Pertanika J. Sci. & Technol. 25 (3): 661 - 674 (2017)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Review Article

Implementation of Building Information Modelling (BIM) in Malaysia: A Review

Nuzul Azam Haron[1]*, Raja Putri Zarifh Ana Raja Soh[2] and Aizul Nahar Harun[3]

[1]*Department of Civil Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia*

[2]*Department of Civil and Construction Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia*

[3]*Department of Management of Technology, Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, 81310 UTM, Skudai, Johor, Malaysia*

ABSTRACT

This paper seeks to clarify Building Information Modelling (BIM) and its implementation in Malaysia. Most developed countries that have implemented BIM in the construction industry have found it effective. This paper reviews existing literature on the implementation of BIM and examines the implementation strategies that have been developed. The review highlights numerous advantages of BIM in construction, which include, among others, reducing cost, time, carbon burden and capital cost. BIM can also help increase broader efficiencies and improve coordination and communication between each party. However, implementing BIM is complicated and requires efforts from both the government and the private sector. While the implementation of BIM may reduce costs in developed countries, it may not do so in developing countries; in Malaysia, for instance, costs act as an initial barrier. Other obstacles to implementing BIM in Malaysia include application system requirements and lack of knowledge and readiness to change. To facilitate its implementation in the construction industry, the Malaysian government needs to hold seminars to promote a better understanding of BIM. They may also introduce a properly structured BIM course by preparing a standard code of practices and guidelines for BIM in the education sector.

Keywords: Building Information Modelling, cost reduction, time reduction, construction industry

Article history:
Received: 12 May 2016
Accepted: 3 November 2016

E-mail addresses:
nuzul@upm.edu.my (Nuzul Azam Haron),
rpzarifhana@yahoo.com (Raja Putri Zarifh Ana Raja Soh),
aizulnahar.kl@utm.my (Aizul Nahar Harun)
*Corresponding Author

ISSN: 0128-7680

INTRODUCTION

This paper explains about Building Information Modelling, which is one of the methods used by companies to smoothly control and manage projects. Most developed

countries use this method in their construction field; Australia is the foremost in implementing BIM (18-75%), followed by the United States (31%), Europe (16%), the Middle East (11%) and India (9%) (Figure 1). Owing to increased consciousness about its advantages, construction companies in Malaysia have recently started to use BIM in their projects.

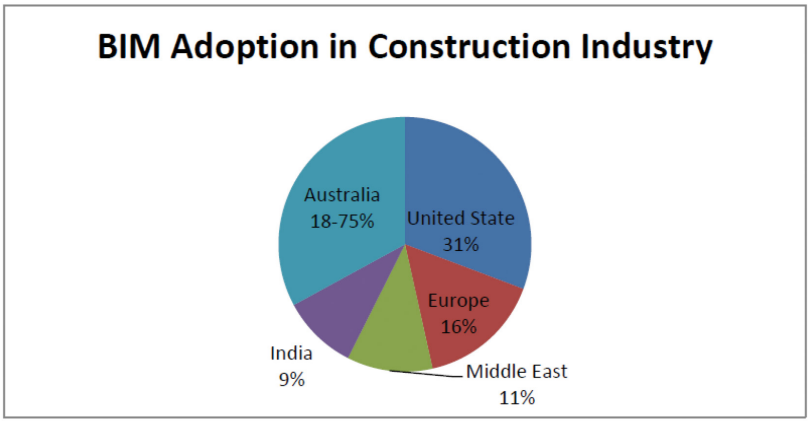

Figure 1. Countries that use BIM (Sawney, 2014)

In Malaysia, the progress of BIM has mainly been driven by the private sector since 2009. The idea to implement BIM in Malaysia was introduced by the Director of the Public Works Department (PWD) in 2007. The first government project to use BIM methodology was announced in 2010. BIM implementation requires the development of reliable tools for information exchange between different software tools while enabling efficient and direct coordination and monitoring processes between project participants and team members. An acceptable level of interoperability and standardisation of work methods must be developed for project participants and team members. The experience of project participants as a team allows us to define the decision-making process prior to BIM implementation in separate projects. It also makes it possible to make recommendations about the process of planning in an environment of small companies with different software and methods of work (Migilinskas et al., 2013).

One of the projects using BIM in Malaysia is the National Cancer Institute (NCI), as highlighted in seminars and workshops organised by CIDB regarding issues and challenges in implementing Building Information Modelling for small and medium enterprises (SMEs) in the construction industry (2014). According to Latiffi et al. (2013), BIM will be implemented in future projects such as the Healthcare Centre Type 5 at Sri Jaya Maran, Pahang, Administration Complex Project of Suruhanjaya Pencegah Rasuah Malaysia (SPRM) at Shah Alam, Selangor, the Primary School at Meru Raya Ipoh, Perak, and the Primary School at Tanjung Minyak 2, Melaka Tengah, Melaka. These are pilot projects and are part of the Malaysian government's initiative to expose government officers to BIM. The main objective of the present study is to understand the Building Information (BIM) as a technology for coordinating project development.

There are mixed perspectives of the benefits of BIM, creating a general misunderstanding of expected outcomes. The frequency and variety of definitions illustrate the existing confusion in defining and quantifying BIM and in considering its potential benefits. Any definition of BIM should not be unilateral, but instead, encompass key characteristics that have been attributed to it. There is a risk in offering a narrow definition of BIM, as that makes it more difficult to establish a baseline for comparisons. A narrow definition also makes it difficult, if not impossible, to improve BIM use by benchmarking (Abbasnejad et al., 2013). At the end of this study, the reader will understand BIM with regards to the benefits, barriers and solutions to its implementation in Malaysia.

REVIEW OF LITERATURE

Building Information Modelling (BIM)

According to Enegbuma et al. (2014), BIM is the process of generating and managing building data during its life cycle. Meanwhile, Sawney (2014) classifies BIM as not just a software tool or simply a technology that can be acquired and implemented. It is rather a paradigm that combines technology with people and process issues in the industry. This results in a tectonic shift in the way we deliver the built environment.

A seminar titled *Issues and Challenges in Implementing Building Information Modelling for Small and Medium Enterprises (SMEs*) organised by CIDB in 2014 presented BIM as one of the emerging technologies to be deployed in design, construction and facility management, in which a digital representation of the building is created to facilitate the exchange and interoperability of information in digital format. Thurairajah et al. (2013) stated that Building Information Modelling represents the formation of digital models used during the planning, design, construction and operation stages of a facility's life. Latiffi et al. (2013) referred to BIM as a set of digital tools that can help manage the effectiveness of a construction project. Zahrizan et al. (2014) stated that BIM can be viewed as a combination of advanced processes and technology that offers a platform for collaboration between different parties in construction projects by exploiting the use of information technology.

Arayici et al. (2012) stated that in the simplest of terms, BIM is the utilisation of a database infrastructure to encapsulate built facilities with specific viewpoints of stakeholders. It is a methodology to integrate digital descriptions of building objects and their relationship with others in a precise manner so that stakeholders can query, simulate, and estimate activities and their effects on the building process as a life-cycle entity. Therefore, BIM can help by providing the required value judgments that satisfy their owners and occupants for creating a more sustainable infrastructure.

BIM has many meanings and can be described in many different ways. Table 1 summarises the diversity of definitions.

Table 1
Summary of BIM Definitions

No.	Statement	Author
1.	The process of generating and managing building data during the building's life cycle	Enegbuma et al. (2014)
2.	BIM is not just a software tool or simply a technology that can be acquired and implemented.	Sawney (2014)
3.	BIM is one of the new emerging technologies to be deployed in 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.	CIDB (2014)
4.	Building Information Modelling (BIM) represents the formation of digital models for use during the planning, design, construction and operation stages of a facility's life.	Thurairajah et al. (2013)
5.	A set of digital tools that can manage the construction project's effectiveness	Latiffi et al. (2013)
6.	BIM can be viewed as a combination of advanced process and technology that offers a platform for collaboration between different parties in the construction project by exploiting the uses of Information Technology (IT).	Zahrizan et al. (2014)
7.	The utilisation of a database infrastructure to encapsulate built facilities with specific viewpoints of stakeholders	Arayici et al. (2012)

Based on the various definitions of BIM, it can be concluded that BIM is a software model that can be used in project planning, design, monitoring and control among construction project group stakeholders in order to ensure project success.

BIM Tools

Due to the complexity of gathering relevant information when working on a building project with BIM, some companies have designed software specifically to work within a BIM framework. In reference to the Autodesk Revit Manual Guidelines (2017), these packages include the Bentley AECOsim Building Designer, ArchiCAD, Tekla Structures, Autodesk Revit, Synchro PRO and Vector Works, among others. These software differs from other architectural drafting tools such as AutoCAD, as they allow the addition of further information such as time, cost, manufacturers' details, sustainability and maintenance information in the building mode.

Probably the greatest example of such software is Autodesk Revit. Autodesk Revit is building information modelling software for architects, structural engineers, MEP engineers, designers and contractors. It allows users to design a building structure and its components in 3D, annotate the model in 2D drafting element and get building information with access from the building model's database. Revit is built with drafting elements in 4D and contains tools to plan and track the various stages in the building's life cycle from concept to construction and, later, demolition. This is clarified in a research report by Latiffi et al. (2013).

In their research report, Latiffi et al. (2013) also highlighted the benefit of using Revit. Revit can be used as a collaboration tool between different disciplines in the sphere of building design. Implementation of BIM in the Malaysian construction industry can be carried out by players from different disciplines with support from BIM tools. Figure 2 shows the tools that can be used by each player. It approaches the programme from various unique perspectives. Each of these perspectives is focussed on completing the discipline's task. Companies that adopt software first examine the existing workflow process to determine if such an elaborate collaboration tool is required.

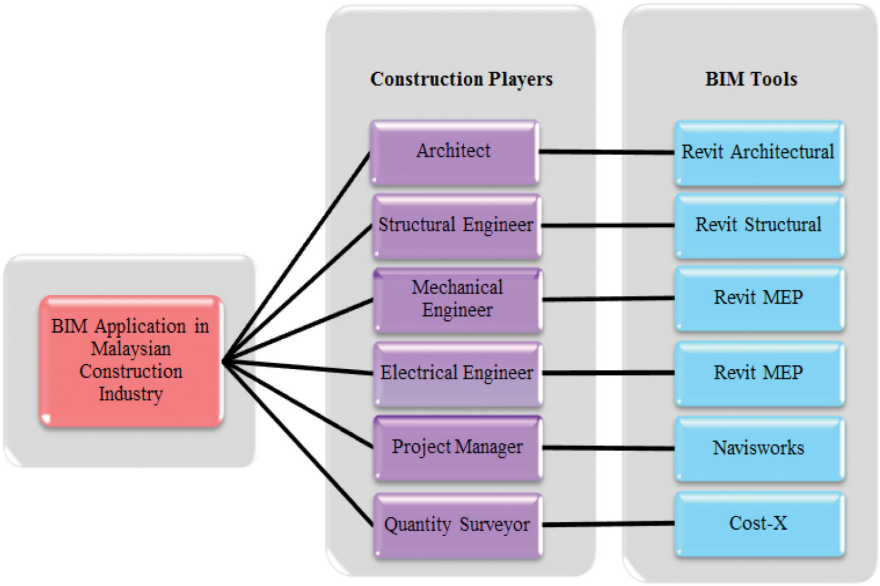

Figure 2. BIM tools suggested by the Director of Public Works Department (PWD) in 2007 (Latiffi et al., 2013)

METHODOLOGY

This section explains the research methodology that is adopted in this study. There are several ways to collect data. Data may be obtained from two sources. Primary data collection is the direct collection and process of information by the researcher, such as from observations, surveys, interviews and focus groups. Secondary data collection is the retrieval of information from pre-existing sources such as research articles, the Internet or library searches. Figure 3 shows the data collection process used in this paper, which was the use of secondary data sources.

Figure 3. The process of data collection

A review of the literature was performed to analyse the current information available with regards to the implementation of BIM, with the aim 1) to determine the proper explanation and meaning of BIM; 2) to identify the problems faced by the players in implementing BIM; and 3) to assist players in the construction industry to implement BIM in Malaysia.

Over 100 sources of information were determined including journal articles, conference proceedings, published case studies, press releases, professional presentations and online articles. We narrowed these down to 40 sources that were published during the past 10 years. Overall, these mostly discuss the meaning, benefits, challenges and strategy connected to adopting BIM.

RESULTS AND DISCUSSION

Advantages of Implementing BIM in Malaysia

BIM helps in reducing cost and time and increasing broader efficiencies (Azhar, 2008; Barlish et al., 2012; Sawney, 2014; Chougule et al., 2015). Therefore, it is gaining popularity in the global built environment sector. It has impressed governments around the world, especially in developed nations, with the results encouraging strong steps to increase BIM adoption. The UK government has prepared a BIM strategy for the UK Government Construction Client Group to reduce the capital cost and carbon burden by 20% from the construction and operation of the built environment sector (Azhar, 2008; Mc Auley, 2012; Sawney, 2014; Dodia, 2015; Kathi, 2015).

Other than that, BIM can save the cost of design by benefiting from earlier access to the construction market. It can cut both time and cost of design by half (Yan et al., 2008). 'Half time at half cost' does not merely save money, it also reduces the time taken to be introduced to the market. BIM not only improves technology but also changes the process of design and build. Yan et al. (2008) stated that Building Information Modelling creates obtainable concurrent information on the performance of the project and the economic aspects of the project in the operation phase. BIM leaves a digital document trail resulting from transformations and developments during operation. Most users of BIM believe that it can reduce dependence on human resources during the entire operation phase.

The benefits of adopting BIM in development are that it can improve project coordination and communication with each side. These apply to the team of workers, where everyone is able to understand the project better. It allows fellow professionals to understand the proposal better (Autodesk, 2007; Becerik-Gerber et al., 2010; Dodia, 2015). According to some research reports, the Malaysian government encourages construction players to apply BIM in their construction projects because it can overcome construction problems such as delay, clash of design by different professionals and construction cost overrun (Becerik-Gerber et al., 2010; Latiffi et al., 2013; Elhag et al., 2014; Kathi et al., 2015). Activities with established duration are connected to a project network plan by taking into account relevant precedence relationships. Project duration is automatically determined from the generated network plan. A BIM model of the construction object is completed by upgrading the 3D model with defined schedules and cost data (Pučko et al., 2014). Thus, BIM helps increase construction project efficiency and the effectiveness of project management. In addition, it helps improve communication

and collaboration between construction players. With BIM, design change becomes a more efficient and smoother process, since different components are linked together and updated accordingly (Elhag et al., 2014).

Researchers conclude that BIM can overcome construction problems and boost the productivity level of the Malaysian construction industry to be at par with that of Australia and the US. Table 2 summarises the advantages of using BIM as suggested by different authors.

Table 2
Advantages of Using BIM in the Construction Industry

No.	Statement	Author
1.0	BIM helps to reduce cost and time and increases other broader efficiencies.	1) Anil (2014) 2) Azhar, S. (2008) 3) Dodia et al. (2015) 4) Kathi et al. (2015) 5) Yan et al. (2008) 6) Liu et al. (2015) 7) Barlish et al. (2012)
2.0	The UK has prepared a BIM strategy for the UK Government Construction Client Group for reducing capital cost and the carbon burden from the construction and operation of the built environment by 20%.	1) Anil (2014) 2) McAuley et al. (2012) 3) Azhar, S. (2008) 4) Dodia et al. (2015) 5) Kathi et al. (2015)
3.0	The two main benefits of adopting BIM in development are an improvement in coordination and communication.	1) Autodesk (2007) 2) Dodia et al. (2015) 3) Becerik-Gerber et al. (2010)
4.0	The Malaysian government encourages construction players to apply BIM to their construction projects because BIM can overcome construction project problems such as delay, clash of the design by different professionals and construction cost overrun.	1) Latiffi et al. (2013) 2) Kathi et al. (2015) 3) Becerik-Gerber et al. (2010) 4) Elhag et al. (2014)

Problems with Implementing BIM in Malaysia

Implementation of BIM in Malaysia is not without challenges. There is a lack of awareness and knowledge among users in the industry. This is consistent with findings of studies on barriers to the use of BIM in Iran (Hosseini et al., 2011) and Pakistan (Masood et al., 2014). The application of BIM in the industry becomes narrower if the government and its agencies consider it useless. Although the government has taken a role in the implementation of BIM, the pace of implementing BIM in Malaysia is still lagging.

In developing countries, one of the benefits of using BIM is cost. However, in Malaysia cost is one of the barriers to implementing BIM (Lindblad, 2013; Gardezi et al., 2014). Research by Liu et al. (2015) and Franco et al. (2015) corroborates this by showing that cost was the most critical barrier to the implementation of BIM. This is followed by the absence of

national standards and lack of skilled personnel. All participants in their research had a common awareness of the critical barriers and most agreed that cost was a critical factor. The initial cost of investing in new technology and time for training personnel is also significant. Table 3 displays the inter-related key variables stated by the participants as contributing to barriers in implementing BIM in construction. Among others, cost showed the highest percentage (26.2%), followed by IT components (23%), time (16.4%) and readiness (14.8%). Meanwhile, knowledge (8.2%), technology (8.2%) and information (3.3%) were among the lowest barriers (CREAM, 2014; Eadie, 2013; Salleh, 2014; Chougule et al., 2015; Hedayati, 2015). The CIDB seminar compiled the variables under four headings of barriers to BIM implementation in Malaysia, including cost, system requirements, lack of knowledge and readiness to change.

Table 3
Barriers to the Implementation of BIM (CIDB, 2014)

Variables	Percentage %
Cost	26.2
Time	16.4
IT (Software, Hardware, Computer)	23.0
Readiness	14.8
Knowledge	8.2
Technology	8.2
Information	3.3

According to Yan (2008) and Manu et al. (2014), about 40% of respondents from the USA and about 20% respondents from the UK believe that their companies need to allocate a lot of time and human resources to the training process. If the understanding of BIM and its possibilities is not well established in the organisation, there is a risk of losing the goal of BIM adoption (Lindblad, 2013). This category poses the largest latent barrier to the application of BIM. Decisions made in organisations are mainly derived from a business perspective (i.e. profit). The AEC industry is not glad to invest in BIM because of the lack of case study evidence of the financial benefit of BIM. Investment in BIM by the AEC industry will increase only when a good business case is made with case study evidence. There is also social and habitual resistance to change, as a number of architects are satisfied with traditional methods to design projects and increase the new functions and advantages of BIM.

Kushwaha (2016) says that Building Information Modelling has revolutionised the AEC industry, but the rate of implementation of BIM in the industry is low because of various barriers. He claims that the lack of initiative from government organisations and educational institutes is the major factor responsible for the limited awareness and implementation of BIM. In addition, shifting from traditional approaches to BIM is not an easy task; it requires collaborative efforts from government agencies as well as private organisations.

Table 3 shows that IT is also one of the challenges faced by construction players in the implementation of BIM. The lack of consistent standards and software incompatibility along the project supply chain remains an issue despite great improvements in recent years

(Manu, 2014; Smith, 2014; Ali, 2015). Fully-integrated project delivery with multi-disciplinary project teams working on a single integrated and compatible BIM model are essential for the optimal use of BIM. Currently, the scope for this remains limited. The use of BIM is considered to be more suited to larger projects with larger clients and contractors who have the scope to demand that all project participants have the necessary technological capability and compatible software. Some players claim that working with BIM projects is not effective against projects that work outside of the BIM model, due to incompatibility issues regarding software, standards and practices. This is also compounded by key parties in the project supply chain not meeting the capabilities required. All the researchers agreed that although these issues would continue to improve, they remained critical for successful BIM implementation across the industry.

Other challenges triggered by BIM adaptation that needs to be considered can be divided into four perspectives, namely (1) process-related obstacles; (2) social context obstacles; (3) technical obstacles; and (4) associated costs. Process-related challenges have three aspects (Talebi, 2014). First, BIM changes the traditional processes in building projects, and accordingly, construction organisations need to adapt to new business processes. However, due to the immaturity of users and absence of clear guidelines, it is difficult to foresee the consequences. Second, there is a need for building new roles; however, it is ambiguous as to how they should be integrated into current processes. The final issue in process-related obstacles is about the need for developing new contractual agreements for BIM-based projects. These agreements must be able to deal with the division of economic incentives and ownership of information.

For BIM to be adopted successfully, all construction players in a project must participate in this change. Therefore, there is a need for developing the ability to make requirements regarding how BIM is supposed to be used. If a single player is not contributing, much value in the models is lost because of the subsequent inability to use them as intended (Lindblad, 2013).

Solutions for Implementing BIM in Malaysia

The government and its agencies need to play the biggest role, as then the driving force in ensuring BIM technology will be successfully implemented in the construction industry (CREAM, 2014; Rogers, 2015). The government may strategically organise a series of awareness and motivation programmes such as seminars and workshops for various levels of industry players. Institutions of higher learning throughout Malaysia are encouraged to incorporate BIM courses in their syllabus to equip graduates to understand BIM technology as preparation for successful careers.

A proper structure of BIM courses for various grades of contractors and practitioners needs to be provided to give required knowledge in the study and application of BIM implementation. Besides that, a standard code of practices and guidelines of BIM is a pre-requisite for standardising new output and enabling efficient communication and integration among stakeholders, thus ensuring that it will be easy to implement and manage.

The government, the AEC industry, educational institutions and BIM providers need to work together to reduce BIM implementation costs, establish BIM implementation strategies and promote BIM education (Mohd-Nor, 2012; Liu, 2015; Rogers, 2015). With investigation

and overcoming of the identified barriers, BIM will help the AEC industry evolve rapidly. Research results indicate that 92.63% of respondents believed that governments should play a vital role in the BIM implementation process and give it due recognition, indicating that respondents had expectations of government support. Besides that, more than half of the respondents (51.6%) believed that governments should play a leading role, which means that governments should take full advantage of their administrative function and actively participate in the promotion process. A further 39.1% of the respondents believed that governments should play a guiding role, which means there is a need not to lead but to inspire the development of the industry. All government staff thought governments should take a leading or guiding role in BIM implementation. Few industry staff thought that governments should not be involved in BIM implementation at all.

National leadership and coordination can also minimise inefficiencies and avoid the many problems created by piecemeal and disjointed approaches. Although government entities should primarily drive this leadership, it needs the support of and collaboration with major industry players, such as private sector clients, contractors and industry/professional associations (Smith, 2014; Rogers et al., 2015). Other than that, the implementation of BIM needs consistent national and global standards to achieve the efficiencies envisioned by the technology. It is contradictory for there to be a range of different systems and piecemeal approaches to BIM development. Global leadership can help ensure that collaboration occurs on a national and global scale. Clearly, if BIM is to be the future of international projects, then common standards need to be adopted. These papers also suggest providing BIM education, training and research to drive not only implementation but also the evolution of the industry. BIM education is required at the tertiary level so that graduates entering the industry have necessary BIM knowledge and capabilities.

We have discussed above how a number of factors obstruct the implementation of BIM. Cost is the major factor that obstructs implementation of BIM, followed by IT components. This major factor has been solved in developing countries such as the US. Agencies such as government agencies, developers and designers need to take up the implementation of BIM in Malaysia as a serious task. Table 4 summarises the solutions suggested in the literature to help construction players solve problems obstructing the implementation of BIM.

Table 4
Summary of Solutions to Barriers in Implementing BIM in the Construction Industry

No.	Solution	Source
1.0	Offer motivation programmes such as seminars and workshops Incorporate BIM courses in the syllabus of educational institutions Offer properly structured BIM courses at the university level Prepare a standard code of practices and guidelines for BIM	1) CIDB (2014) 2) Smith, P. (2014) 3) Rogers et al. (2015)
2.0	Support and enforce the implementation of BIM by the government Promote BIM training programmes Seek initiative of senior management and related industry players	1) Zahrizan et al. (2014) 2) Smith, P. (2014)

CONCLUSION

BIM has many benefits that can help contractors manage their projects effectively and effortlessly. BIM has the potential to be adopted in the construction field and expanded into the engineering field. Unfortunately, in Malaysia, BIM is lagging behind because of a few factors acting as barriers to its implementation. Cost is one of these factors. It appears that the best way to overcome obstacles to BIM implementation is that governmental agencies and private developers need to play bigger roles to uphold the role of BIM technology in Malaysia.

REFERENCES

Abbasnejad, B., & Moud, H. I. (2013). BIM and basic challenges associated with its definitions, interpretations and expectations. *International Journal of Engineering Research and Application*, *3*(2), 287–294.

Ali, M., Mohamed, Y., Taghaddos, H., & Hermann, R. (2015). BIM obstacles in industrial projects: A contractor's perspective. In *Proceedings of ICSC15: The Canadian Society for Civil Engineering 5th International/11th Construction Specialty Conference* (pp. 1–10). http://doi.org/10.14288/1.0076376

Arayici, Y., Egbu, C., & Coates, P. (2012). Building information modelling (BIM) implementation and remote construction projects: Issues, challenges, and critiques. *Electronic Journal of Information Technology in Construction*, *17*(May), 75–92. http://doi.org/ISSN 1874-4753

Autodesk. (2007). Revit Structure and BIM. *Architecture, 0*(0), 1–9.

Azhar, S., Nadeem, A., Mok, J. Y. N., & Leung, B. H. Y. (2008). Building information modelling (BIM): A new paradigm for visual interactive modelling and simulation for construction projects. In *Proceedings of the First International Conference on Construction in Developing Countries (ICCIDC-I)* (pp. 435-446). Karachi, Pakistan.

Barlish, K., & Sullivan, K. (2012). How to measure the benefits of BIM – A case study approach. *Automation in Construction*, *24*, 149–159. http://doi.org/10.1016/j.autcon.2012.02.008

Becerik-Gerber, B., & Rice, S. (2010). The perceived value of building information modelling in the US building industry. *Journal of Information Technology in Construction*, *15*(February), 185–201. Retrieved from http://www.itcon.org/2010/15

Chougule, N. S., & Konnur, B. A. (2015). A review of building information modelling (BIM) for construction industry. *International Journal of Innovative Research in Advanced Engineering*, *2*(4), 98–102. Retrieved from http://www.ijirae.com/volumes/Vol2/iss4/17.APAE10106.pdf

CREAM. (2014). *Issues and challenges in implementing building information modelling (BIM) for SME's in the construction industry*. Kuala Lumpur, Malaysia: Construction Research Institute (CREAM). Retrieved from http://www.cidb.gov.my/images/pdf/announcement/BIM/bim

Dodia, S. M., & Hariharan, S. (2015). Evaluating effectiveness of BIM application in construction projects. *International Journal of Engineering and Computer Science*, *4*(9), 14076–14078. http://doi.org/10.18535/ijecs/v4i9.01

Eadie, R., Odeyinka, H., Browne, M., McKeown, C., & Yohanis, M. (2013). An analysis of the drivers for adopting building information modelling. *Journal of Information Technology in Construction*, *18*(February), 338–352.

Elhag, T., & Al-sharifi, M. (2014). The viability of BIM for UK contractors. In *Proceedings of International Conference on Construction in a changing* World (pp. 4-7). Retrieved from http://www.cib2014.org/proceedings/

Enegbuma, W. I., Ologbo, A. C., Aliagha, U. G., & Ali, K. N. (2014). Product lifecycle management for a global market. In S. Fukuda, A. Bernard, B. Gurumoorthy, & A. Bouras (Eds.), *11th IFIP WG 5.1 International Conference, PLM 2014, revised selected papers* (pp. 51–62). Yokohama, Japan. Berlin, Heidelberg: Springer Berlin Heidelberg. http://doi.org/10.1007/978-3-662-45937-9_6

Franco, J., Mahdi, F., & Abaza, H. (2015). Using building information modelling (BIM) for estimating and scheduling, adoption barriers. *Universal Journal of Management*, *3*(9), 376–384. http://doi.org/10.13189/ujm.2015.030905

Gardezi, S. S. S., Shafiq, N., Nurudinn, M. F., Farhan, S. A., & Umar, U. A. (2014). Challenges for implementation of building information modelling (BIM) in Malaysian construction industry. *Applied Mechanics and Materials*, *567*(JUNE), 559–564. http://doi.org/10.4028/www.scientific.net/AMM.567.559

Hedayati, A., Mohandes, S. R., & Preece, C. (2015). Studying the OBSTACLES TO IMPLEMENTING BIM in educational system and making some recommendations. *Journal of Basic Applied Science Research, 5*(3), 29–35.

Hosseini, M. R., Azari, E., Tivendale, L., & Chileshe, N. (2011). Barriers to adoption of building information modelling (BIM) in Iran: Preliminary Results. In *proceedings of the The 6th International Conference on Engineering, Project, and Production Management (EPPM2015)* (pp. 384-394).

Kathi, V., Vasam, S., Rao, K. J., & Rao, M. V. S. (2015). A critical review on new advancements in implementation of IT in construction industry: Integration of BIM with could computing. *International Journal of Research in Engineering and Technology, 4*(1), 145–150.

Kushwaha, V. (2016). Contribution of building information modelling (BIM) to solve problems in architecture, engineering and construction (AEC) industry and addressing barriers to implementation of BIM. *International Research Journal of Engineering and Technology, 3*(1), 100-105.

Latiffi, A. A., Mohd, S., Kasim, N., & Fathi, M. S. (2013). Building information modelling (BIM) application in Malaysian construction Industry. *International Journal of Construction Engineering and Management, 2*(A), 1–6. http://doi.org/10.5923/s.ijcem.201309.01

Lindblad, H. (2013). *Study of the implementation process of BIM in construction projects: Analysis of the barriers limiting BIM adoption in the AEC industry.* (Unpublished Master's Thesis). University of Stockholm, Sweden. Retrieved from http://kth.diva-portal.org/smash/get/diva2:633132/FULLTEXT01

Liu, S., Xie, B., Tivendal, L., & Liu, C. (2015). Critical barriers to BIM implementation in the AEC industry. *International Journal of Marketing Studies, 7*(6), 162–171. http://doi.org/10.5539/ijms.v7n6p162

Manu, P., Wildin, K., Shelbourn, M., Navendren, D., & Mahamadu, A. M. (2014). Briefing: Towards exploring profession-specific BIM challenges in the UK. *Proceedings of the ICE - Management, Procurement and Law*, *167*(4), 163–166. http://doi.org/10.1680/mpal.14.00004

Masood, R., Kharal, M. K. N., & Nasir, A. R. (2014). Is BIM adoption advantageous for construction industry of Pakistan? *Procedia Engineering*, *77*, 229–238. http://doi.org/10.1016/j.proeng.2014.07.021

McAuley, B., Hore, A., & West, R. (2012). Use of building information modelling in responding to low carbon construction innovations: An Irish perspective. In *Proceedings of the Joint CIB W055, W065, W089, W118, TG76, TG78, TG8 International Conference on Management of Construction: Research to Practice* (pp. 523–538). Montreal. Retrieved from http://arrow.dit.ie/beschreccon/9/

Migilinskas, D., Popov, V., Juocevicius, V., & Ustinovichius, L. (2013). The benefits, obstacles and problems of practical BIM implementation. *Procedia Engineering*, *57*, 767–774. http://doi.org/10.1016/j.proeng.2013.04.097

Mohd-Nor, M. F. I., & Grant, M. P. (2012). The development of digital architecture modelling in the Malaysian architecture industry. In *Recent Advances in Computer Engineering, Communications and Information Technology. World Scientific and Engineering Academy and Society* (pp. 77–84). Retrieved from http://www.wseas.us/e-library/conferences/2014/Tenerife/INFORM/INFORM-10.pdf

Pučko, Z., Nataša, N., & Klanšek, U. (2014). Building information modelling based time and cost planning in construction projects. *Organization, Technology and Management in Construction: An International Journal*, *6*(1), 958–971. http://doi.org/10.5592/otmcj.2014.1.6

Rogers, J., Chong, H. Y., & Preece, C. (2015). Adoption of building information modelling technology (BIM). *Engineering, Construction and Architectural Management*, *22*(4), 424–445. http://doi.org/10.1108/ECAM-05-2014-0067

Salleh, H., & Fung, W. P. (2014). Building information modelling application: Focus-group discussion. *Journal of the Croatian Association of Civil Engineers*, *66*(08), 705–714. http://doi.org/10.14256/JCE.1007.2014

Sawhney, A. (2014). *State of BIM adoption and outlook in India* (pp. 1–32). India: RICS School of Built Environment, Amity University.

Smith, P. (2014). BIM & the 5D project cost manager. *Procedia - Social and Behavioural Sciences*, *119*, 475–484. http://doi.org/http://dx.doi.org/10.1016/j.sbspro.2014.03.053

Smith, P. (2014). BIM implementation – Global strategies. *Procedia Engineering, 85,* 482–492. http://doi.org/10.1016/j.proeng.2014.10.575

Talebi, S. (2014). Exploring advantages and challenges of adaptation and implementation of BIM in project life cycle. In *2nd BIM International Conference on Challenges to Overcome* (pp. 1–20). BIM Forum Portugal, Lisbon, Portugal.

Thurairajah, N., & Goucher, D. (2013). Advantages and challenges of using BIM: A cost consultant's perspective. In *49th ASC Annual International Conference Proceedings* (pp. 1–8). California Polytechnic State University (Cal Poly) in San Luis Obispo, CA.

Yan, H., & Damian, P. (2008). Benefits and barriers of building information modelling. In *12th International Conference on Computing in Civil and Building Engineering* (Vol. 161, pp. 1-5). Beijing.

Zahrizan, Z., Ali, M., Haron, T., & Marshall-Ponting, A. (2014). Exploring the barriers and driving factors in implementing building information modelling (BIM) in the Malaysian construction industry: A preliminary study. *The Institute of Engineers, Malaysia, 75*(1), 1–10. http://doi.org/10.1017/CBO9781107415324.004