study proposed a framework to understand tools and drivers that motivate BIM adoption for refurbishment projects [20, 21]. In addition, another study also focused on the clients as homeowners preferences and how it influences BIM adoption for refurbishment projects [5]. Essentially, homeowners' choice is mainly "cost" against the method of refurbishment as "thermal performance" preferred by contractors. Furthermore, there is an investigation for the essential barriers to hinder BIM adoption for housing refurbishment [22]. The barriers are twofold; the first is from the clients indicating lack of knowledge about refurbishment technologies, while the second is the construction professionals indicating lack of skills, and fragmented practices. Therefore, these construction professionals may underestimate the real BIM benefit for refurbishment projects. Although one benefit of BIM for refurbishment project is that it enables life cycle data management which facility managers (FM) can use to maintain an existing facility [3], [19] suggested that there are hindrances to adoption of BIM for existing buildings considering the lack of research to investigate the bottleneck barriers for refurbishment stakeholders and facility managers (FM) in adopting BIM for existing building facilities. While a previous study is of the view that the bottleneck barriers is due to low participations of FM and refurbishment stakeholders towards the development of strategies to adopt BIM for refurbishment projects [23], other authors believe that the main barriers relies on the type of attributes identified on different construction and refurbishment projects [10-14].

## 3. Methods

This study adopted a semi-structured interview by allowing the respondent to actively engage them to sharing their views using their own terms [24]. The respondents are the experts in construction industries in New Zealand. Considering the limited nature of expert in refurbishment project execution and with BIM experience, a case study refurbishment project and snowball approach was adapted. The first approach was to identify a refurbishment project case study whereby its previous operation contains a number of stakeholders that were involved in its execution. The second approach was to identify the potential stakeholders with deeper knowledge in refurbishment project execution in tertiary institutions in New Zealand. The refurbishment project case study is a multi-purpose building facility in a tertiary institution in Auckland. This project was selected based on the difficulties and challenges during its execution. Although, the project was fast tracked, there were many loses and uncertainties during the project execution. Request for interview participations was sent out, the initial interviewers suggested potential participants. In total, 14 people

were interviewed that accepted our interview request. This sample size is considered appropriate for the sample size as [25] affirmed that 12 interviews are sufficed to achieve saturation. Therefore, this study employs a descriptive interpretative research to understand the project attributes of refurbishment project and to formulate mitigation plan to enhance BIM adoption. According to [26], a descriptive interpretative methodology seeks to extract meaning from the experiences of several refurbishment professionals. This process allows a deeper understanding of individuals experience about refurbishment barriers and setbacks to BIM adoption. This is because poorly conceptions can be prevented when the researcher is in active inquiry with the participants [27]. The research participants were interviewed according to their individual preferences for example is by the use of face-to-face interview, and online communication tool platform through Skype. The interviews were held in Auckland, New Zealand. Before conducting the qualitative interview, approval was sought from the [28]. This was to protect the safety, privacy, health, welfare and social sensitivities of the various participants involved in the provision of research data. Table 1 details the demographic representation of the research participants
The interviews have been recorded with recording device both for face-to-face interview and the skype interviews. The transcription of the audio interview into text write up was done manually by the researcher. The interview transcripts were categorized based on the simple themes and analyzed using a pattern coding technique.

Table 1: over view of the participant demographic information

| CODE | Categories of participants | No of experts | Years of experience |
|---|---|---|---|
| PM1, PM2 | Project Managers | 2 | 5 – 12 |
| MC | Main Contractor | 2 | 8 – 15 |
| SB1, SB2 | Sub-contractors | 2 | 10 – 16 |
| M1, M2, M2 | BIM Managers | 4 | 4 – 8 |
| C1, C2 | Consultants | 2 | 10 – 22 |
| AR1, AR2 | Architects | 2 | 8 – 15 |
| CR | Client representative | 1 | 8 – 12 |
| SU | Space Users | 3 | 6 – 10 |
| Total | | 18 | |

The demographics of the participants reveal different levels of experience, and the categories of participants majorly from client organisation (tertiary institution). This could enhance the transferability of the results to readers for their applications, and this can promote the validity and reliability of findings [29]. Adequate care was put in place in order to avoid mistakes during the transcript transcribing stage [30].

## 4. Results and Discussion

For a descriptive interpretative research, the analyses are semi-structured, and therefore the qualitative interview starts with open questions that allow the opportunity for the interviewer to explore themes or responses further [31]. However, thematic analysis was carried out with suitable coding scheme to identify units of meaning from the main statements and are classified into recurring themes. In this section, three reoccurring themes were analysed: The nature of refurbishment projects in tertiary institution in New Zealand; The challenges of refurbishment project to motivate BIM adoption; the solution to adopt BIM to solve refurbishment project problems.

### *4.1. The characteristics of refurbishment projects?*

All the interviewees were asked to briefly describe the nature of refurbishment projects they have participated for organisations such as in tertiary institution.

*4.1.1 There is a periodic refurbishment for most of the existing buildings*.

All the respondents stated that most of the existing buildings are multipurpose building and can be refurbished annually due to several demands by clients or organisation and government. Such demands as highlighted by the participants includes; “Many tertiary institutions would want to meet up with the international learning standards. So, there is the

tendency that such organisations will embrace modern methods changes and teaching methods, and as well, try to embrace a collaborative modern and open learning method between different groups and learners […]

A similar number of participants noted that during there are other attributes persistent in the management of refurbishment projects. For example, half of the participants indicated that "there are lot of stakeholders and user involvement to determine a particular layout […] In addition, all the participants also highlighted that "There is lack of ability to communicate new layout to who will be occupying these spaces […]

*4.1.2 There is always lack of building information***.**

All the participant indicated that "There are lots of refurbishment project which are starting with poor building information […] one of the participants also stated that "as a consultant, there are lots of uncertainties to encounter which affects some stakeholders like the contractors who mainly bears the risks during the construction stage […] while another participant explained that "as a sub-contractor, I think that refurbishment projects has thoroughly unknown factors […]

*4.1.3 There is fear on the cost of BIM.*

Majority of the participants highlighted that most stakeholders tends to avoid BIM adoption due to fear of the cost for BIM. For example, "A lot of things come back to old buildings. Existing buildings in the past 15 years are not done with BIM. There may be design document that are not suitable for design activities for refurbishment project. Old tradition is not very efficient especially when it involves manual measures, and these tend to be expensive to upgrade with BIM. These days, traditional method is prone to error. Added that most refurbishment project starts with poor project information […]

Hence, the research participants concluded that with the typical nature of these refurbishment project, there is always poor assumptions and the most significant in New Zealand is that of typical project duration when doing a refurbishment of existing building.

### *4.2. The challenges of refurbishment project that motivates BIM adoption?*

To gain deeper understanding on the nature of the refurbishment projects as found in tertiary institutions in New Zealand, interviewees were asked how the nature of complex refurbishment projects influence BIM adoption for existing buildings.

*4.2.1 Poor project collaboration*

The participants believe that to improve collaboration is very significant in this venture. According to a participant: "It is about working with good team. When all get on to a common goal, it is easier to manage these unknowns [...] Hence, as long as you have positive approach and people you work with have the same positive attitude in a rewarding environment is what matters. If not, the unknowns will create huge problems for the stakeholders. While another participant: indicated that "I do think that the personality and experience of the people involved brings out a greater outcome […] The interviewees opinions are in line with previous authors that effective collaboration is an essential tool for improved project performance and supports the view of [32] for improved collaboration for project stakeholders. Also, according to [33], team communication and collaboration is critical to the success of building construction. Considering previous knowledge on BIM adoption for refurbishment project [5, 34, 35],

*4.2.2 Peoples attitude*

The attitude to technology adoption is still a challenge. Many of the participant highlighted that: "if you bring a really rigid attitude to technology, and you are a perfectionist, you are going to be really upset about that, but if you are flexible, adaptable and you understand, and you think quickly and carefully what alternatives are, you definitely get a good outcome […] Half of the participant observed that: Most contractors may not be honest to the cost of the project and therefore they tend to cut down the cost of the project to ensure that the project is awarded to them […] Another participants supported by saying that:
"The cut down cost impact on the finishing trades and interior trades, so they try to recover some of their lost time and the programmes are quite regularly cut […]

*4.2.3 Lack of skills*

Many of the participants emphasized there are still skill shortages to manage refurbishment projects and these impacts on accepting new technology for maximum project performance: "Restructuring older houses with older technique to a new technique can be very challenging […] Hence, most of the document produced in a traditional method lacks complete as-built documentation. Another interviewee who supported in view stated that: "Most old buildings have not been done with BIM especially in the past 15 years. Starting with documentation, most of these documentations are not suitable for refurbishment project execution […]

*4.2.4 Poor project documentation*

All the participant highlighted that: "there are lot of refurbishment project which are starting with poor building information. Which means BIM is a significant requirement for upfront investment in acquisition of building information. For example "One thing we care for is having a complete information for all the stakeholders but when the information is unavailable, there will be delay in execution of projects […] Consequently, the participants believed that when this information is not properly managed, it results to project difficulties. Two other participants supported: "There are a lot of assumptions, or incomplete records of buildings. There is incomplete information most times, and it takes time to obtain this information […] Hence, the lack of information and management may have effect on the integrity of project outcome from the view of few participants: "When a program is drawn, and there is lack of information, this will cause delays […] "Based on the provided traditional building information, the contractor makes assumption based on the uncertainties and when these does not go as expected, the contractor will start to lose money […]

*4.2.5 Nature and scope of the refurbishment project.*

About one-third of the participant believed that adoption of BIM for refurbishment project should be relied on the building type. For instance: "It depends on the type of building to be refurbished and also by case by case and quality of building […] "It all depend on the nature of scope of the refurbishment project entails […] "It depends on the nature of the building that is being refurbished, I think some are risky than others, and older building might have hidden secrets and problems within them and with poor infrastructure, like rewiring that you submit for needs doing or foundation extra works, compared to a new building where it might be what one could call a "lacking of promise of paid jobs and a better of do-ups […]

### *4.3. The solutions towards adoption of BIM for refurbishment projects*

As highlighted by the participant, there are several ways to increase BIM adoption. These has been discussed under the following paragraph;

There is a need to develop program and assessment criteria to check each stage. For instance: "At the start of every project, there should be something called the BIM execution plan. Where this is not set up at the early stage can be a huge risk *"Establish a program, list a set of mile stone to adopt BIM for the project and set up an assessment to check each stage"* These was in line with a previous author regarding using a development assessment criteria to improve the issues of cloud in BIM Alreshidi, Mourshed [32].

The laser scanner can be used to pick points. This would be more efficient according to the participants when the whole ceiling is turned apart for manual measuring for example. While few of participants argue that the main thing is uncovering the unexpected, majority of participant believed that physically, they can try to mitigate that by ensuring that the point cloud is done. In this way, the main users can trash so much about those issues about coordination and ensuring that the proposed signs does align with the physical building that exist on the site and the way to mitigate that is modelling the existing building and the point cloud carries the information about the existing building.

Develop a positive culture. Majority of the participants has concern about positive culture in our industries towards innovation such as BIM: *"I think, you need good team people, a positive culture. You also need to have good document to reduce the risks"* The first thing is about the leadership of the project. So, the key players need to have good

communication. Creating a good culture of communication and perhaps addressing these things at the beginning of the project that these are the way we work, meeting times etc.

Focus on the building section that require refurbishment other than the whole entire building complex: "In the past, as highlighted by a participant, the whole building model is done for a whole existing building, these are not necessary, it increases the cost of BIM, and makes the model to lack focus at that moment. *"BIM should be implemented for that particular level of the building, where the refurbishment is to be taken place"*. This would help the stakeholders to produce a better-quality model, and with less cost. The laser scanner can merge these parts refurbishments point clouds capture to become one full building model. This contrasts [34] BIM adoption framework, who suggested whole building modelling which can make the BIM implementation very expensive.

The time frame should be made more accommodating to work out a program for the refurbishment project BIM adoption effectiveness. Hence, instead of minor capital work done yearly, it can be run on two-yearly bases. So, when the contractors are pricing the project, they do that for two years' time bases, hence, they can give room for a lot of BIM consideration. This will help to get the outcome before the project starts. The short time frame also plays a part to neglect BIM adoption decision.

Make BIM an obligation to enhance adoption of BIM for refurbishment projects. For the educational institution facilities, it is important to use this as a new technology, as a kind of obligation for the students. Moreover, city council in New Zealand can also incorporate BIM as a regulatory factor during the consent. Hence, to improve the level of adoption for BIM, there should be a legislature to mandate BIM into law.

Finally, by considering these processes remains a better avenue to motivate adoption of BIM for refurbishment projects in New Zealand. Starting from the complex buildings in tertiary institutions as found in New Zealand, these existing buildings are refurbished periodically to suit a particular purpose and demands a high-performance standard. Majority of these houses are traditionally managed. The client organisations who manage these buildings should make effort to consider engaging with their refurbishment stakeholders to consider adoption of BIM for the management of their existing buildings in tertiary institutions. Furthermore, New Zealand government should also consider making a stronger awareness on the existing buildings in tertiary institutions through authorising BIM for every existing building in New Zealand tertiary institutions.

## 5. Conclusion

This paper examined the characteristics of refurbishment projects and how its attributes contributes to BIM adoption barriers. The results show that despite most of the complex buildings in tertiary institutions are refurbished annually with traditional methods, there are still many challenges faced by her project stakeholders in managing these existing projects. BIM adoption can leverage the potential to improve the performance of these projects. However, the study pointed out several stakeholders' traits which impacts on BIM adoption including, people's attitude, lack of skills and expertise, lack of information management, lack of openness, and nature and scope of refurbishment projects. The study also offered solutions to BIM adoption such as (1) Develop a programme and assessment criteria, (2) Adopt tools for information sharing/collaboration, (3) Develop a positive culture, (4) Re-address project timeframe, (5) Focus the laser scanner survey on the required space for refurbishment, and (6) Make new policies for BIM adoption motivation. This research contributes to the current knowledge on BIM adoption for refurbishment projects by providing solutions to client organisations, and FM in tertiary institutions in New Zealand and other stakeholders that refurbishes multipurpose buildings for the formulation of effective strategies to adopt BIM. Further studies will investigate the real benefits of BIM for refurbishment project stakeholders.

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