Barriers to Adoption of Building Information Modeling (BIM) in Iran: Preliminary Results

M. Reza Hosseini[1], Ehsan Azari[2], Linda Tivendale[1] and Nicholas Chileshe[3]

Abstract

This study focuses on presenting the preliminary results of an ongoing study aimed at picturing the current state of BIM in Iran based on the perceptions of Iranian construction practitioners. The findings presented in this paper are based on a questionnaire survey completed by 44 construction practitioners active on construction projects in Iran. Through deploying data visualization methods alongside statistical analyses, it came to light that industry practitioners in Iran are not interested in BIM and are inexperienced as to its use. That is, 29.5% of construction companies are involved in some level of BIM adoption whereas 56.8% have had no exposure to BIM and 36.4% even do not have any plans to adopt BIM in the near future. The findings also identified the most high ranked barriers to adoption of BIM in Iran are almost entirely associated with the structure of the Iranian market, the nature of the construction industry and business environment in the country and lack of attention by policy makers and the government. Lack of knowledge on BIM adoption process, unavailability of an appropriate infrastructure, lack of support from managers to accept changing current practices, and lack of practical standards and guidelines in the country were also identified as barriers to BIM adoption in Iran. The clear message is that widespread adoption of BIM in Iran will not occur in the absence of a supportive regulatory environment and financial assistance by policy makers. The paper contributes to the field by sharing the preliminary findings of the first study conducted on BIM in Iran, which paves the way for further inquiries on the topic.

Keywords: Building Information Modeling (BIM), barriers, construction industry, Iran.

Introduction

Low productivity is still a major problem for the construction industry in Iran. This mainly stems from the dominance of traditional methods and lack of attention to embracing the advantages of information communication technology (ICT) in delivering construction projects (Alaghbandrad *et al.*, 2012). On the other hand, the diverse capabilities of BIM for enhancing performance and productivity on construction sites has been observed in seminal studies from different countries e.g. (Azhar, 2011). Thus, a growing interest towards BIM adoption and implementation has been observed throughout the construction industry. This includes a wide range of countries in the Middle East, which have attempted to promote BIM implementation on their construction projects according to the report by buildingSMART (2011). In spite of such prominence for promoting BIM, no body of knowledge hitherto has been allocated to provide the field with a picture of the current state of BIM in Iran and

1 School of Architecture and Built Environment, Deakin University, Geelong, Victoria, Australia. Emails: reza.hosseini@deakin.edu.au; linda.tivendale@deakin.edu.au

2 Tehran Institute of Technology, Email: azari.ehsan.iran@gmail.com

3 School of Natural and Built Environments, University of South Australia, Adelaide, South Australia. Email: nicholas.chileshe@unisa.edu.au

unearth the barriers to its adoption within the Iranian construction industry. Existing studies from the Middle East e.g. (buildingSMART, 2011) have had a bias towards countries in the Persian Gulf and have not covered all the countries in the Middle East including Iran, Israel and Turkey. Moreover, available published studies on BIM in Iran such as the paper by Kiani *et al.* (2015) merely focused on the application of BIM for scheduling projects, thus the broad status of BIM in Iran has remained overlooked. Against this backdrop, acquiring a comprehensive understanding of the status of BIM in the country's market has been regarded as a precursor for promoting BIM (buildingSMART, 2011), which has been the principal raison d'être for the present study.

As the first broad study on BIM in Iran, the present paper is aimed at identifying the barriers to widespread adoption of BIM alongside the evaluation of the current level of awareness and knowledge of BIM among construction practitioners. It is contended that the findings of the present study can provide support for the Iranian construction industry and policy makers in their move towards promoting adoption of BIM in the country.

Background

BIM has been described as the next paradigm shift in the construction industry since the move from conventional architect–contractor project delivery process (Shelden, 2009). As such, BIM has been promoted as "one of the most promising recent developments in the architecture, engineering, and construction (AEC) industry", capable of reducing project cost, enhancing productivity and quality and decreasing the time for project delivery (Azhar, 2011, p. 241). The construction sector in developed economies has observed a growing interest in using BIM due to the myriad of benefits found through its implementation (Eastman *et al.*, 2011). For project planning, design, construction, and maintenance phases, such benefits include resource savings, productivity enhancements (Azhar, 2011) and improvement of quality (Ashcraft, 2008; Chen and Luo, 2014). Implementing BIM fosters a more reliable and timely exchange of information among project stakeholders that accordingly promotes earlier creation of pivotal data necessary for designing and detailing (Ashcraft, 2008).

In spite of such advantages, the extent to which BIM has permeated the construction industry varies significantly among different countries as argued by Gu and London (2010). Identifying the barriers to adoption of BIM has been regarded as a prelude for enhancing BIM adoption (Kassem *et al.*, 2012). In response to this, investigators have attempted to identify the barriers to BIM adoption in different countries.

According to Gu and London (2010), lack of initiative, knowledge and training, fragmented nature of the construction industry, varied market readiness across organizations and geographies, and industry's resistance to change traditional working practices are generic barriers to BIM adoption. For the construction industry in the UK, "…the inefficiency in the evaluation of the business value of BIM and 4D; the shortage of experience within the workforce, and the lack of awareness by stakeholders…" were recognized by Kassem *et al.* (2012, p. 1) as main barriers to BIM. In developing countries, BIM has not hitherto become an active field of research with few studies available from the context of developing countries (Aboushady and Elbarkouky, 2015).

As shown in Table 1, the findings by Bin Zakaria *et al.* (2013) showed that lack of knowledge and awareness, absence of support from the government and unavailability of BIM standards and guidelines are among the hurdles to higher level of BIM adoption in Malaysia. Nanajkar and Gao (2014) investigated the status quo of BIM in India and concluded that the cost of software, the steep learning curve and incompatibility issues among different software packages were perceived as the principal barriers to BIM adoption by Indian construction experts. In China, the main barriers to BIM turned out to be the lack

of qualified in-house personnel, unavailability of training/education, absence of standards, and lack of client demand as identified by Chan (2014). The major barriers to BIM adoption in Nigeria were discovered as the resistance to change in the industry, lack of training, education and cost associated with training, lack of support and involvement of the government (Abubakar *et al.*, 2014).

Table 1. Barriers to BIM adoption in developing countries in previous studies

Barriers to BIM	References
Lack of knowledge and awareness	(Bin Zakaria *et al.*, 2013)
Lack of support from policy makers	(Bin Zakaria *et al.*, 2013; Abubakar *et al.*, 2014)
Unavailability of standards and guidelines	(Bin Zakaria *et al.*, 2013; Chan, 2014)
Initial costs	(buildingSMART, 2011; Abubakar *et al.*, 2014; Rogers *et al.*, 2015)
Training and learning issues	(buildingSMART, 2011; Abubakar *et al.*, 2014; Chan, 2014; Nanajkar and Gao, 2014)
Incompatibility and interoperability problems	(Nanajkar and Gao, 2014; Rogers *et al.*, 2015)
Lack of demand	(Chan, 2014; Rogers *et al.*, 2015)
Lack of skilled personnel	(buildingSMART, 2011; Chan, 2014; Rogers *et al.*, 2015)
Resistance to change	(Abubakar *et al.*, 2014; Rogers *et al.*, 2015)

The study by buildingSMART (2011) in a number of countries in the Middle East brought to light the fact that higher adoption of BIM is hampered by unavailability of staff and required training. This was also revealed that although the market is avidly interested and optimistic, the construction industry is still in initial stages of its move towards harnessing the benefits of BIM. According to buildingSMART (2011, p. 3) "overall the findings represent a market that is optimistic and aware, but inexperienced in BIM". In essence, as illustrated in Table 1, major barriers to higher level of BIM adoption seem to be stemmed from novelty of the BIM methodology in developing countries. That is, lack of awareness and unavailability of training and skilled personnel were observed in India, China, Malaysia and Nigeria as the primary barriers to BIM adoption. Such barriers are exacerbated by the lack of support from policy makers in developing countries and absence of incentives to compensate initial costs of adopting BIM in construction firms as argued by (Rogers *et al.*, 2015).

Likewise, BIM is a novel method within the Iranian construction industry, yet a number of attempts have been made to promote BIM in Iran. These include establishing the BIM Council in Iran (www.iranbimcouncil.com/) and the Iran BIM Association (http://www.ibima.ir/en/) aimed at disseminating the knowledge of BIM among practitioners and expediting the process of BIM assimilation into construction projects. However, studies conducted on BIM in Iran are very few. To the best of the authors knowledge, except for the study by Kiani *et al.* (2015), no other empirical study on BIM in Iran is available in the body of knowledge. As such, the findings of review of literature reaffirm the discussions regarding the necessity of conducting an exploratory study on BIM in Iran as described next.

Research Methods

The questionnaire for the study was divided into three main sections. The first section provided the demographics of respondent, with the 2nd section comprising six questions for the evaluation of the current state of BIM on construction projects. The 3rd section presented

thirteen items identified from the literature to elucidate the perceptions of respondents regarding barriers to BIM adoption in Iran. The questionnaire was designed based on a seven-point Likert rating scale comprising a range from 1=very strongly disagree to 7= very strongly agree with a neutral phrase in the middle. For designing the questions, the items used in the survey conducted by buildingSMART (2011) were deployed to provide a basis for comparison with other countries in the Middle east. Using a previous-applied survey is justifiable as according to Punch (2005, p. 94) "…we would need good reason for passing over an already existing instrument, particularly if the variable is a central variable in a research area." The developed questionnaire was pilot tested by sending it to four construction practitioners and the feedback obtained was incorporated into the questionnaire prior to delivering the survey to the population of interest.

The target population included contractors and consultants active in all types of construction activities in Tehran. According to the formal classification of contractors currently in place in Iran, construction companies active in government projects are classified into 5 categories. Those in class 1 are the largest in size and are allowed to undertake projects of highest value (Ghoddousi and Hosseini, 2012) while companies in class 5 are usually newly-established companies that carry out small projects. Apart from these 5 categories, some companies are active in housing developments in the private sector. The target population covered both private sector companies and companies from the 5 classes as described above. In addition, consultants are categorized into 3 grades in which grade one consultants are able to provide services for the largest projects. Invitations for participation in this research were sent through the professional association of engineers in Tehran (http://www.tceo.ir/), which is an umbrella organization for all professionals active in construction activities in Tehran. As a result, the study followed a 'quota' sampling approach as termed by Rowley (2014). That is, "cases are selected on the basis of set criteria …, to ensure that the sample has a spread of cases in different categories…" (Rowley, 2014, p. 319). As a result, cases in the present study were selected considering their affiliation with the aforementioned association with the aim of covering various construction practitioners in different categories.

Having a population of over 10 million (i.e. 1/7 of Iran's population), Tehran is among the most populated capitals in the world and is Iran's largest city. Due to the concentration of a wide range of socio-economic opportunities, construction practitioners from all professional areas and from other regions of the country migrate to Tehran in search of work as according to estimations by the Ministry of Roads and Urban Development (http://www.mrud.ir) around half of construction practitioners in Iran live in Tehran. Hence, Tehran was regarded as a representative of a pool of a wide range of construction practitioners from various backgrounds as argued by Ghoddousi *et al.* (2014). Data collection commenced in January 2015. In May 2015, 560 companies in Tehran had received the invitation, but only 44 had completed the survey. Subsequent follow up contacts with the companies revealed that most of companies had opted not to complete the questionnaire due to lack of experience and awareness of the concept of BIM.

Results and Discussions

Respondents Profile

The profile of the respondents as illustrated in Table 2 is reflective of the diversity of respondents in terms of the nature of activity and their role in the construction industry. Around 75% of respondents were from small companies with fewer than 50 employees. This is no surprise considering the structure of the construction industry in developing countries as according to Edmonds (1979) only around 10% of companies in the construction industry

employ more than 50 personnel. As well, around 23% were consultants, 61% contractors and 16% belonged to the urban housing developers' category. In terms of the length of service in the construction industry, more than 80% of companies had more than 7 years of experience in the construction industry. As a result, the respondents were deemed adequately knowledgeable and diverse enough to provide information regarding the current state of BIM in the Iranian construction industry.

Table 2. Profile of respondents

Role of the company	Number of Employees				Total
	1-49 employees	200-999 employees	50-199 employees	More than 1000 employees	
Consultant Grade 1	4	0	1	0	5
Consultant Grade 2	1	0	0	0	1
Consultant Grade 3	4	0	0	0	4
Contractor Grade 1	5	1	4	3	13
Contractor Grade 2	3	0	0	0	3
Contractor Grade 3	5	1	1	0	7
Contractor Grade 5	4	0	0	0	4
Urban housing	7	0	0	0	7
Total	33	2	6	3	44

BIM Level of Use

As illustrated in Figure 1, merely 29.5% of companies claimed that they have used BIM while 36.4% stated that they have no plans for using BIM. Unlike the report by buildingSMART (2011) that implied the market in the Middle East is interested in BIM, results in Iran as reflected in Figure 1 manifest a slow move towards BIM based on the fact that 36.4% of companies had no plans for BIM while only 18.2% indicated an interest in using BIM in one year.

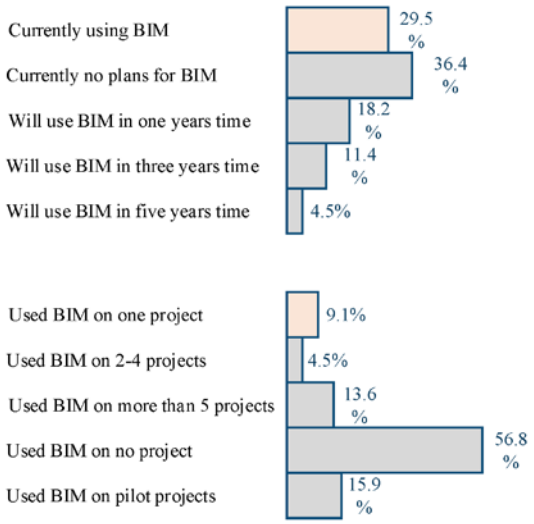

Figure 1. Level of BIM Use in Iran

The experience with BIM in the Middle East turned out to be much higher in comparison to the case of Iran. That was because, around 40% of contractors participating in the survey by buildingSMART (2011) claimed to have experience with BIM in more than 5 projects whereas only 13.6% of Iranian companies had used BIM in more than 5 projects. In essence, the findings manifest an unexperienced market for BIM in Iran. In addition, the trend of harnessing BIM in projects seems to be slow and by far lagging behind other countries in the Middle East.

Barriers to BIM

The reliability analysis for the measurement items for barriers to BIM (comprising the 13 items) resulted in the Cronbach's Alpha coefficient value of 0.92, which exceeded the accepted norm of 0.7 according to Nunnally and Bernstein (1994) implying the reliability of the measurements deployed in the questionnaire. The items reflective of barriers to BIM were ranked based on the Coefficient of Variation (CV). This approach of using the CV obtained by dividing the mean score with the standard deviation has been recommended by Sheskin (2003) and has been accepted within construction research (Ghoddousi and Hosseini, 2012). The CV is reflective of the variability in responses of respondents; hence smaller CVs show higher levels of agreement on the item as indicated by the respondents. Table 3 summarises the results of analysis of barriers to adoption of BIM based on the overall sample of respondents.

Table 3. Relative importance of barriers to BIM in the Iranian construction industry

Barriers	N	Mean	Std. Deviation	CV	Rank
Lack of support and incentives from construction policy makers	38	4.78	1.43	0.299	1
We don't know where to start	40	4.50	1.41	0.314	2
Necessary training is not available	39	4.28	1.46	0.342	3
BIM industry standards and codes are not available	39	4.59	1.66	0.362	4
Cost associated with purchasing necessary packages and software	38	3.84	1.40	0.365	5
BIM requires radical changes in our workflow, practices and procedures	39	4.12	1.54	0.373	6
BIM is regarded as a low return-on-investment	40	3.55	1.35	0.382	7
ICT facilities and internet structure in the country are not available on projects	39	4.23	1.64	0.388	8
Cost of hardware upgrade	40	3.87	1.55	0.401	9
Lack of buy-in from other trades in the market	40	4.10	1.66	0.405	10
Unavailability of skilled staff	39	3.74	1.55	0.414	11

Benefits of BIM have not been conclusively proven	40	3.60	1.49	0.416	12
Current methods are adequate for our projects and BIM is an unnecessary investment	38	3.05	1.46	0.481	13
Valid N (listwise)	33				

As inferred from Table 3, the most important barrier to BIM adoption for the Iranian construction practitioners was the lack of support and absence of incentives for promoting BIM by the policy makers in the construction industry. This was in close consistency with the findings of the studies on barriers of BIM in Malaysia (Bin Zakaria *et al.*, 2013) and Nigeria (Abubakar *et al.*, 2014) where the role of government was highlighted in promoting increased levels of BIM adoption in the construction industry. That is, construction companies in Iran as other developing countries usually have to conform to the requirements of the policy makers because their businesses strongly depend on the budget allocated to construction projects by policy makers. Thus, the policy makers could be a major driving force for construction companies to take actions as discussed by Kaliba *et al.* (2009). This becomes understandable in view of the great role of the state and policy makers in the economy and manipulating the business environment in Iran as argued by Alizadeh *et al.* (2000).

The second, third and fourth most important barriers all pointed to the lack of knowledge, awareness and experience in adoption of BIM in Iran, which makes companies cautious in adopting BIM. This resonates with the observations made in Malaysia by Bin Zakaria *et al.* (2013) denoting that lack of experience and knowledge and unavailability of documents to instruct practitioners are major barriers to widespread adoption of BIM on construction projects in developing countries. This highlights the role of policy makers in the construction industry again because according to the regulations in Iran, the government or its associated professional associations are in charge of preparation of mandatory and instructive documents (such as standards and building codes) regarding construction activities. In this context, construction companies evaluate adoption of any novel method such as BIM as difficult and riddled with uncertainties. Thus, they commonly opt not to adopt the innovative method and retain their traditional methods according to the theories of innovation diffusion in the construction industry as asserted by Hosseini *et al.* (2015).

Barriers ranked as the fifth to 9th most important ones were mostly derived by resistance to change within construction companies and the costs associated with establishing BIM on projects. This finding echoes the observations by Abubakar *et al.* (2014) in Nigeria implying that one of the most important inhibitors of BIM adoption turned out to be the high level of resistance to change within the construction industry. The structure of the construction industry in Iran is dominated by traditional methods of project delivery (Ghoddousi and Hosseini, 2012). The necessity of radical change in the current working routines that is required for adopting BIM faces a great level of resistance by construction practitioners in the country. Lack of interest in changing the methods is reflected in Figure 1 as well indicating that companies do not consider BIM in the near future. On the other hand, the speed of the internet and the infrastructure required for adopting BIM and collaboration is still a problem within the Iranian construction industry particularly for projects delivered in remote areas due to immaturity of Iran in implementing ICT solutions (Alaghbandrad *et al.*, 2012). Therefore, the 8th and 9th barriers have roots in problems associated with the infrastructure and the significant costs of providing necessary hardware for adopting BIM on projects as reflected in Table 3.

Lack of buy-in from trades in the Iranian market further minimizes the adoption rate because construction companies usually are interested in implementing innovative methods adopted by their competitors in the market (Hosseini *et al.*, 2015). Thus, slow uptake and general lack of interest in the market deters decision makers to put in effort into adopting BIM as illustrated in Table 3 as the 10th barrier to BIM in Iran. The 11th barriers as illustrated in Table 3 reflects a generic problem hindering higher levels of BIM adoption in a wide range of countries. That is because, benefits of BIM are identified and understood only by experienced users of BIM as the case observed by buildingSMART (2011). As a result, lack of experience with BIM in Iran results in lack of awareness of the potential benefits of BIM, which in turn inhibits companies from putting in effort for adopting BIM on their projects.

Effects of respondents' attributes

One-way analysis of variance (ANOVA) is a procedure that enables researchers of determining if responses provided by different groups of respondents are different in cases participants vary on a single independent variable. In the present study, independent variables were the attributes of respondents in terms of size of the company and role of the company within the Iranian construction industry. Given the relatively small sample size of the study, non-parametric methods were deployed to conduct the analysis as recommended by the seminal study by Siegel and Castellan (1988). *Kruskal-Wallis H* test provides a non-parametric equivalent for one-way ANOVA with very few assumptions regarding the nature of submitted data (Cronk, 2014). Table 4 illustrates the results of conducting Kruskal-Wallis for comparing the barriers among different company sizes and among companies with different roles (see Table 2).

Table 4. Independent-samples Kruskal-Wallis Test for barriers

Barriers	Role of company		Size of company	
	Test statistics	Asymptotic Sig.	Test statistics	Asymptotic Sig.
Unavailability of skilled staff	1.726	0.973	0.218	0.975
Lack of support and incentives from construction policy makers	7.263	0.402	1.350	0.717
Cost associated with purchasing necessary packages and software	7.556	0.373	4.750	0.191
Necessary training is not available	6.324	0.502	0.038	0.998
Cost of hardware upgrade	8.214	0.314	6.199	0.102
BIM industry standards and codes are not available	7.263	0.402	1.852	0.604
Lack of buy-in from other trades in the market	5.420	0.609	1.785	0.618
BIM requires radical changes in our workflow, practices and procedures	8.736	0.272	6.587	0.086
Benefits of BIM have not been conclusively proven	8.472	0.293	1.689	0.639
Current methods are adequate for our projects and BIM is an unnecessary investment	9.255	0.160	7.435	0.059
ICT facilities and internet structure in the country are not available on projects	8.078	0.326	5.475	0.140
BIM is regarded as a low return-on-investment	6.627	0.469	1.871	0.600
We don't know where to start	5.035	.656	3.057	0.383

As inferred from Table 4, no significant difference ($p > 0.05$) was observed among different sizes of Iranian companies in terms of their perceived barriers to adoption of BIM on their projects. Besides, difference in roles among companies does not seem to be influential in defining the barriers for a company for adopting BIM. This brings to light that similar policies for overcoming barriers could be equally used for different sizes of companies and for contractors, consultants and practitioners with other roles within the Iranian construction industry.

Conclusion

The findings of the study confirmed the anecdotal evidence in Iran indicating low level of adoption and lack of interest in the construction industry for adopting BIM. The data collected brought to light that the Iranian construction industry is significantly lagging behind other countries in the Middle East particularly countries in the Persian Gulf with respect to awareness and adoption of BIM on construction projects. Additionally due to lack of attention from policy makers and the government, construction companies are not interested in adopting BIM in comparison to the level of interest expressed by construction practitioners in other countries in the Middle East. Given the great role of policy makers and the government in controlling the business environment in the Iranian construction industry and the advantages of BIM, policy makers should pay particular attention to measures geared towards promoting BIM in the country. This should include mandating delivering projects by BIM in large-sized construction projects, funding research projects to deliver pilot studies using BIM and sharing the knowledge gained throughout the whole construction industry. As well, publication of instructive documents to assist construction practitioners in their move towards higher level of BIM adoption on their projects could be of value. In the absence of support and attention from policy makers, the shift of the Iranian construction industry towards adopting BIM would be a slow process with unclear outcomes.

The findings of the study provide an illuminating insight into the general status quo of BIM within the Iranian construction industry. Yet, the findings should be considered in view of the limitation of the present research. The main limitation of the study is having a relatively small sample from Tehran, which might not be representative of the whole construction practitioners in Iran. Besides, respondents almost entirely came from small companies with only a few from large-sized firms. As a result, findings might not be indicative of the perception of large construction companies in Iran as another limitation for the present study. Nevertheless, such limitations warrant further research on the topic through using larger sample and respondents from large companies.

References

Aboushady, A. M., & Elbarkouky, M. M. G. 2015. Overview of Building Information Modeling Applications in Construction Projects. Paper presented at the AEI 2015: Birth and Life of the Integrated Building, Milwaukee, Wisconsin.

Abubakar, M., Ibrahim, Y., Kado, D., & Bala, K. 2014. Contractors' Perception of the Factors Affecting Building Information Modelling (BIM) Adoption in the Nigerian Construction Industry. Paper presented at the Computing in Civil and Building Engineering (2014), Orlando, Florida, United States.

Alaghbandrad, A., Asnaashari, E., & Preece, C. 2012. Problems and barriers of ICT utilization on Iranian construction sites: Case study on the successful use of ICT in remote construction sites. 17, 93-102.

Alizadeh, P., Hakimian, H., & Karshenas, M. 2000. The economy of Iran: The dilemma of an Islamic state. New York, NY: IB Tauris.

Ashcraft, H. W. 2008. Building information modeling: a framework for collaboration. *Construction Lawyer*, 28(3), 5-18.

Azhar, S. 2011. Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadership and Management in Engineering*, 11(3), 241-252.

Bin Zakaria, Z., Mohamed Ali, N., Tarmizi Haron, A., Marshall-Ponting, A., & Abd Hamid, Z. 2013. Exploring the adoption of Building Information Modelling (BIM) in the Malaysian construction industry: A qualitative approach. *International Journal of Research in Engineering and Technology*, 2(8), 384-395.

buildingSMART. 2011. BIM in the Middle East 2011. buildingSMART ME.

Chan, C. T. W. 2014. Barriers of Implementing BIM in Construction Industry from the Designers' Perspective: A Hong Kong Experience *Journal of System and Management Sciences*, 4(2), 24-40.

Chen, L., & Luo, H. 2014. A BIM-based construction quality management model and its applications. *Automation in Construction*, 46(0), 64-73.

Cronk, B. C. 2014. How to Use SPSS : a step-by-step guide to analysis and interpretation (8th ed.). Glendale, CA: Pyrczak Pub.

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. 2011. BIM Handbook : A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, 2 ed. Hoboken: Wiley.

Edmonds, G. A. 1979. Construction Industry in Developing Countries. *International Labour Review*, 118, 355-370.

Ghoddousi, P., Bahrami, N., Chileshe, N., & Hosseini, M. R. 2014. Mapping site-based construction workers' motivation: Expectancy theory approach. 14(1), 60-77.

Ghoddousi, P., & Hosseini, M. R. 2012. A survey of the factors affecting the productivity of construction projects in Iran. *Technological and Economic Development of Economy*, 18(1), 99-116.

Gu, N., & London, K. 2010. Understanding and facilitating BIM adoption in the AEC industry. *Automation in Construction*, 19(8), 988-999.

Hosseini, M. R., Chileshe, N., Zuo, J., & Baroudi, B. 2015. Adopting global virtual engineering teams in AEC Projects: A qualitative meta-analysis of innovation diffusion studies. *Construction Innovation*, 15(2), 151-179.

Kaliba, C., Muya, M., & Mumba, K. 2009. Cost escalation and schedule delays in road construction projects in Zambia. *International Journal of Project Management*, 27(5), 522-531.

Kassem, M., Brogden, T., & Dawood, N. 2012. BIM and 4D planning: a holistic study of the barriers and drivers to widespread adoption. *KICEM Journal of Construction Engineering and Project Management*, 2(4), 1-10.

Kiani, I., Sadeghifam, A. N., Ghomi, S. K., & Marsono, A. K. B. 2015. Barriers to Implementation of Building Information Modeling in Scheduling and Planning Phase in Iran. *Australian Journal of Basic and Applied Sciences*, 9(5), 91-97.

Nanajkar, A., & Gao, Z. 2014. BIM Implementation Practices at India's AEC Firms. Paper presented at the International Conference on Construction and Real Estate Management, Kunming, China.

Nunnally, J. C., & Bernstein, I. H. 1994. Psychometric theory. New York: McGraw-Hill.

Punch, K. F. 2005. Introduction to social research: Quantitative and qualitative approaches. Thousand Oaks, Calif.: Sage Publications Ltd.

Rogers, J., Heap-Yih, C., Preece, C., McCaffer, R., & Thomson, D. 2015. Adoption of Building Information Modelling technology (BIM): perspectives from Malaysian

engineering consulting services firms. *Engineering, Construction and Architectural Management*, 22(4).
Rowley, J. 2014. Designing and using research questionnaires. *Management Research Review*, 37(3), 308-330.
Shelden, D. 2009. Information Modelling as a Paradigm Shift. *Architectural Design*, 79(2), 80-83.
Sheskin, D. J. 2003. Handbook of Parametric and Nonparametric Statistical Procedures: Third Edition. Florida, USA: CRC Press.
Siegel, S., & Castellan, N. J. 1988. Nonparametric statistics for the behavioral sciences (2nd ed.). New York, NY: McGraw-Hill.