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Barriers to Implement Building Information Modeling (BIM) to Construction Industry: A Review

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Abstract. Construction industry is one of the largest economic sectors in the world in 2017. Building Information Modeling (BIM) is the set of powerful technologies to design, construct and manage which has strengthen the construction industry. BIM has significant benefits for the project lifecycle even after its lifecycle has ended. Yet this benefit can't be gained by the project because of the failure to successfully implementing BIM technology to the construction industry. The main objectives of this study is to identify the most crucial barrier to implement BIM and develop a relative rank with their relative impact on this issue. The study was conducted by a comprehensive literature review. The necessary data for the experiment was also collected by literature review. A set of barriers were developed by the literature review containing 37 barriers which curb the implementation of BIM technology to the construction industry. Relative rank was calculated based on their frequency for each barrier identified in the literature review. Relative impact was calculated from the relative impact equation. The five most crucial barriers to the implementation of BIM are B17 (Social and habitual resistance to change), B19 (Traditional methods of contracting), B3 (Training expense and the learning curve are too expensive), B20 (High cost of software purchasing) and B33 (Lack of awareness about BIM). The five most impactful barriers are B19 (Traditional methods of contracting), B17 (Social and habitual resistance to change), B33 (Lack of awareness about BIM), B2 (Unavailability of proper training on BIM) and B28 (Lack of BIM experts). To gain the tremendous benefits of BIM technology, it is necessary to overcome the barriers based on priority with the help of government and all the stakeholders of project

Keywords: BIM; Barrier; Literature Review; Relative Impact; Construction Industry

1. Introduction

According to Autodesk, the developer of various Building Information Modeling (BIM) tools, "BIM (Building Information Modeling) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure" (Autodesk, 2017). Another definition is, "A digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward" (NIBS, 2015). BIM is a significant technological advancement of the construction industry for drawing, modeling, simulation, management and control. It has been becoming the most essential part of entire Architecture, engineering and construction (AEC) industries in the world. The concept of BIM originated for the simple computing applications at 1960s and improved for solid modeling programs at 1970s (Smith, 2014). A source states that development of ArchiCAD software is considered as the true evaluation of BIM and application of Revit software is the effective implementation of modern advance BIM (Quirk, 2012). The major idea behind BIM is to complete a project virtually before the construction of the project has started physically in order to find out potential risks, problems and conflicts. It also analyzes the techniques and processes of construction and viability of socio-economic factors during the early design phase of project. BIM means the effective and efficient organizing system of collaboration of appropriate personnel and information which was planned for different predefined processes and technology rather than the application of CAD and 3D modeling. BIM is a data based, object-oriented, intelligent and virtual presentation of facilities that help to make decision and improve the process of construct and delivery (Azhar, 2011). The key factors of BIM is personnel, process, information and technology (Arayici, Egbu, & Coates, 2012).

A Building Information Modeling (BIM) in the building construction case is a 3D modeling which deals with design, planning, construction and operation (Kymmell, 2007). The 3D model contained with rich data about structural, technical and management is used to analyze building performance, sustainability, schedules and cost issues (Uddin & Khanzode, 2013). At the early age, Building information modeling (BIM) was used for designing and analysis of different stages of building construction but now it is used for monitoring, controlling and managing the operation and to maintain building and performance as well as in production and services industries. BIM is developed an advanced and appropriate set of techniques and process involve in project whole lifecycle (Demian & Walters, 2014).

Building Information Modeling (BIM) redefined the architecture, engineering, and construction (AEC) industry from the very late of twenty century. The modern concept of BIM was developed with the idea of 3D modeling of project but later expanded the concept to 4D associated with the construction processing and scheduling, 5D modelling with cost estimation of project, 6D modelling with sustainability of project, 7D modelling with facilities management and application and even nD modelling (Mohanta & Das, 2017). It is broadly believed that BIM can play a widespread role in integrating the various phases all through the entire lifecycle of a production project (Jung & Joo, 2011). To overcome the low productivity of construction project and other risks and barriers which affect the improvement of construction industry, BIM was strangely implemented at AEC industry at early 1990s (Teicholz, 2004). BIM technology gives a range of direct and indirect benefits and makes the whole design and construction process more simplified and transparent in many aspects (Lee, Park, & Won, 2012).

About 40% unbudgeted costs are being reduced with the help of BIM technologies and it is also reducing the time to deliver the project to the client without any major conflict by 7% and approximately 80% contraction in the time it takes to bring about cost estimates with a higher rate of accuracy around

3% (Azhar, 2011). Construction Industry Institute estimated in 2004 that 57% of money spent on construction is non-value added which is wastage. The U.S. construction market estimated at US$1.288 trillion for 2008, at 57% waste, over $600 billion per year is being wasted (AL-OTAIBI, 2017). BIM aided the UK Government in saving approximately $1.7 billion in construction costs in 2013–2014, creating the road for the Digital Built Britain policy for construction and procurement which is fully BIM-driven in the UK (Blackwell, 2015). The BIM technology can integrate design, construction, maintenance and control. It is a rich model with sufficient data for the lifecycle and assists all stakeholders with improvements in performance efficiency. BIM is the best technology for the sustainable design and development by reducing costs, risk and wastage as well carbon emissions and environmental pollutions. BIM technology also results in hard worked marketplace enhancements, strengthens greater collaborative working practices, and improves communication between project stakeholders (Porwal & Hewage, 2013).

The objectives of this study is to identify the critical barriers in implementation of BIM technology to the construction industry by conducting a comprehensive literature review while also identifying the benefits that might be brought by overcoming the barriers in implementation of BIM to the construction industry.

2. Methodology

The critical factors affecting the implementation of BIM and the benefits of BIM implementation are designed as questionnaire for the study by conducting a comprehensive literature review. The questionnaire design was finalized from an intensive review of journal papers, research papers, technical and review papers, books, articles, websites and blogs. For this study we review (Abubakar, Ibrahim, Kado, & Bala, 2014; AL-Btoush & Haron; AL-OTAIBI, 2017; Arayici et al., 2012; Arayici, Khosrowshahi, Ponting, & Mihindu, 2009; Autodesk, 2017;

Azhar, 2011; Azhar, Carlton, Olsen, & Ahmad, 2011; Banawi, 2017; Blackwell, 2015; Cao, Li, Wang, & Huang, 2017; Chan, 2014; Demian & Walters, 2014; Diaz, 2016; Eadie, Odeyinka, Browne, McKeown, & Yohanis, 2014; Elmualim & Gilder, 2014; Enshassi, AbuHamra, & Mohamed, 2016; Gerges et al., 2017; Jung & Joo, 2011; Jupp, 2013; Kymmell, 2007; Lee et al., 2012; Liu, Xie, Tivendal, & Liu, 2015; Manning, 2012; Matarneh & Hamed, 2017; Mohanta & Das, 2017; Morrison, 2010; NIBS, 2015; Padmini, 2016; Porwal & Hewage, 2013; Quirk, 2012; Sahil, 2016; Smith, 2014; Stewart, Mohamed, & Marosszeky, 2004; Teicholz, 2004; Teo, Ofori, Tjandra, & Kim, 2015; Uddin & Khanzode, 2013; Yan & Demian, 2008; Zuhairi, Marshall-Ponting, Ahmad, Nasly, & Zahrizan, 2014).

The relative ranking and relative impact were found from the barrier to implement BIM technology to the construction industry based on the frequency on literatures. Then the relative impact of each barrier was calculated from the equation (1);

$$\text{Relative Impact, RI} = F/(H*A*P) \qquad (1)$$

In equation (1), F is the frequency of the barrier, P is the highest rank and A is the lowest rank found from literature review of the barrier. H is the highest frequency among all barrier (H=28 for this study).

3. Result and Discussion

The study identifies the main critical barrier to the implementation of Building Information Modeling (BIM) to the construction industry. Table-1 shows the relative rank among the critical factors affecting the successful implementation of BIM technology in construction industry based on the existing frequency from reviewing literature materials. Figure-1 also represents frequency against the barriers graphically. The top twelve factors affecting the implementation of BIM technology to the construction sector are (1) Social and habitual resistance to change (F=28), (2) Traditional methods of contracting (F=28), (3) Training expenses and the learning curve are too expensive (F=27), (4) High cost of software purchasing (F=26), (5) Lack of awareness about BIM (F=26), (6) High cost of BIM hardware and tools (F=25), (7) Initial set up of BIM is difficult (F=24) , (8) Lack of BIM experts (F=24), (9) High Maintenance costs (F=24), (10) unavailability of proper training on BIM (F=23), (11) Complexity of BIM (F=23) and (12) BIM licensing problems (F=23). The lowest impacting factors affecting the implementation of BIM are (1) Unavailability of BIM risk insurances (F=5), (2) Poor Internet Connectivity (F=6), (3) Frequent Power Failure (F=6), (4) Construction market is not suitable and ready yet (F=7).

Table 1: Rank of factors of barrier

ID	Barrier	Frequency F	Rank	Relative Impact
B1	Construction market is not suitable and ready yet	7	34	0.0317
B2	Unavailability of proper training on BIM	23	9	0.0730
B3	Training expenses and the learning curve are too expensive	27	2	0.0667
B4	Higher authority and decision maker do not provide full support	16	21	0.0635
B5	Unavailability of BIM risk insurances	5	37	0.0159
B6	The system of single-discipline design but not integrated design	12	28	0.0476
B7	Benefits are not tangible enough to warrant its' use	21	15	0.0567
B8	Contractor do not usually empirically prove the benefits of BIM to clients	22	13	0.0492
B9	Difficult to having everyone on project to make BIM effort worthwhile	15	25	0.0317
B10	Too many legal barriers exit	17	19	0.0397
B11	The legal barriers overcome cost	9	32	0.0317

B12	Lack of global use in local construction industry	18	17	0.0643
B13	Not sufficient demand from clients and/or other organizations on projects	20	16	0.0714
B14	lack of guidelines and standards of the way BIM have to be implemented for construction industry	16	21	0.0794
B15	Uncertainty of the benefits of BIM implementation	10	31	0.0556
B16	Current technology in construction is enough	9	32	0.0635
B17	Social and habitual resistance to change	28	1	0.0833
B18	Complexity of BIM	23	9	0.0563
B19	Traditional methods of contracting	28	1	0.0817
B20	High cost of software purchasing	26	4	0.0643
B21	High cost of BIM hardware and tools	25	5	0.0587
B22	BIM licensing problems	23	9	0.0317
B23	High Maintenance costs	24	7	0.0508
B24	Low computer skills among a lot of participants in the construction industry	22	13	0.0492
B25	Requirement of advanced electronics equipment	13	26	0.0476
B26	The shortage of sufficient time to evaluate BIM and its training	16	21	0.0159
B27	Absence or incomplete national standard for BIM	18	17	0.0556
B28	Lack of BIM experts	24	7	0.0722
B29	Lack of information sharing in BIM	12	28	0.0794
B30	Firms are not familiar enough with BIM use	16	21	0.0556
B31	It does not help if your counter-parties	11	30	0.0397

	are not using the BIM			
B32	Initial set up of BIM is difficult	24	7	0.0579
B33	Lack of awareness about BIM	26	4	0.0802
B34	People comparing BIM to CAD	13	26	0.0397
B35	Poor internet connectivity	6	36	0.0238
B36	Frequent power failure	6	35	0.0159
B37	Product liability risks	17	19	0.0079

The social and habitual resistance to change is a natural factor within every living beings. The uncertainty of change drives everyone to have the urge of remain unchanged, same as the involved stakeholders in construction project. The second most significant factor is the traditional method of contracting. The involved parties are familiar and adapted with the traditional method for a long time which made them expert and quick with this method. Hence replacing these methods is not easy for stakeholders and also not acceptable for everyone. Some people have low self-confidence, especially related with implementing new technology due to the lack of knowledge (O'Brien, 2000). Training expenses and the learning curve are too expensive for the successful implementation of BIM technology to the construction industry. For this reason, the local construction firms are not interested in adopting the BIM technology as their concern is of investing huge capital. The high cost of software value for initiation of BIM is another top barrier to implement BIM. The information gap about BIM has strengthened the process of failure in implementing BIM technology to the construction industry. Without significant knowledge and awareness of BIM each parties of the construction project is reluctant to the adoption of BIM.

On the other hand, the less impactful factors affecting the successful implementation of BIM technology to the construction industry are not as responsible as the top factors are. Unavailability of BIM risk insurance is the top 'less important factor' that affect the implementation of BIM. Due to the lack of knowledge about BIM, insurance company do not provide insurance for BIM. The sufficient internet connection and frequent power failure also have some impact to the resistance of the implementation of BIM. Without internet and power BIM technology can't be implemented and run along progressive ways because most of the BIM tools need continuous power and internet based.

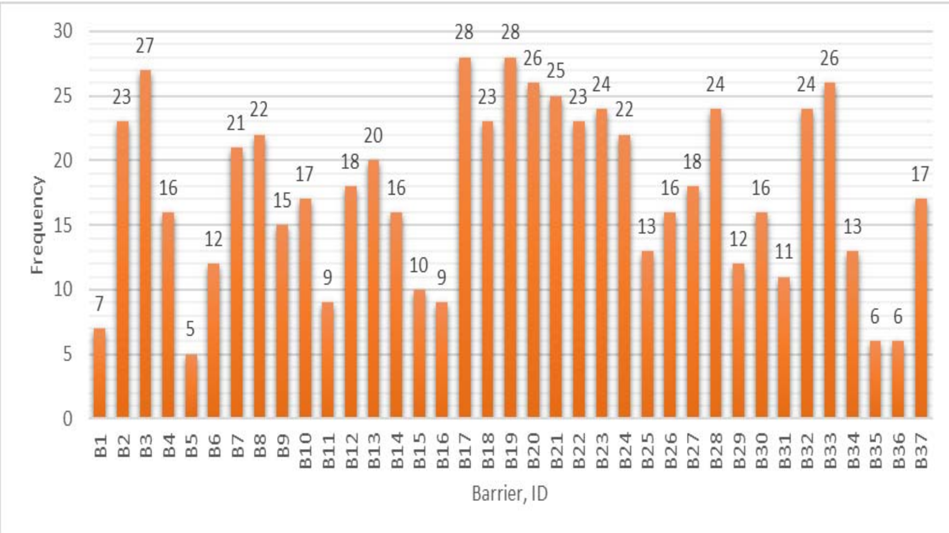
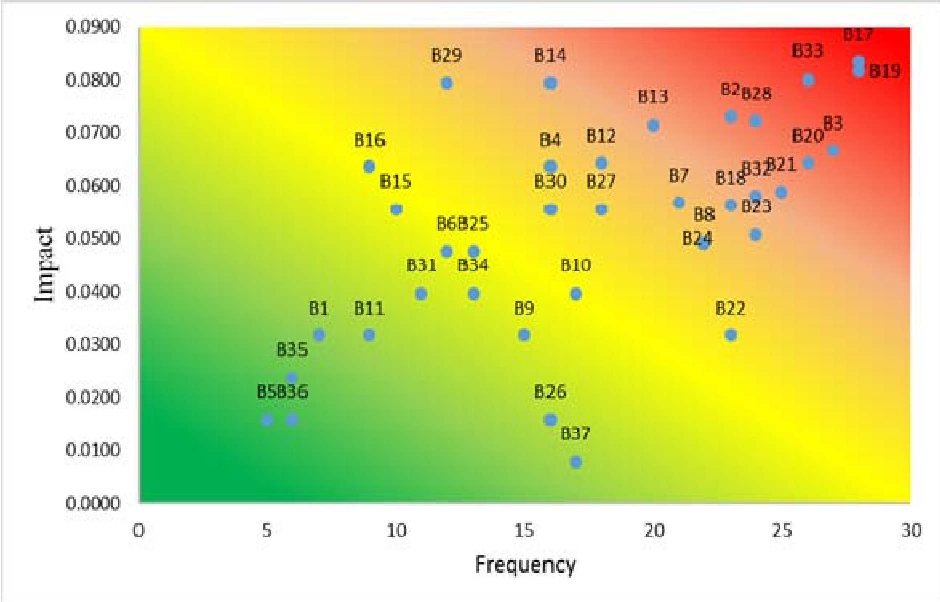


Fig. 1: Frequency against the each barrier to implement of BIM

For overcoming the barriers to implement BIM technology to the construction industry, it is important to prioritize the barriers according to the impact value. Some barriers are not so crucial compare to others and some are necessary as these have higher impact values. Figure-2 shows the impact of each barriers perfectly with their frequency. These barriers should be solved by their impact in the implementation of BIM. In this study B19 (traditional methods of contracting), B17 (social and habitual resistance to change), B33 (Lack of awareness about BIM), B2 (unavailability of proper training on BIM) and B28 (lack of BIM experts) are the high ranked high impactful barriers to the implementation of BIM. To overcome this issue these high ranked high impactful barriers is the key barrier to solve first. The low ranked low impactful



barriers come to last to solve them to overcoming the BIM implementation problem in construction industry. Such low ranked low impactful barriers are find in this study are B37 (Product liability risks), B5 (Unavailability of BIM risk insurances), B36 (Frequent Power Failure) and B35 (poor internet connectivity).

Fig. 2: Impact matrix of barrier of implementation of BIM

4. Conclusion

Enough evidence proved that building information Modelling (BIM) can promote the construction performance .However the rate of implementing BIM within the construction industry has been at a slow tempo. A good number of factors that contributed to this issue are identified in this study such as (1) Social and habitual resistance to change, (2) Traditional methods of contracting, (3) Training expenses and the learning curve are too expensive, (4) High cost of software purchasing and (5) Lack of awareness about BIM. These problems need to be addressed if the government wants to see the construction industry capable of compete globally. Besides that, supports from the government also plays a tremendous role to increase the rate of BIM implementation in the construction sector. Countries like United Kingdom (UK), Australia, Hong Kong and Singapore have implemented the usage of BIM in their construction industry through their governments (Zuhairi et al., 2014). In the United Kingdom, for instance, the authority is mandating BIM; Australia is assisting BIM, Singapore enforces the usage of BIM as part of their policy and terms of contract and Hong Kong is supporting BIM (Khemlani, 2005; Lin & FATT, 2006; Succar, 2009). By means of just having a solid support from the government alone isn't effective; therefore, the construction stakeholders including owner, consultants and contractors should play their very own role by transferring the paradigm from using the traditional method right into a greater innovative method. It can be concluded that the construction industry can get over the barriers in implementing BIM by the progressive participation of government authorities, all stakeholders of construction.

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