Implementing BIM in architecture, engineering and construction companies: Perceived benefits and barriers among local contractors in Palembang, Indonesia

Heni Fitriani, Civil Engineering Department, Universitas Sriwijaya, Indonesia
Andy Budiarto, Civil Engineering Department, Universitas Sriwijaya, Indonesia
Saheed Ajayi, Built Environment and Engineering, Leeds Beckett University, UK
Yakni Idris, Civil Engineering Department, Universitas Sriwijaya, Indonesia
heni.fitriani@unsri.ac.id

ABSTRACT

Despite the booming construction activities in Indonesia, and increasing adoption of BIM across the globe, there has been a little mention of BIM as well as its poor implementation in Indonesia. This study investigates the level of BIM awareness, knowledge, perceived benefits and barrier to its implementation among local construction businesses in Indonesia. The research was conducted through structured questionnaires. The respondents were requested to rate the significance of some identified factors according to a five-point Likert scale. Data collected from the survey was analysed using SPSS and evaluated using reliability analysis and descriptive statistics to present the characteristics of the study variables. The study shows that while most respondents recognized Revit and ArchiCAD as BIM enabling tools, there is a need for more sensitisation of local contractors on the purpose and benefits of BIM adoption. The high cost of software and hardware, lack of knowledge, and lack of awareness of BIM were the main barriers to its implementation in AEC companies. The study was carried out within Palembang region and was limited to local construction professionals, with the exclusion of expatriates. Since BIM has facilitated performance and productivity in many nations, it is expected that the technology would be valuable to the Indonesian construction industry. Local Indonesian businesses would need to be motivated to adopt BIM technology for their advancement.

KEYWORDS: Architecture Engineering and Construction, Barrier, Building Information Modeling, Technology.

INTRODUCTION

As information technology develops, there is a need to apply a system or method that may facilitate effective working and collaboration in the construction industry. Information exchange, design change, cost estimating, scheduling, construction and maintenance have become core issues in construction projects (Assaf & Al-Hejji, 2006). Researchers are continuously improving methods, particularly in information technology, to accelerate project works and prevent cost and time overrun. The emergence of Building Information Modeling (BIM) synergizes the construction process of a building from planning to the completion of the project, and it has been touted as an effective way of addressing many issues that affect the productivity of the construction industry (Arayici *et al.*, 2009).

According to Sabol (2008), BIM is a complete 3D digital representation for facilitating an accurate modelling as well as database of a building system. BIM shares the information of a building throughout its lifecycle. This indicates that the concept of BIM is not merely a software technology. It is one holistic process which consists of 3D, 4D and 5D of the digital representation of a building system. BIM represents the identity and attribute of each component in a building. It has been identified that BIM gives several benefits such as visual coordination, collaboration, accuracy and data consistency, easy quantity take-offs and scheduling, among others (Arayici *et al.* 2011; Farnsworth *et al.,* 2014). Most designers all over the world implemented BIM as a virtual technology for their companies. However, among project participants in Architecture, Engineering, and Construction (AEC) industry, there is a need for sharing and exchanging information to improve coordination and communication to support business processes. Additionally, BIM supports the construction methodologies involving all stakeholders throughout the entire lifecycle of the project for effective management and productivity improvement.

Research in the area of BIM adoption has been emerging over the last few decades. Won *et al.* (2013) studied the critical success factors of embracing BIM in construction companies. The study found that project managers' interest as well as their willingness to adopt BIM as the most critical success factors in successful BIM implementation. Arayici *et al.* (2011) discussed issues and challenges of BIM adoption. The study found that poor management and communication have caused many problems in the AEC industry. Fruitful adoption of BIM was significantly influenced by many factors such as people's attitudes, organization culture, and project characteristics (Nitithamyong & Skibniewski, 2003).

The development of BIM in the world is growing with a promising future. According to Smart Market Report (2015), the highest increase has been reported in Brazil where the rate more than tripled from 2013 to 2015, jumping from 24% to 73%. Japan experienced the smallest increase rate of about 16% - 27% in 2013, hurdling to 43% in 2015. However, if compared to other countries, the US had the highest progress in using BIM as shown by a rate of usage of 79% in 2015. On the other hand, South Asian countries like India, construction projects still rely on a 2D drawing (Nanajkar & Gao, 2014).

Similar to most other developing nations, activities in the construction market and building material sector in Indonesia has been rising. This development is driven by the rapid growth of the property market, private investment, and government spending. The sector's contribution to GDP has grown from 7.1% in 2009 up to 13% in 2014 (Construction Magazine, 2017). This condition has triggered the growth of building materials and construction industry in Indonesia. Notwithstanding this growth in the construction industry of Indonesia and increasing adoption of BIM as a vehicle for improving productivity in many nations, the adoption of BIM still remains poor in the Indonesian construction industry (Telaga, 2018). Rayendra and Soemardi (2014) highlighted the application of BIM at the pre-construction stage for logistic planning. The study used Revit to represent whole project information using layout planning for tower crane and materials positions within a real project. However, the study did not discuss the barriers and challenges to BIM adoption despite its poor adoption in the Indonesian construction industry. Although it was revealed that BIM Autodesk have been applied in Indonesia as shown by the growing number of software demand, it was also reported that the actual BIM implementation in Indonesia is still very low compared to other neighbouring countries like Singapore, Malaysia, Philippines, Thailand, and Vietnam (Tempo, 2013). Many

contractors and consultants in Indonesia are still solely using 2D and 3D drawings, whereas BIM is a bit more, covering aspects of design through to operation and maintenance of building projects.

While the few studies on the implementation of BIM in Indonesia (Rayendra & Soemardi, 2014; Telaga, 2018) have come to the same conclusion that there is low adoption of BIM, especially among the local contractors, there is paucity of study that investigates the barriers to its adoption in spite of the booming construction activities and its well-touted benefits. The level of BIM understanding among the local contractors is also unexplored. These represent the gap in knowledge that this study seeks to address. In line with this, the overall aim of the study is to investigate the current understanding of BIM as well as the barrier to its implementation in the Indonesian Construction Industry. The study will fulfil its aim through the following objectives:

1. To investigate the level of BIM awareness and knowledge among Indonesian contractors

2. To explore the perceived benefits of BIM implementation

3. To understand the barriers to BIM implementation among local contractors in Indonesia.

Using a questionnaire as a means of data collection, the study adopts a quantitative method of data collection and analysis. The data was analysed using reliability analysis and descriptive statistics to determine the knowledge, benefits and barriers to BIM implementation as perceived by construction professionals in Indonesia.

The following section presents a review of literature on BIM implementation. This is followed by a justification and description of the methodological approach to the study. The findings and discussion section is then presented before culminating the study in the conclusion section.

LITERATURE REVIEW

Building Information Modeling (BIM) is a model represented in a digital format containing various information of a building system. Kumar and Mukherjee (2009) described BIM as the documentation process consisting of information about different phases of a project such as design, planning, construction, facility management and operation. BIM is also a holistic process of documentation that benefits the organization for operational visualization and construction applications such as estimating, scheduling, and design coordination. Ashrae Inc. (2009) also defined BIM as physical and functional characteristics of a facility. BIM can share the knowledge and information about a facility as well as a reliable basis for decision makings during its lifecycle. According to Azhar (2012), Building Information Modeling (BIM) can be applied at every stage of the project lifecycle. For instance at the design stage, BIM is used to conceptualise a building, and at the construction stage, BIM is used to monitor the progress of the project.

Studies on BIM adoption have increased over the years (Bryde *et al*. 2013; He *et al.* 2017; Lu *et al*. 2016; Aibinu & Ventakesh. 2014; Yan & Damian. 2008; Cao *et al*. 2014). The use of BIM throughout project lifecycles has shown tremendous effect to the development of digital information technology in cost estimation and virtual prototyping (Eastman et al., 2008). Several researchers focused on BIM at design stages (Eastman *et al*. 2008; Liu *et al.* 2017) and

at construction stages (Rayendra & Soemardi. 2014). It is known that advances in technology have a profound effect on the construction industry. Moreover, BIM makes work more efficient regarding cost and time when compared to conventional methods. Lu *et al.* (2016) focused on the use of BIM for cash flows analysis and project financing. Lu *et al's* study developed a framework that can help contractors make financial decisions. Eadie *et al.* (2013 and 2014) analysed the obstacles that occurred in implementing BIM in the UK.

Nanajkar and Gao (2014) investigated BIM adoption among India AEC firms. The study found that BIM were not fully implemented due to high cost of investment and lack of commitment by senior management. Dabo (2010) studied the application of BIM in the local construction industry in major cities in Malaysia. It was found that the majority of users simply use AutoCAD for their design services. The study recommended some strategic ways to help reduce the barriers to BIM implementation. Liu et al. (2010) researched factors influencing the adoption of BIM using survey via email to AEC companies. The study revealed the problems and challenges in implementing BIM such as different perceptions on the benefits of BIM as well as lack of budget. Hussain and Choudry (2013) discovered that there was approximately 65% of the projects in Pakistan construction industry where BIM was not considered, and the remaining 35% mentioned the constraints in technology to implement BIM. In addition, the study suggests that only 11% of construction companies in Pakistain have applied BIM on their projects. Those studies have broadly evaluated the benefits of BIM in project life-cycles. Though researches on BIM adoption have had wide coverage in these studies, none of the studies discussed the characteristics or potential of BIM adoption by their local companies.

The potential use of BIM among AEC companies is often characterized by the level of BIM knowledge, BIM benefits and its barriers. Table 1 presented the variables and sub-variables for BIM knowledge level, functions, benefits and barriers identified in extant literature and that were considered for the current study.

RESEARCH APPROACH

The scope of this study covers the analysis of the potential use of Building Information Modeling (BIM) by considering perceptions on the possible benefits and barriers of BIM among Indonesian construction professionals. The potential use of BIM was identified based on four criteria's associated with knowledge level, functions, benefits, and barriers as illustrated in Table 1.

The research was carried out in Palembang, the central city of South Sumatra Province of Indonesia, which largely represents the dynamics of the nation. The subjects of the study were professionals in the AEC companies who were in the middle (M) work qualification and above. The Indonesian National Construction Board (www.lpjk.net) has divided the companies' qualification into three categories (Small (K), Middle (M) and Large (B) companies) and further classified into seven levels (Grade 2-Grade 7) indicating low to high capacity companies. These categories are classified based on several criteria such as company finance, labour use, and work experience. According to the Local Construction Board (2016), the numbers of companies in the middle or higher qualification were approximately 149 companies. The companies were approached for data collection, and 100 of them completed the questionnaire, representing 67% of the whole population. This study adopted a two-step approach for analysing the potential use and barriers of BIM in Indonesia. First, it gathered considerable variables of potential use and barriers based on previous studies in the area of

Table 1. Variables and Sub-variables for BIM Knowledge Level, Functions, Benefits & Barriers

Variable	Sub-Variable	Indicators	References
Level of BIM knowledge		Research and study of BIM College courses on BIM The concept of BIM technology Information of using BIM in project management Introduction of BIM technology BIM software (Revit & ArchiCAD) Use of BIM technology at work Importance of BIM technology for AEC companies BIM technology has a positive impact	Ashraf (2008); Baldwin (2012); Azhar *et al.* (2008)
BIM Functions	Modelling	3D modelling & visualisation Lighting, energy and information simulation Change management & automatic modification Visualisation & building simulation	Ashraf (2008); Baldwin (2012)
	Schedule	Visualisation schedule	
	Cost	Estimated costs Site planning and utilisation Security monitoring Materials and labour efficiency	
	Maintenance Management	Facility management Future expansion Maintenance schedule Optimisation of building energy Data & report archives Metadata management Information disclosure	Ashraf (2008); Baldwin (2012); Eastman *et al.* (2008)
BIM Benefits	Modelling	Enhancement of design ideas Support for decision making Team collaboration Improvement of design quality Design build sustainability Improvement of safety Selection of construction components	Ashraf (2008); Baldwin (2012); Eastman et al. (2008)
	Schedule	Improvement of understanding of construction activities Work coordination Quality of fabrication & cost reduction Site security planning Schedule planning	Ashraf (2008); Baldwin (2012); Eastman et al. (2008)
	Cost	Costs estimation Improvement of communication between parties Change/variation reduction Clashes reduction Project duration & cost reduction	Ashraf (2008); Azhar (2011); Baldwin (2012); Eastman *et al.* (2008); Farnsworth *et al* (2015)
	Maintenance Management	Waste of materials reduction during construction Easy search of building information Management & operations of project development System coordination, alarm system, lighting, air conditioning etc. Energy & building sustainability saving Development of facility maintenance strategy Assets controlling Marketing of #D model Disaster management	Ashraf (2008); Azhar (2011); Baldwin (2012); Becerik-*Gerber et al.* (2010); Eastman *et al.* (2008); Farnsworth *et al* (2015)
BIM Bariers	Cost	High initial cost of BIM software & hardware	Azhar (2011); Azhar *et al.* (2008); Becerik-Gerber *et al.* (2010); Kekana *et al.* (2012)
	Work Culture	Lack of awareness of BIM implementation by stakeholders Lack of knowledge on BIM software application CAD has met the needs of the project efficiently Lack of awareness of the benefits that BIM provides Lack of effective collaboration Refusal to adopt new technology	Azhar (2011); Azhar *et al.* (2008); Becerik-Gerber *et al.* (2010); Kekana *et al.* (2012)
	Competitiveness	Lack of financial ability for small companies The company focuses more on projects The difficulty of finding stakeholders who can compete in BIM	Ashraf (2008); Azhar (2011); Becerik-Gerber et al. (2010); Eastman *et al.* (2008); Faia & Aia (2004), Liu *et al* (2010)
	Regulation	Lack of government support to implement BIM Lack of requests and disinterest from clients Lack of real cases that had been proven Lack of interest	Ashraf (2008); Azhar (2011); Becerik-Gerber et al. (2010); Eastman *et al.* (2008); Faia & Aia (2004), Liu *et al* (2010)
	Human Resources	Lack of BIM skills for Architects'/Engineers Lack of education/training on BIM Reluctance to learn new applications due to education culture Reluctance to train Architects/Engineers due to high training costs	Ashraf (2008); Azhar (2011); Becerik-Gerber et al. (2010); Eastman *et al.* (2008); Faia & Aia (2004), Liu *et al* (2010)

BIM adoption. Second, it quantitatively analysed the significant variables through a survey questionnaire of practitioners in AEC companies. Figure 1 is a conceptual framework displaying the constructs used in the current study.

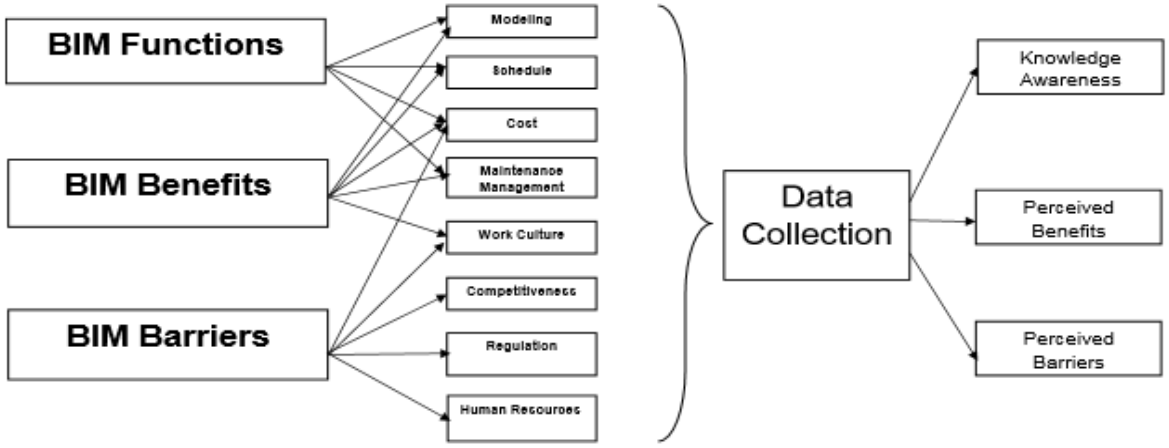

Figure 1: The Research Construct

The research was conducted using structured questionnaires divided into five (5) parts, covering data of the respondents, level of BIM knowledge, perceptions about functions, benefits, and barrier. The questionnaires were given to the owners or Directors of the companies. The respondents were requested to rate the significance of each factor according to a five-point Likert scale, with one (1) being strongly disagree and five (5) being strongly agree. The research was designed to use mean analysis to assess the level of BIM knowledge, the function of BIM as well as its benefits and barriers. Data collected from the survey was analysed using SPSS (Statistical Package for Social Sciences) and also evaluated using descriptive analysis to present the characteristics of the variables. The demography of the respondents, and information related to their awareness and use of BIM is presented in Table 2.

To validate the results of the questionnaires, Cronbach's Alpha was used to measure the internal consistency of the survey. The variables are said to be reliable if it gives Cronbach's Alpha value greater than 0.60 (Cronbach's Alpha > 0.60) (Nunnally & Bernstein, 1994). Based on the results, it was found that the minimum value of Cronbach's alpha was 0.870. These prove that the research instrument used is reliable and suitable as a measuring tool. In addition, the results also indicate a high level of internal consistency of the questionnaires. In line with the objectives of the study, descriptive statistics were carried out to determine the perceived benefits of BIM and the barriers to its implementation in the Indonesian construction industry. Using mean ranking as a measure of significance, the key benefits of BIM and barriers to its implementation as perceived by the respondents were identified.

RESULTS AND DISCUSSIONS

Based on the objectives of the study, the discussion section is divided into three. The first section discusses the level of BIM knowledge and awareness, the second section discusses the key benefits of BIM implementation as perceived by the Indonesian construction professionals and the third section discusses the barrier to BIM implementation in the Indonesian

construction industry. Table 3 and Table 4 present findings on the perceived functions and benefits to BIM implementation respectively.

Table 2. Characteristics of Respondents

No	Characteristics	Category	Total Responses	Percentage
1	Education	Diploma/Bachelor	85	85
		Master's Degree	10	10
		Doctoral Degree	5	5
2	Type of Company	Consultant	50	50
		Contractor	45	45
		Construction Management	5	5
3	Qualification/Specialty	Civil	65	65
		Architect	30	30
		Electrician	1	1
		Mechanics	1	1
		Others	3	3
4	Work Experience	Designer	67	67
		Supervisor	15	15
		Estimator	8	8
		Others	10	10
5	Frequency of using 3D application	< 5 years	45	45
		5 - 10 years	51	51
		> 10 years	4	4
		< 25%	23	23
		25 - 50%	34	34
		50 – 75%	20	20
		> 75%	23	23
6	Types of Software used in projects	AutoCAD	100	100
		ArchiCad	89	89
		Staadpro	25	25
		MS Project	56	56
		3D Max	76	76
		MS Office	100	100
		Others	45	45
7	Company Qualification	M	75	75
		B	23	23
		B1	1	1
		B2	1	1
8	Project Cost	500Million- 1 Billion (IDR)	9	9
		1 - 5 Billion (IDR)	45	45
		5 - 20 Billion (IDR)	45	45
		> 20 billion (IDR)	1	1
9	Types of Projects	Hotel	23	23
		Market	45	45
		Hospital	15	15
		Office	76	76
		Religious	20	20
		Sport stadium	10	10
		Others	45	45

BIM Awareness and Knowledge among Indonesian Contractors

Although the concepts of BIM extends beyond software knowledge, it is facilitated by the use of various software tools (Azhar et al., 2011). This suggests that the lack of awareness and knowledge of relevant software tools could imply an inadequate knowledge of BIM. Although most respondents recognized Revit and ArchiCAD BIM-enabling software tools, all the respondents have only used AutoCAD and Microsoft Office in their projects while there has been a limited use of such BIM tools as StaadPro and ArchiCAD. This suggests that there is

still a low level of BIM awareness and implementation of BIM among the construction professionals; thus confirming an earlier study by Telaga (2018).

To further ascertain the understanding of BIM among the construction stakeholders, respondents were asked about the purpose of BIM in construction. As shown in Table 3, the main roles of BIM as perceived by the respondents were in facilities management, 3D modelling and visualization, simulation, optimization and visualization respectively. While these are some of the benefits of using BIM (Arayici *et al*., 2011), most of the roles, with the exception of facilities management are not the unique benefits of BIM (Won & Lee, 2016). Surprisingly, some of the key purposes of BIM adoption such as change management, building information archive and its future use were ranked low by the respondents. This suggests that low level of BIM adoption in the Indonesian construction industry might be due to the lack of adequate understanding of its potential benefits at the design and construction stages of project delivery. Most contracts for construction projects do not extend to facilities management (Hughes et al., 2015), which is perceived as the main reason for BIM adoption in the current study. The reluctance to adopt BIM could be traced to this preconception.

Table 3. Perception of BIM functions among respondents

Code	Barriers	Mean	Rank
F10	Facility management	3.76	1
F1	3D modelling and visualisation	3.74	2
F2	Lighting, energy and information simulation	3/64	3
F13	Optimisation of building energy	3.58	4
F4	Visualisation and building simulation	3.54	5
F6	Estimated costs	3.45	6
F7	Site planning and utilisation	3.43	7
F3	Change management and automatic notification	3.33	8
F12	Maintenance schedule	3.28	9
F5	Visualisation schedule	3.16	10
F15	Matadata management	3.15	11
F14	Data and report archive	3.13	12
F8	Security monitoring	3.11	13
F16	Information disclosure	3.09	14
F11	Future expansion	3.06	15
F9	Materials and labour efficiency	2.57	16

Perceived Benefits of BIM Implementation

Due to its many benefits, BIM is revolutionizing the construction industry as it has the potentials for cost savings, better-informed decision making, reduced design clash, better collaboration and improved project performance, among others (Farnsworth et al., 2014). In order to determine the understanding of the Indonesian construction professionals on the benefits of BIM, the potential benefits of BIM adoption perceived by the respondents, were ranked as shown in Table 4.

From the results, the most significant benefit was considered to be its tendency of reducing the cost and duration of a project. This result aligned with the research conducted by Berlian et al. (2016) which analysed the advantages of BIM method compared to conventional methods. Using questionnaires, interviews and case studies, Berlian et al's research examined the building planning and performance efficiency in terms of time, human resource and cost of a project. They concluded that the BIM concept can accelerate project planning time by ± 50%, reduce the need for human resources by 6.7%, and save personnel expenses by 52.25% compared to using conventional applications.

Table 4. Perceived benefits of BIM implementation among construction professionals

Code	Benefits	Mean	Rank
M17	Perceived benefits of BIM implementation among the construction professionals	4.00	1
M20	Manage and operate project development	3.89	2
M13	Estimate costs	3.85	3
M15	Reduce change/variation	3.76	4
M9	Coordinate the work	3.68	5
M18	Reduce waste of materials during construction	3.61	6
M19	Ease the building information search	3.60	7
M8	Improve understanding of construction activities	3.45	8
M21	Operate system coordination, alarm system, lighting, air conditioning etc.	3.45	9
M16	Reduce clashes	3.43	10
M24	Control assets	3.41	11
M2	Support decision-making	3.40	12
M25	Market via 3D model	3.38	13
M10	Produce quality prefabrication and reduce cost	3.35	14
M26	Manage and overcome disaster	3.31	15
M22	Save energy and building sustainability	3.28	16
M1	Enhance design ideas	3.27	17
M3	Collaborate team	3.27	18
M23	Develop facility maintenance strategy	3.26	19
M4	Improve design quality	3.25	20
M11	Plan site security	3.24	21
M12	Plan the schedule	3.22	22
M5	Design building sustainable	3.17	23
M6	Improve safety	3.15	24
M7	Select construction components	2.90	25
M14	Improve communication among parties involved	2.76	26

Despite the highest ranking motivation for BIM adoption aligning with previous studies, some key factors that lead to the BIM movement across the globe were not considered to be the major benefits of BIM implementation by the respondents. For instance, as a global leader in BIM adoption and implementation, the UK government has mandated the use of BIM for the public project as a result of poor collaboration and information sharing in the construction industry (HM Government, 2012). Whereas in the current study, the benefits of BIM as a vehicle for improved collaboration and communication were ranked as 18th and 25th respectively. This

suggests the needs for more education on the benefits of BIM among local contractors in Indonesia.

On the other hand, cost estimation and change reduction were ranked as the 3rd and 4th benefits of BIM implementation respectively. While some BIM tools such as CostX could help in facilitating cost estimation, it could be argued that the goal of BIM adoption is not for cost estimation as against its higher ranking. Similarly, notwithstanding that BIM could facilitate seamless change in the project and prevent changes due to poor coordination among the project stakeholders (Farnsworth et al., 2014).), its main goal is not necessarily to reduce change as perceived by the respondents.

Barriers to BIM Implementation among Local Contractors in Indonesia

Table 5 shows how the respondents ranked the barriers to BIM implementation in the Indonesian construction industry. According to the ranking, the top five barriers to BIM implementation are include cost and knowledge/awareness. Lack of government support, which could be thought to be a barrier to BIM implementation had the lowest scores of mean values, suggesting that it was not a barrier to its implementation in Indonesia.

Table 5. Barriers to BIM Implementation in Indonesian Construction Industry

Code	Barriers	Mean	Rank
H1	High cost of BIM software and hardware required	4.65	1
H3	Lack of knowledge applies BIM software	4.30	2
H2	Lack of awareness of BIM implementation by stakeholders	4.03	3
H18	Reluctance to train Architects / Engineers due to expensive training	3.99	4
H5	The lack of awareness of the benefits that BIM provides	3.98	5
H12	Lack of requests and disinterest from clients	3.83	6
H16	Lack of education/training on the use of BIM	3.81	7
H4	CAD has met the needs of the project efficiently	3.76	8
H8	Lack of financial ability for small companies	3.73	9
H10	The difficulty of finding stakeholders who can compete in BIM	3.69	10
H6	Lack of effective collaboration	3.67	11
H14	Lack of interest	3.67	12
H9	The company focuses more on projects	3.65	13
H7	Refusal to adopt new technology	3.51	14
H17	Reluctance to learn new applications due to education culture	3.34	15
H11	Lack of government support to implement BIM	3.33	16
H15	Lack of Architects/Engineers skilled in using BIM	3.10	17
H13	The lack of real cases that has been proven	3.02	18

The highest ranked barrier is the initial cost associated with both software and hardware. Most of the respondents perceived the high initial cost of BIM software as the main barrier to implementing BIM in ACE companies in Palembang. The ability of companies to access the

technology is still very limited to gain high productivity on projects as compared to total project costs. Although the local companies surveyed were in the category of middle to high levels in terms of self-finance, their ability to purchase the BIM and associated software are still limited due to the high cost of initial investment. According to Berlian *et al.* (2016) and Nanajkar and Gao (2014), construction companies are still reluctant to adopt the technology due to the high price of licences and large hardware specification. BIM enables data exchange and information sharing among stakeholders.

Similar to the cost of setting up the BIM system is the reluctance to train architects and engineers due to the associated cost. Unlike in the UK and other nations where the government as a public client and some private clients request the use of BIM (Eadie *et al.*, 2015), there is no institutional motivation for BIM adoption in Indonesia. What this implies is that any cost associated with setting up the system or providing the relevant training could not be easily offset from project costs.

Moreover, one of the key requirements for BIM adoption is to have the knowledge or expertise in fully implementing it in those construction companies (Azhar *et al*., 2008; Succar & Sher, 2014). It is essential to have extra skills and to master multiple disciplines to use BIM. Lack of people's awareness and the lack of the actual knowledge of BIM implementation by construction firms was ranked first and second most significant barriers. Based on these findings, it can be concluded that BIM has failed to be an important vehicle for enhancing construction project performance as a result of the poor knowledge of its implementation and how to use the associated software, that are costly to acquire.

Confirming the earlier section on BIM knowledge and awareness, the 5th ranked barrier to BIM implementation among the Indonesian local construction professionals is the lack of knowledge on the benefits of its implementation in construction projects. This implies that there is a need to educate the construction professionals on the short and long-term benefits of BIM before encouraging and facilitating its implementation in the industry.

CONCLUSIONS

BIM is revolutionizing the construction industry, and it is fast becoming conventional for construction practice across the globe. Despite the booming construction activities in Indonesia, there has been a relatively low awareness BIM as well as some reluctance to its implementation. This study investigates the level of BIM awareness, knowledge, perceived benefits and barrier to its implementation among local construction businesses in Indonesia. Using quantitative research method, local construction professional were surveyed through a Likert scale questionnaire.

The study suggests that there is a low level of awareness and knowledge of the BIM tools, with a poor understanding of the purpose for BIM adoption among the local construction professionals. Although facilities management as a reason for BIM adoption was ranked high by the construction professionals, the main motivation for BIM adoption in developed nations such as information management and change coordination were ranked low among the participants. This suggests that poor understanding of BIM adoption and implementation might be due to the preconception that it is only valuable when the construction contracts extend to facilities management, which is not usually the case.

Although the abilities for BIM to enhance cost and time performance of projects was ranked high by local construction professionals in Palembang, the fundamental benefits and arguably a predominant motivation for BIM adoption through which other benefits are achieved were not considered to be significant. The lowly-ranked benefits include building information management and improved communication/collaboration among the project stakeholders through which cost and time performance benefits could be achieved. Other periphery construction-related activities, such as cost estimation, were also considered to be a major benefit of BIM adoption. These suggest that the reluctance to BIM adoption in Indonesian construction is largely due to a poor understanding of its use and benefits. A further investigation of the impediments to BIM implementation confirmed that an inadequate understanding of the BIM technology and process, as well as the cost of its implementation, are the major barriers to its adoption.

The future of BIM could be both stimulating and challenging, especially in a developing country like Indonesia. It is therefore important that the local construction professionals are well prepared by sensitizing them on the benefits of BIM implementation as well as how it could be implemented on construction projects. To achieve this, professionals and educational institutions, as well as government and its agencies have significant roles in BIM awareness, support and implementation. Although the respondents have not ranked government policy as a barrier to BIM implementation, lack of enlightenment and policy directions from the Palambang government could have contributed to the low level of its awareness considering how the government has driven the BIM implementation in such nations as the UK.

The current research is ground breaking in Indonesia. It established the level of awareness of BIM and its potential use. The study also covered the benefits of using BIM as well as its practice and limitations in Indonesia as a developing country. This study provides a benchmark to establishing the level of BIM understanding among the local contractors as well as the hindrances to its implementation. There is such a promising extent for development due to the current construction boom. Since BIM has been facilitating construction performance and productivity in other countries, it is expected that the technology would be valuable to the Indonesian construction industry.

REFERENCES

Aibinu, A. and Venkatesh, S. (2014). Status of BIM Adoption and the BIM experience of Cost Consultants in Australia. *Journal of Professional Issues in Engineering Education and Practice, 140*(3), 4013021. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000193

American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE), Inc. (2009). An Introduction to Building Information Modelling (BIM): A Guide for ASHRAE members. Georgia: ASHRAE Inc.

Arayici, Y., Coates, P., Koskela, L.J., Kagioglou, M., Usher, C. and OReilly, K. (2011). BIM adoption and implementation for architectural practices. *Structural Survey, 29*(1), 7-25. https://doi.org/10.1108/02630801111118377

Arayici, Y., Khosrowshahi, F., Amanda M.P. and Mihindu, A. (2009). Towards implementation of Building Information Modelling in the Construction Industry. Fifth International Conference on Construction in the 21st Century (CITC-V) "Collaboration and Integration in Engineering, Management and Technology" May 20-22, 2009, Istanbul, Turkey.

Ashraf, H.W. (2008). Implementing BIM: A report from the field on the issues and strategies. Proceedings of the 47th annual meeting of invited attorneys. June 2008. Seattle, WA. 53-84

Assaf, S.A. and Al-Hejji, S. (2006). Causes of delay in large construction projects. *International Journal of Project Management*, *24*(4), 349-357. https://doi.org/10.1016/j.ijproman.2005.11.010

Azhar, S. (2011). Building Information Modelling (BIM): Trends, benefits, risks, and challenges for AEC industry. *Leadership and Management in Engineering.* 241-252. https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127

Azhar, S. (2012). Building Information Modeling (BIM): Now and beyond. *Australian Journal of Construction Economics and Building*, *12*(4), 15-28. https://doi.org/10.5130/AJCEB.v12i4.3032

Azhar, S., Hein, M. and Sketo, B. (2008). Building Information Modeling: Benefits, risks and challenges. Proceedings of the 44th ASC National Conference, Auburn, Alabama, USA.

Baldwin, M. (2012). BIM implementation & execution plans. *BIM Journal*, *3*(35), 73-76.

Becerik-Gerber, B. and Kensek, K., (2010). Building Information Modeling in Architecture, Engineering, and Construction: Emerging research directions and trends. *Journal of Professional Issues in Engineering Education and Practice*, *136*(3), 139-147. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000023

Berlian, C.A., Adhi, R.P., Hidayat, A. and Nugroho, H. (2016). Comparison of time, cost and human resources efficiency between Building Information Modeling (BIM) and conventional methods (Case Study: The Planning of Building 20 Floors). *Jurnal Karya Teknik Sipil*, *5*(2), 220-229. http://ejournal-s1.undip.ac.id/index.php/jkts

Bryde, D., Broquetas, M. and Volm, J.M. (2013). The project benefits of building information modelling (BIM). *International Journal of Project Management*, *31*(7), 971-980. https://doi.org/10.1016/j.ijproman.2012.12.001

Cao, D., Li, H. and Wang, G. (2014). Impacts of isomorphic pressures on BIM adoption in construction projects. *Journal of Construction Engineering and Management*, *140*(12), 4014056. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000903

Construction Magazine. (2017). Construction Service Industry has become an Excellent Construction Business. May, 6-7. http://www.yasapatriaperkasa.co.id/

Construction Service Development Board. (2016). http://www.lpjk.net/. Accessed on December 19, 2016.

Dabo Baba, H. (2010). Building Information Modeling in local construction industry. Unpublished Masters thesis. University Technology Malaysia, Johor Baru.

Eadie, R., Browne, M., Odeyinka, H., McKeown, C. and McNiff, S. (2015). A survey of current status of and perceived changes required for BIM adoption in the UK. *Built Environment Project and Asset Management*, *5*(1), 4-21. https://doi.org/10.1108/BEPAM-07-2013-0023

Eadie, R., Browne, M., Odeyinka, H., McKeown, C. and McNiff, S. (2013). BIM implementation throughout the UK construction project lifecycle: An analysis. *Automation in Construction, 36*, 145-151. https://doi.org/10.1016/j.autcon.2013.09.001

Eadie, R., Odeyinka, H., Browne, M., McKeown, C. and Yohanis, M. (2014). Building Information Modelling adoption: An analysis of the barriers to implementation. *Journal of Engineering and Architecture. 2*(1), 77-101.

Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2008). BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, John Wiley and Sons, NY, 2008. https://doi.org/10.1002/9780470261309

Faia, P.G.B. & Aia, J.H.P. (2004). Barriers to the Adoption of Building Information Modeling in the Building Industry. , (1), pp.1-14.

Farnsworth, C., Beveridge, S., Miller, K. and Christofferson, J. (2015). Application, advantages and methods associated with using BIM in commercial construction. *International Journal of Construction Education and Research, 11*(3), 218-236. https://doi.org/10.1080/15578771.2013.865683

He, Q., Wang, G., Luo, L., Shi, Q., Xie, J. and Meng, X. (2017). Mapping the managerial areas of Building Information Modeling (BIM) using scientometric analysis. *International Journal of Project Management, 35*(4), 670-685. https://doi.org/10.1016/j.ijproman.2016.08.001

HM Government. (2012). Building Information Modelling - Industrial strategy: government and industry in partnership. London: Crown Publications

Hughes, W., Champion, R. and Murdoch, J. (2015). Construction contracts: law and management. Routledge. https://doi.org/10.4324/9781315695211

Hussain, K. and Choudhry, R.M. (2013). Building Information Modeling (BIM) uses and applications in Pakistan construction industry. In: N. Dawood and M. Kassem (Eds.), Proceedings of the 13th International Conference on Construction Applications of Virtual Reality, 30-31 October 2013, London, UK.

Kekana, G., Aigbavboa, C. and Thwala, W. (2015). Overcoming barriers that hinders the adoption and implementation of Building Information Modeling in the South African construction industry.

Kumar, J.V. and Mukherjee, M. (2009). Scope of Building Information Modeling (BIM) in India. *Journal of Engineering Science and Technology. 2*(1), 165-169. https://doi.org/10.25103/jestr.021.30

Liu, R., Issa, R.R.A. and Olbina, S. (2010). Factors influencing the adoption of building information modeling in the AEC Industry. Proceedings of the International Conference on Computing in Civil and Building Engineering, Nottingham University Press.

Liu, Y., van Nederveen, S., & Hertogh, M. (2017). Understanding effects of BIM on collaborative design and constructionAn empirical study in China. International *Journal of Project Management*, *35*(4), 686-698. https://doi.org/10.1016/j.ijproman.2016.06.007

Lu, Q., Won, J., & Cheng, J. C. P. (2016). A financial decision making framework for construction projects based on 5D Building Information Modeling (BIM). *International Journal of Project Management*, *34*(1), 3-21. https://doi.org/10.1016/j.ijproman.2015.09.004

McAuley, B., Hore, A., & West, R. (2016). BICP Global BIM Study.

Nanajkar, A. and Gao, Z. (2014). BIM implementation practices at India's AEC firms. Proceedings International Conference on Construction and Real Estate Management, Kunming, China. September. https://doi.org/10.1061/9780784413777.016

Nitithamyong, P. and Skibniewski, M.J. (2003). Critical success/failure factors in implementation of web-based construction project management systems. Proceedings Construction Research Congress, ASCE, Reston, VA, 1-8. https://doi.org/10.1061/40671(2003)110

Nunnally J.C. and Bernstein I.H. (1994). Psychometric Theory. McGraw Hill, New York

Rayendra and Soemardi, B.W. (2014). A study of the application of BIM for Pre-Construction. National Symposium RAPI XIII - 2014 FT UMS

Sabol, L. (2008). Building Information Modeling & Facility Management. IFMA World Workplace.

Smart Market Report. (2015). Percentage of contractors at very high BIM implementation levels. Bedford, MA.

Succar, B. and Sher, W. (2014). A competency knowledge-base for BIM learning. In *Australasian Journal of Construction Economics and Building-Conference Series*, *2*(2), 1-10. https://doi.org/10.5130/ajceb-cs.v2i2.3883

Telaga, A.S. (2018). A review of BIM (Building Information Modeling) implementation in Indonesia construction industry. *In IOP Conference Series: Materials Science and Engineering*, *352*(1), 012030. IOP Publishing. https://doi.org/10.1088/1757-899X/352/1/012030

Won, J. and Lee, G. (2016). How to tell if a BIM project is successful: A goal-driven approach. *Automation in Construction*, *69*, 34-43. https://doi.org/10.1016/j.autcon.2016.05.022

Won, J., Lee, G. and Dossick, C. (2013). Where to focus for successful adoption of Building Information Modeling within organization. *Journal of Construction Engineering and Management*, *139*(11), 4013014. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000731

Yan, H. and Damian, P. (2008). Benefits and barriers of building information modelling. Proceedings 12th International Conference on Computing in Civil and Building Engineering 2008, Tsinghua University, Beijing, China.