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Awareness of Building Information Modeling Implementation in Retrofitting the Existing Residential Building in Malaysia

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Abstract. Building Information Modeling (BIM) is a new paradigm in the architecture, engineering, and construction industry in Malaysia. In the literature, there are numerous reviews of BIM implementation on new buildings, while the BIM application in retrofitting existing buildings is rather disregarded yet. Only limited research has investigated the use of the potential of BIM in residential retrofit projects. This study seeks to investigate the current status of implementation of BIM for retrofitting residential buildings practicality. The research used the questionnaire as a quantitative method to collect data in the current study. One hundred twelve professionals were chosen for this study, and the response rate was 49 percent (55 respondents). The sample of the questionnaire survey consists of the academic experts and construction engineers and architects, BIM software designers, and construction organizations in Malaysia. The data collected through the respondents are analyzed using the Statistical Package for the Social Sciences software (SPSS Version 22). The results revealed that most of the respondents (47.3%) have a low level of awareness about BIM, and the majority of the respondents (29.1%) do not use BIM in their projects. Based on the investigation, the adoption of BIM residential buildings is timely. The most common obstacles to the BIM adoption for residential retrofit are the lack of customer demand, high initial investments, and lack of standards. In conclusion, this research provides information about the feasibility of BIM adoption for retrofitting the existing residential building. It is expected that this knowledge could be useful for BIM development and tackle barriers regarding BIM adoption in the Malaysia construction sector.

1. Introduction

Although the Malaysian construction industry plays a critical role in the economy, it needs to develop in the era of globalization gradually. The construction industry has not changed much in terms of technology or construction approach since 1960 and still be led by traditional methods. Therefore, this sector must upgrade the existing construction approach concerning technology, practice, and management to be worldwide competitive [1].

In recent years, the construction companies have been interested in using BIM in their projects due to many advantages during all stages of new building construction [2,3]. Few industries began the Improvement of 3-D modeling, based on the early computer-aided design (CAD) during the 1970s.

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BIM was utilized in pilot projects in the mid-2000s [4] to support architects and engineers in building design. Most BIM research trends concentrated on improving planning and design, visualizing, detecting clashes, costing, and data management [5, 6].

BIM implementation has been widely spread in the architecture, engineering and construction (AEC) industries in most developed and developing countries such as Australia, the United States, Hong Kong, Finland, Denmark, and Singapore [2, 7-10]. The government of these countries has started to mandate the utilization of BIM in their projects. For example, the Public Procurement Service of Singapore made BIM mandatory for all construction projects over S$50 million and for all public projects by 2016 [11]. However, the implementation of BIM in the Malaysian construction sector is relatively new [12, 13]. Moreover, there is an absence of proof to indicate the engagement of construction companies in projects using BIM. There are only a few studies that investigated the implementation of BIM in the construction industry of Malaysia generally [14]. This paper has focused on exploring the status of BIM in the Malaysian construction industry comprising public and private sectors. It has also investigated the feasibility of the implementation of BIM for retrofitting residential buildings.

2. Literature Review

2.1. Existing Residential Building in Malaysia

Today, Malaysia's construction industry is rapidly showing growth and increment in the country's economic growth. Moreover, current on-going mega projects of green buildings and newly-announced projects offer the promise to earmark sustainable city and living in Malaysia. However, the construction of a new green building only represents a small proportion of total buildings in Malaysia, while existing buildings portray all buildings [15]. Figure 1 summarizes the existing residential buildings in Malaysia for 2018, and the numbers are going to increase in the following years [16]. Some of these buildings have remained for many years or even decades in Malaysia, and most were not built concerning energy efficiency and sustainable [17].

Review Period	States	Single Storey Terrace	2 - 3 Storey Terrace	Single Storey Semi-Detach	2 - 3 Storey Semi-Detach	Detach	Town House	Cluster	Low Cost House	Low Cost Flat	Flat	Condominium/ Apartment	Total
EXISTING STOCK													
Q3 2018*	W.P. Kuala Lumpur	17,153	66,924	506	6,391	7,079	5,398	1,698	6,172	100,037	35,330	230,611	477,299
	W.P. Putrajaya	0	2,102	0	1,005	203	96	0	0	0	2,538	6,668	12,612
	W.P. Labuan	936	1,118	98	974	5,140	11	0	1,264	692	1,312	896	12,441
	Selangor	168,177	468,549	15,280	47,698	61,268	20,811	10,761	95,188	182,718	104,508	352,535	1,527,493
	Johor	192,921	212,441	23,844	21,804	63,893	1,393	9,723	151,989	50,200	24,279	55,796	808,283
	Pulau Pinang	49,259	72,766	10,156	19,830	77,174	2,795	3,762	18,054	62,545	106,562	83,693	506,596
	Perak	138,475	109,753	24,192	14,239	73,443	2,277	2,631	85,543	8,269	4,573	12,638	476,033
	Negeri Sembilan	95,655	56,097	11,384	6,559	33,474	2,656	3,971	29,534	6,393	8,212	13,614	267,549
	Melaka	67,160	34,486	10,450	6,104	12,386	1,535	1,154	33,605	3,336	8,245	12,435	190,896
	Kedah	86,305	33,555	53,499	16,646	26,164	208	622	101,035	6,742	998	2,288	328,062
	Pahang	76,887	29,811	21,433	5,678	58,705	271	252	60,277	4,884	3,690	9,739	271,627
	Terengganu	19,490	7,305	10,532	3,100	31,323	154	104	20,051	5,951	826	1,237	100,073
	Kelantan	24,948	6,795	2,928	965	12,937	0	172	26,976	813	1,221	2,531	80,286
	Perlis	7,082	1,430	4,258	935	738	0	0	9,098	1,378	396	480	25,795
	Sabah	23,664	51,097	3,542	13,134	5,873	840	852	20,762	28,047	14,319	49,878	212,008
	Sarawak	65,715	72,847	12,093	31,189	10,984	1,002	1,037	25,920	8,244	5,790	18,376	253,197
	MALAYSIA	1,033,827	1,227,076	204,195	196,251	480,784	39,447	36,739	685,468	470,249	322,799	853,415	5,550,250

Figure 1. Residential units by type in Malaysia (Source: National Property Information Centre (NAPIC)).

There is empirical evidence that existing residential buildings are one of the significant greenhouse gas (GHG) emitters and heavy energy consumers [18-20]. A study made by LaSalle in 2010 found retrofitting at least 80 percent of existing buildings has enormous potential to achieve a reduction in the country's emission target by the year 2020 compared to focusing on new buildings [21]. Existing buildings are one of the main drivers for excessive energy consumption in Malaysia because when the building gets older, it demands more energy for building operation as its performance level has decreased over time [22]. On the other hand, the demolition project of the existing building for new construction will generate more waste as demolition waste is double the amount of construction waste [23]. The wastes collected in Malaysia are usually dumped in the landfill, which will lead to the economy, environment, and social problems [24].

2.2. BIM Application for Retrofitting Existing Buildings

One of the important and influential sections that can manage and handle Malaysia's economy is the Malaysian construction industry. Apart from the vital role of the construction industry, it as ben listed as the lowest economic productiveness levels due to the lack of adopting new technologies and efficient operations [25]. Hence, accepting and applying new technology and developed construction, like information and communications technology (ICT), as the right way will push and keep the industry for long-lasting global competitiveness in the target.

The Malaysian Construction Industry Development Board (CIDB), developed the Construction Industry Transformation Programme (CITP) to authorize and strengthen the construction sector as espoused in the pushes of the 11th Malaysia Plan [26]. The main aim of CITP is to prepare the Malaysian construction sector for competition at the world level. CITP promotes the adoption of productivity-enhancing IT construction, such as Building Information Modelling (BIM), which will modify the industry into new techniques of design, construction, and maintenance of buildings. CIDB defined BIM is one of the new emerging technologies to be deployed in the design, construction, and facility management, where a digital representation of the building is created to facilitate the exchange and interoperability of information in digital format [27]. BIM is admitted as a modern ICT with the capability of changing the construction industry by increasing proficiency, quality, and productiveness. Public Work Department (PWD) presented and launched BIM among construction participants in Malaysia since early 2007[14]. PWD implemented several BIM projects such as Primary School of Meru Raya, at Ipoh, Perak, and Primary School of Tanjung Minyak at Melaka, Administration Complex of Suruhanjaya Pencegah Rasuah Malaysia (SPRM) at Shah Alam, Selangor and Healthcare Centre Type 5 at Maran, Pahang [9].

The BIM process evolves in a few stages is identified by the level of collaboration. The range of levels is described as BIM maturity levels from Level zero to Level 3 (including; Manual 2D CAD, 3D Modeling, Collaboration-based 3D Model, and Full Integration). Presently, BIM adoption in the Malaysian construction industry is at stage one [26]. This stage is attained when BIM-based software is used within only one discipline. Engaged construction industry participants in government plans with a value of more than 100 million will be demanded to gain a minimum of forty percent growth rate of performing stage 2 BIM by 2020. Stage 2 BIM adaptation requires two or more disciplines to collaborate through the usage of BIM-based software [26].

Although the government of Malaysia has made many efforts to enhance BIM implementation in construction projects, however, the technology adoption rate is slow when compared to other countries of the world. This could be happened due to barriers such as; high cost of technology, high training cost, lack of BIM knowledge, high cost of software, and Insufficient BIM training [9].

Most research about ICT, application software, and data exchange methods are focusing on new construction projects, and there are lacking studies of retrofit related processes [28]. The perception given is that BIM is interconnected in all process of new construction (design, management, etc.), while less interrelated with existing buildings [29].

The specific review of the literature, including BIM standards and guidelines and review of academic publications, revealed that planning, design, construction, operation, and maintenance are the most concerning factors in BIM standards and guidelines. Although Retrofit is useful, especially in sustainability, unfortunately, there are limited standards, rules of thumbs, and academic publication in these two extents. Concisely apart from the existence of several expanding research upon the use of BIM in different phases of the projects, there is a lack of studies about how BIM might be used practically in retrofit [30, 31]. Therefore, exploratory research was conducted to examine the feasibleness of BIM employment in the housing retrofit projects to fill this gap.

3. Research Methodology

A questionnaire survey is adopted in the current study to collect related and suitable information. The questionnaire is a tool to obtain the most related and essential data from selected respondents. One of the advantages of the questionnaire survey is time-saving, which helps to collect a vast amount of data in a shorter time. The preparing, distributing, and tabulating of responses is also easier, and it makes respondents more comfortable to answer the question faster [32].

The questionnaire survey, as quantitative survey research, was conducted to determine BIM's suitability for the residential retrofit project [33], because BIM has been rarely used for residential retrofit plans in Malaysia.

A sample refers to a group of people, units, or things that have common characteristics of interested in researchers [34]. The sample of this study consists of 112 professionals include academic experts, and construction engineers and architects, BIM software designers, and construction organizations as a population. The convenience sampling method was used to select Kuala Lumpur and Johor Bahru in Malaysia as a scope of study due to time investing and cost investing and the researcher convenience. The Questionnaire was designed to investigate and cover three subjects about BIM, including 1) awareness and present status, 2) challenges, and; 3) the possibility of using BIM for residential retrofit projects. The self-administrated questionnaire with multiple options and rating questions were adapted from previous studies conducted by the National Building Specifications [35] and distributed among respondents to collect the required data for analyses.

4. Result and Discussion

4.1. Respondents' characteristics

One hundred twelve professionals were chosen for the BIM feasibility study, and the response rate was 49 percent (55 respondents). Several parameters have been used to describe the sample characteristics. Most of the respondents were 36-45 years old, and respondents' age average was approximately 39 years old. Regarding the construction industry experience, most of the respondents had 17-20 years of work background in the construction industry (41.8%). The average of the work experience was about 17 years. With respect to the type of organization, most of the respondents were working in public and private organizations.

4.2. Level of awareness and BIM Usage

Respondents were asked to determine the level of BIM awareness among their colleagues. The results are presented in Figure 2. As the Figure demonstrates, most of the respondents (n=26, 47.3%) have a low level of awareness about BIM, and the least of them (n=7, 12.8%) have high and very high BIM awareness. The government, through its agencies, should promote BIM via events to enhance the awareness of the construction industry.

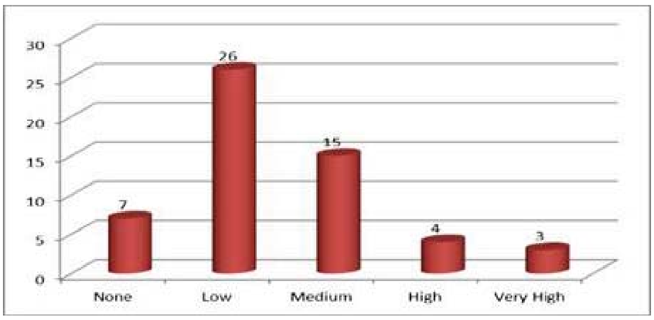

Figure 2. Frequency chart of BIM awareness among the colleagues (Y-axis: number of respondents).

Respondents were asked to identify the level of BIM implementation in their projects. According to Figure 3, the majority of the respondents mentioned that their organizations do not use BIM (n=16, 29.1%). Moreover, 25.5% of them implemented BIM at the heavy level (30% to 59%). Most of the respondents who utilize BIM at the heavy level were architects (7 respondents). This result demonstrated that the implementation of BIM is not routine, but some organizations rarely use it. This could be because of insufficient information regarding the BIM implementation benefits in projects. It can be stated that the BIM implementation in the Malaysian construction industry is at an initial stage.

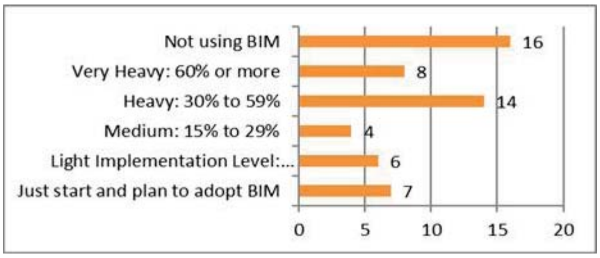

Figure3. Frequency chart of BIM implementation in the projects (X-axis: number of respondents).

Respondents were asked to determine the level of adopting and using BIM in the projects. As Figure 4 shows, most of the respondents (n=37, 52.10%) use Visualization Stage -3D modeling for communication among the project team, and 14% only adopt and use BIM for the first project.

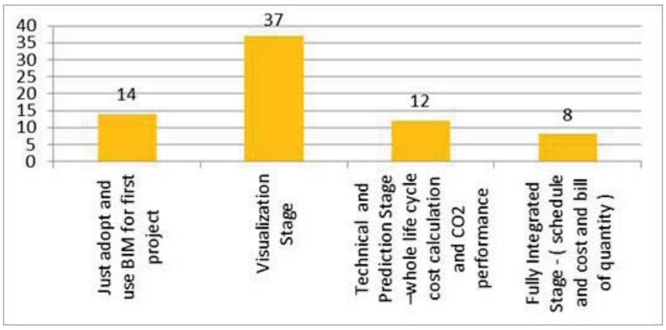

Figure 4. Chart of adopting and using BIM in the projects (Y-axis: number of respondents).

4.3. Feasibility and barriers of BIM usage in Malaysia

Respondents were asked to indicate the barriers to adopt BIM for residential retrofit. As can be seen from Figure 5, the most of the respondents believed that lack of client demand, high initial investments and lack of standards are the most common the barriers to adopt BIM for residential retrofit (n=13, 23.6%, n=12, 21.8% and n=11, 20%), respectively. The current client demand is low because of the unawareness of BIM technology advantages; therefore, they refuse to invest in BIM in their projects. Besides, the lack of standards and guidance for BIM implementation of retrofitting residential projects cause uncertainty in collaboration and commination among team members. This research also suggested critical actions to overcome these obstacles and enhance the application of BIM in the next section.

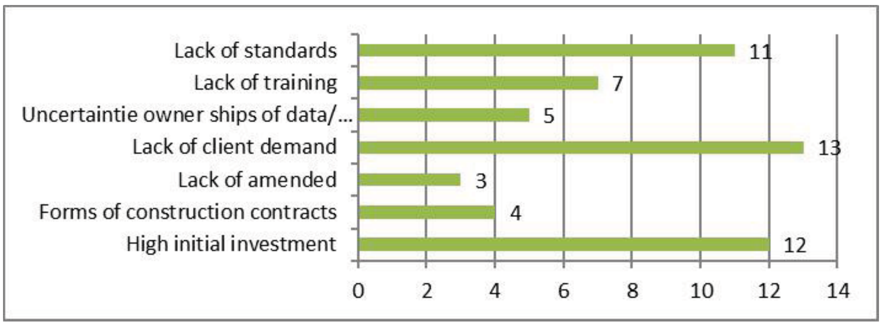

Figure 5. Chart of the barriers to adopting BIM for residential retrofit (X-axis: number of respondents).

Respondents were asked to indicate critical actions to overcome the obstacles and enhance the application of BIM in the residential retrofit. As Figure 6 shows, the majority of the respondents said that create residential retrofit standards or guidance and BIM Training /education are the most effective action to adopt BIM in the residential retrofit (n=30, 43.5%, and n=22, 31.9%), respectively. The construction team training and BIM introduction in the university education program can be beneficial for improving the BIM application.

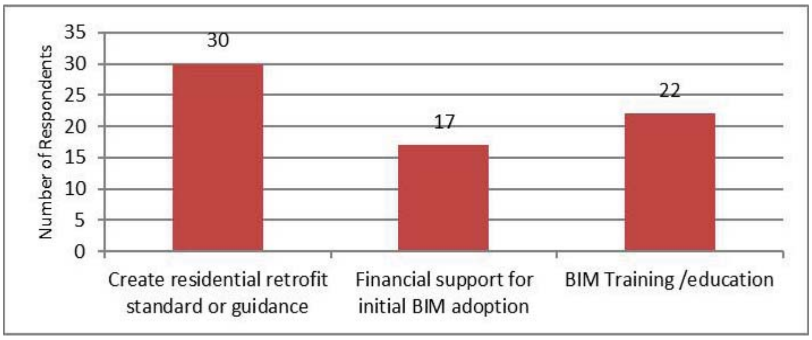

Figure 6. Frequency chart of the most critical action to adopt BIM in residential retrofit.

Construction experts and professionals as respondents were asked to present their opinion if the BIM adoption for residential building retrofit is feasible and well-timed. This question also asked respondents to explain their reasons if they were interested. As Figure 7 reveals, most of the respondents (n=25, 45.5%) said that the BIM adoption for retrofitting residential buildings is timely. Moreover, 30.9% of the respondents believed that the BIM adoption for retrofitting residential buildings is late. The respondents who believed BIM adoption is timely explained their reasons that BIM will help the Malaysia construction industry to achieve sustainability goals (e.g., reduce energy demands and GHG emissions) on retrofit projects, as stated in Eleventh Malaysia Plan (2016–2020). The experts also mentioned that the construction industry has the readiness to implementation of BIM technology for large and small-scale retrofit projects. Notably, this readiness is required proper legislation and standards.

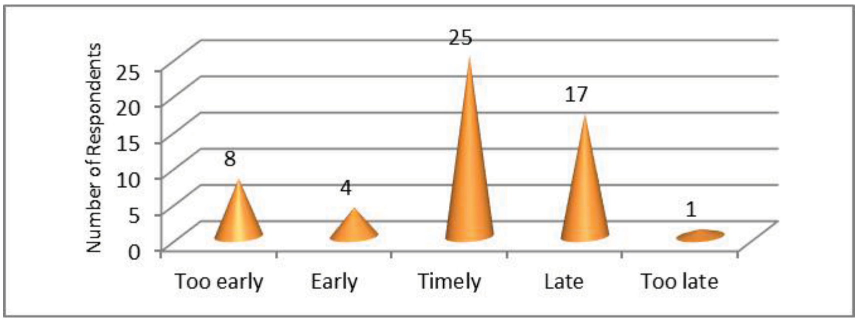

Figure 7. Frequency chart of the time for BIM adoption.

5. Conclusion

From the pilot study that considered the feasibility of BIM use for housing retrofit, it was showed that most of the respondents have a low level of awareness about BIM, and the majority of the respondents do not use BIM in their projects. Moreover, the findings show that most of the respondents use Visualization Stage -3D modeling for communication among the project team.

The results show that the majority of the respondents believe that lack of client demand, high initial investments, and lack of standards are the most common barriers to adopt BIM for residential retrofit. Moreover, based on the findings, the majority of the respondents said that create residential retrofit standards or guidance and BIM training /education are the most critical action to adopt BIM in residential retrofit, and most of the professionals said that BIM adoption for residential buildings is timely. In conclusion, this research provides information about the feasibility of BIM adoption for retrofitting the existing residential building in Malaysia construction industry. It is expected that this knowledge could be useful for BIM development and tackle barriers regarding BIM adoption in the construction sector.

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References
[1] Malaysia C 2009 Construction Industry Review 1980-2009 *Construction Industry Development Board (CIDB)* (Kuala Lumpur)
[2] Eastman C Teicholz P Sacks R and Liston K 2011 *BIM Handbook: A guide to building information modeling for owners, managers, designers, engineers, and contractors* (Hoboken : John Wiley & Sons)
[3] Jaafar M Ramayah T Abdul-Aziz A R and Saad B 2007 *Eng. Constr. Archit. Manag.* **14** 180-191
[4] Alshawi S, Irani Z, Baldwin L 2003 *BIJ.* **10** 414-423
[5] Stewart R and Mohamed S 2003 *Integrated Information Resources: Impediments and Coping Strategies in Construction* (Sydney: Australian Centre for Construction Innovation, University of New South Wales) 52-57
[6] Construction M-Hill 2008 *Building Information Modeling Trends SmartMarket Report* (New York)
[7] Monteiro A and Martins J P 2013 *Automat Constr.* **35** 238-253
[8] Wong A K Wong F K and Nadeem A 2011 *Constr. Innov.* **11** 61-76
[9] Latiffi A A Mohd S Kasim N and Fathi M S 2013 *J. Constr. Eng. M* **2** 1-6
[10] Zakaria Z B Mohamed Ali N Tarmizi Haron A Marshall-Ponting A and Abd Hamid Z 2013 *Int. J. Res. Eng. Techno.* **2** 384-395
[11] Building and Construction Authority 2011 *The BIM Issue. Build Smart BCA* (Singapore)
[12] Kubba S 2016 *Handbook of Green Building Design and Construction: LEED, BREEAM, and Green Globes* 2nd ed (Butterworth: Heinemann) p 1064
[13] Nor M F I M Usman I M S and Tahir M M 2009 *Euro. J. Soc. Sic* **9** 677-683
[14] Latiffi A.A, Brahim J and Fathi M.S 2016 *MATEC Web of Conferences* **66**
[15] Nazri A Q Mohammad I S Baba M Zainol N N Lokman M A A Woon N B and Ramli N A 2015 *J. Teknol.* **75**
[16] National Property Information Centre 2018 *Residential Property Stock Report NAPIC*
[17] Miller E and Buys L 2008 *J. Pro. Inv. Fin.* **26** 552-561
[18] Jiang P Dong W Kung Y and Geng Y 2013 *J. Clean. Prod.* **58** 112-120
[19] Zuo J Read B Pullen S and Shi Q 2012 *Habitat. Int.* **36** 278-286
[20] Russell-Smith SV Lepech M D Fruchter R and Meyer Y B 2015 *J. Clean. Prod.* **88** 43-51
[21] LaSalle J L 2008 *Results of the 2008 CoreNet and Jones Lang LaSalle global survey on CRE and sustainability report*
[22] Che Husin S M Mohd Zaki N I and Abu Husain M K 2019 *Int.J.Civil Eng.Technol.* **10** 1450-1471
[23] Kasra Kermanshahi E Harirchian E and Zaeimbashi Isaabadi M. H 2015 *IOSR. J. Mech. Civil Eng.* **12** 94
[24] Vasudevan G 2015 *Int. J. Sci. Eng. Technol.* **4** 131-135
[25] Malaysia Productivity Corporation 2016 *23rd Productivity Report 2015/2016*
[26] CIDB 2016 *The Malaysia Building Information Modelling (BIM) Report 2016*
[27] CIDB 2014 *Building Information Modeling Roadmap for Malaysia's Construction Industry, Workshop Report (Series 2)* pp 1-21
[28] Gökgür A 2015 *Current and future use of BIM in renovation projects* Master Thesis (Chalmers University of Technology)
[29] Di Mascio D Wang X 2013 *Int. Conf. on Cooperative Design, Visualization and Engineering*, (Berlin, Heidelberg) 205-212

[30] Arayici Y Coates P Koskela L Kagioglou M Usher C and O'Reilly K 2011 *Structural Survey* **29** 7-25
[31] Chong H-Y Lee C-Y Wang X 2017 *J. Clean. Prod.* **142** 4114- 4126
[32] Memon A H Rahman I A Memon I and Azman N I A 2014 *Res. J. Appl. Sci. Eng. Technol.* **8** 606-614
[33] Yin R K 2003 *Case study research: design and methods* 3rd revised edn *(Thousand Oaks: CA)*
[34] Uma S and Roger B 2003 *Research methods for business: A skill building approach*
[35] NBS 2017 *Building Information Modelling Report*