The Ninth International Conference on Construction in the 21st Century (CITC-9)
"Revolutionizing the Architecture, Engineering and Construction Industry through Leadership, Collaboration and Technology"
March 5th-7th, 2017, Dubai, United Arab Emirates

An Investigation into the Building Information Modeling Software Tools

Amin Hosseini
Msc Researcher, Department of Civil & Construction Engineering, I. Azad University, Central Tehran Branch, Tehran, Tehran, Iran
hosseini7641@gmail.com

Reza Mohajeri Borje Ghaleh
PhD Researcher, Department of Civil & Construction Engineering, I. Azad University, Central Tehran Branch, Tehran, Tehran, Iran
rmohajer2012@gmail.com

Javad Majrouhi Sardroud
Assisteant Professor,Department of Civil & Construction Engineering, I. Azad University, Central Tehran Branch, Tehran, Tehran, Iran
j.majrouhi@iauctb.ac.ir

Abstract

The Nature of construction industry includes uncertainties which result to rework, interfering, waste and other relevant concerns. It has been some decades that we are deploying computer aided programs to minimize the uncertainties and increase the predictability and confidence in Architecture, Engineering & Construction (AEC) related works. Building Information Modeling (BIM), as a new and more intelligent approach in involving the physical and functional characteristics of a building and organizing a digital representation of that, is nowadays being deployed by many construction industry professionals across the buildings and infrastructure sectors. In this article we aim to compare a number of most recognized construction management BIM-based programs by considering some of the most important criteria and measures that any BIM construction management software application should meet to satisfy the managerial needs and requirements of the project management team. The required data to put into analysis in this article is gathered by a series of technical tools from variety of resources including expert users, project managers, and technical reviews. The result of this research will enable project managers and site coordinators to select the most suitable BIM based construction management software for their project in accordance with the technical and implementation issues and also financial considerations.

Keywords

Building Information Modeling (BIM), Project Management, Construction Management Tools

1. Introduction

It has been for decades that Architecture, Engineering & Construction (AEC) companies had been suffering from conflicts and uncertainties in multi-discipline levels due to old-fashioned methods and practices(Khosrowshahi and Arayici, 2012). New technologies in AEC industry are developing promptly and in the recent decade the Building Information Modeling (BIM) has appeared to present a new way to decrease uncertainties and facilitate design, engineering , construction , and any other advantages in resource saving during the life cycle of the project(Volk et al., 2014), "BIM provides an emerging technological and procedural shift in the AEC industry"(Succar, 2009) . It is for a few years that project owners, consultants and contractors have started to realize that the use of BIM streamlines the design, construction and operation of their projects (Arayici et al., 2011), increases value, productivity, efficiency , quality and decreases risk, misunderstandings , uncertainties , ambiguities and etc. Finland, Sweden, Norway, Germany, France, Singapore and Australia were engaged in undertaking and documenting pilot BIM projects over the last decade to determine the capacity of using BIM in construction industry(Khosrowshahi and Arayici, 2012).

BIM adoption by players in AEC industry in 2009 and 2012 is demonstrated in Figure 1. the exhibited trend confirms that more architects are using BIM than contractors and also more contractors are using BIM as engineers(McGrow-Hill Construction, 2012), presumably due to the benefits of integrating such mechanism into the process.

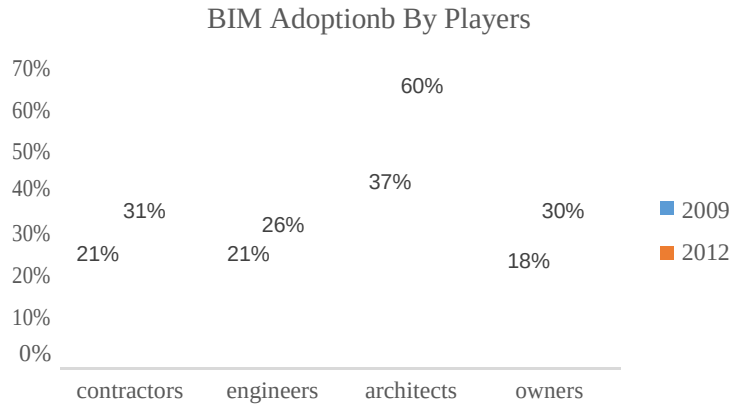


Figure 1-BIM Addoption By Players (After McGrow-Hill Construction, 2012)

Since almost all the top construction management BIM software packages are reinforced with similar features and capabilities, selecting one BIM based software to implement in a project could be a challenge. Besides, BIM adoption is much more common among architectures rather than other AEC industry professionals (Masood et al., 2014) hence, comparing practical and not just technical aspects and features of BIM based programs could play a big role in increasing the momentum of BIM adoption in AEC industry.

Obviously comparing detailed aspects of any systems, whether computer programs, cars or societies needs profound knowledge and experience. Yet in this article we aimed to compare practical aspects-and not just technical aspects, of six different BIM programs based on available journal articles, books and most importantly construction managers and technical users. Features and capabilities that are supposed to create a clear vision for the project and construction managers to deploy a BIM based construction management software program.

1.1 Building Information Modeling (BIM) Definition

BIM is neither a pure virtual representation of a project nor a restricted building information collection(Lu and Li, 2011).According to the US National Building Information Modeling Standard "BIM 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 lifecycle from inception onward." Also International Standard organization (ISO) defines BIM as (Volk et al., 2014) : "shared digital representation of physical and functional characteristics of any built object […] which forms a reliable basis for decisions". To demonstrate the practice of BIM program in different stages of a project, figure 2 is presented(Cao et al., 2015) As development of BIM suggests that it can assist in the management of construction projects , in a long run, exercising BIM in projects leads to a good Return of Investment(ROI) (Bryde et al., 2013). Considering managerial aspects of each program and not just focusing on technical concerns, is a turning point for construction managers since some construction managers are developing in-house BIM teams to establish BIM model of projects prior to construction(Thomsen et al., 2009). According to this diagram, the most use of BIM in design stage appears to be in 3D modeling of the project while in construction stage it is clash detection.

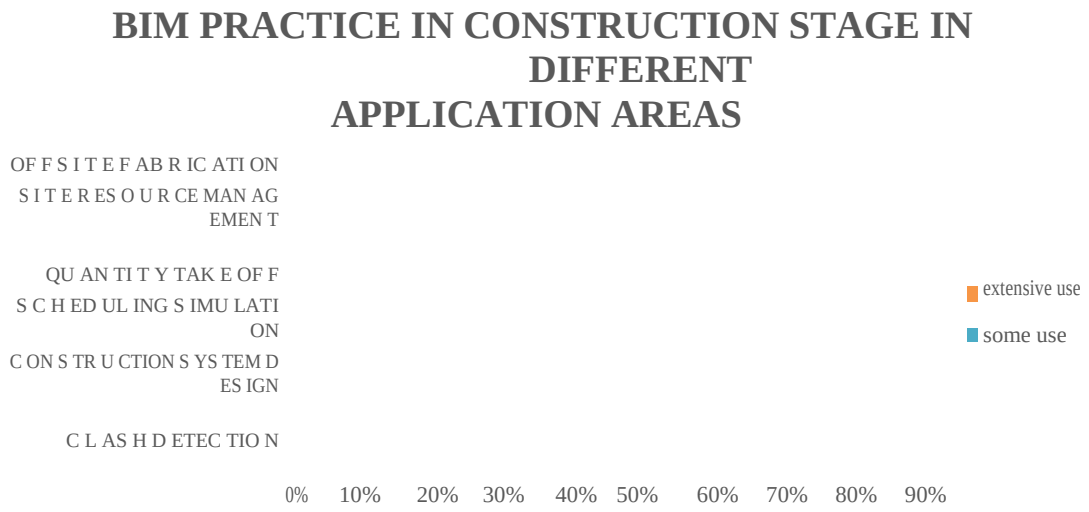
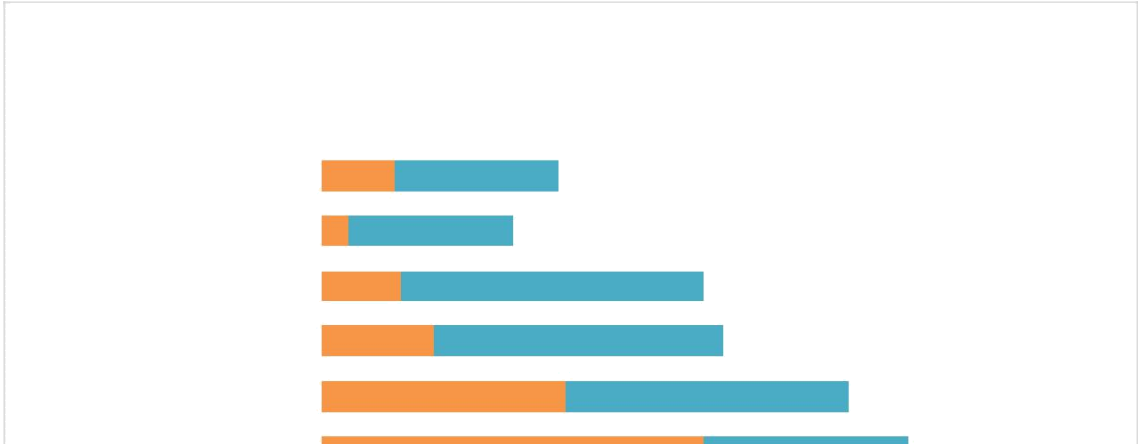


Figure 2- BIM Practice in Construction Stage of a Project (After: Cao et al., 2015)



2. Criteria and Assessment

BIM vendors normally provide a table of comparison including their own BIM program and a couple of other vendors, trying to highlight the features they excel in usually in a biased manner. Such tables in diverse configurations are available, hence the below table tries to demonstrate some of the key performance features required for a BIM construction management program. It is obvious that every program being considered in this article has specific advantages and disadvantages compared to the other programs, yet the point is, this article tries to compare these programs with a project management point of view. Hence, the detailed comparison is not supposed to be conducted in this article to compare technical pros and cons and features of each software, since such comparisons have been conducted formerly by technical specialists. Expectations from BIM alter in different disciplines. Designers expect BIM to be more facilitating in visualization and navigation while construction managers and contractor are more willing to find it a more sophisticated Document Management System (DMS) solution through analysis, scheduling, risk assessment, scenario reviews, cash flow modeling and simulation.(Gu and London, 2010).The following tables demonstrate the data extracted from above mentioned programs by using the software, referring to the website, FAQ pages, review forums or interviews with professional users. Data are extracted in three essences, criteria which is met labeled as "YES", criteria which is not met by the software is labeled as " NO" and eventually criteria of which there is no available information about is labeled as "INFO. N.A" abbreviated for "Information Not Available". Data are classified in 2 categories as follows;

1. Collaboration and Compatibility: introducing information such as collaboration capabilities, Open BIM access, IFC (Industry Foundation Classes) and Construction Operations Building Information Exchange (CoBie) support, BIM dimensions and clash detection.
Clash detection is the most applicable characteristic in a BIM based construction management program and almost in every BIM case study, clash detection is a part of scope. in a construction project, clashes are described as 3 groups : Automatically detected clashes, Manually detected clashes and field detected clashes during construction .(Leite et al., 2009).BIM provides a mutual basis for common information shaping in a building(Pittard, 2013) .

Collaboration in BIM actually means the process of working toward a unique goal by construction actors and organizations (Bråthen, 2015).BIM based construction management programs should provide a common environment for different construction organizations and players to shape a unique integrated model from variety of data from different disciplines in AEC industry.

Pinning notes to specific elements, sharing notes and aggregated models, BCF (BIM Collaboration Format) support, issue management and Open BIM certificate, Cobie support and model comparison are aspects of collaboration.

There is no doubt that management of constructions is directly pinned to time and cost and BIM based construction management programs are supposed to demonstrate functionality of projects in terms of time and cost properly next to clash detection ability in a collaborative environment. BIM Collaboration Format, also known as BCF is developed in 2009 by Solibri Inc. and Tekla Inc. as an open file format based on XML (Extensible Markup Language) that enhances communication over "issues" in a BIM model. (Succar, 2009). Support of BCF collaboration format by BIM Construction Management software programs enhances the collaboration and communication among project partners.

Construction Operations Building Information Exchange (COBie), is one of the most recently developed information exchange standards that can be leveraged to transfer data from design and construction stage to operation and facility management phase. Studies show that linking COBie and BIM provides benefits

for the owners and operators of buildings, for instance it can cut potential costs related to redundant equipment overhaul or replacement during the warranty period. (Anderson et al., 2012).

Building Smart, formerly known as International Alliance for Interoperability (IAI), was established in 1996 aiming to focus on the benefits of interoperability in building industry between many software programs being used. In 2008 IAI changed its name to Building Smart. It is now a reliable reference in BIM and building interoperability practices. Solibri Model Checker is the only certified software program which has obtained Coordination View version 2 certification(CV2.0) to this point, according to Building Smart list of certified programs.

Table 1- Comparing collaboration and compatibility features

	Autodesk Naviswor ks Manage	**Tekla BIMsight**	**Solibri Model Checker**	**Bentley Navigator V8i**	**Vico Office Suite 5D**	**Synchro PRO**
Create notes to specific element	yes	yes	yes	yes	Info. N.A	yes
Share notes	yes	yes	yes	no	Info. N.A	Info. N.A
Sharing the aggregated model	yes	yes	no	Info. N.A	yes	Info. N.A
BCF support	yes	yes	yes	no	Info. N.A	no
Issue Management	Info. N.A	yes	yes	Info. N.A	no	Info. N.A
Open BIM - Building Smart Certified	no	no	yes	no	no	no
Cobie Support	yes	Info. N.A	yes	Info. N.A	no	no
Model Comparison	yes	no	yes	Info. N.A	yes	yes
Generating presentations	Info. N.A	no	yes	yes	no	no
Scheduling (4D)	yes	no	yes	yes	yes	yes
Estimating(5D)	no	no	yes	no	yes	no
Automatic Clash Detection	yes	yes	yes	yes	yes	yes
Rulesets - design quality control	no	no	yes	yes	no	no
Quantity takeoff	yes	no	yes	no	Info. N.A	Info. N.A
Cloud-based licensing	yes	Info. N.A	yes	Info. N.A	Info. N.A	yes

2. Implementation: Presenting information regarding free trials, program purchase and annual subscription prices and training resources. Implementation of information systems is a great consideration in construction industry(Masood et al., 2014) .BIM is a combination of interacting policies, procedures and technology to provide the project team with a "methodology to manage the essential building design in digital format in the life-cycle of a project" (Penttilä, 2006).Implementation of such programs could be a challenge for a company since all the disciplines (i.e. architecture and engineering, structure, MEP, facility management, etc.) must be modelled in BIM environment with adjusted coordination and applicable

elements, then aggregated into one model to be analysed and managed using one of the BIM construction management programs.
Compatibility is a considerable issue when it comes to integration of a model from different BIM programs and multi-disciplines areas. It is of great importance for the BIM construction management programs to be able to coordinate the model into an integrated model properly without any mistake and incoordination. It is
experienced by a lot of users that some compatibility issues happen when multi-disciplinary design teams use different BIM programs for each discipline.

Industrial Foundation Class (IFC) formats with different versions are available in different BIM based CM programs. The evolution of IFC introduces more compatible model integration capability to a software.

Table 2-Comparing implementation

	Autodesk Navisworks Manage	Tekla BIMsight	Solibri Model Checker	Bentley Navigator V8i	Vico Office Suite 5D	Synchro PRO
Free trials	yes	Info. N.A	yes	yes	yes	yes
Free Trial Period	30 days	Info. N.A	14 days	Info. N.A	30 days	30 days
Free Training Videos	Info. N.A	Info. N.A	yes	Info. N.A	Info. N.A	Info. N.A
Free Books and Instructions	Info. N.A	Info. N.A	yes	Info. N.A	Info. N.A	Info. N.A
Free Webinars	Info. N.A	Info. N.A	yes	Info. N.A	Info. N.A	Info. N.A
Live Training	no	no	no	yes	no	no
Price	9995 USD	free	from 5900 USD	1500 USD	from 2495 USD	5755 USD
Annual maintenance, Subscription and overhead Cost	1345 USD	Info. N.A	Info. N.A	300 USD	Info. N.A	Info. N.A

5. Conclusion

This article does not aim to compare BIM based construction management software programs in detailed technical aspects, yet it does try to provide a basis for construction managers and directors to realize the capabilities, short comes, advantages and disadvantages of each BIM construction management software in project and construction management level in a biased manner and helps them decide with clear understanding about each. To achieve that, in the context of this article we have collected some basic information about each of the construction management software programs from the view of a project management team. By considering the above mentioned BIM based construction management software programs and reviewing them in comparing tables, highlighting their main project management related features and capabilities, it is easier to come up with a decision to meet the needs and required capabilities which project management team demands. For instance, if a project management team demands to review an integrated model by emphasizing the scheduling, planning and control in a 4D environment, it is clear that Synchro Professional has a chance. In the other hand, if financial limits to purchase a software matters very much for the project management team, Tekla BIMsight, despite its short comes can fill the gap. If Open BIM Smart-Building certificated is required, then Solibri Model

Checker is the only option. If COBie support is a must for the project management team, available programs are Navisworks manage and Solibri Model Checker. It is to mention that, other parameters and criterions such as level of development, sophisticated report generation or clash detection methods are potential subjects for further study.

6. References

ANDERSON, A., MARSTERS, A., DOSSICK, C. S. & NEFF, G. Construction to operations exchange: Challenges of implementing COBie and BIM in a large owner organization. Construction Research Congress, 2012. 688-697.

ARAYICI, Y., COATES, P., KOSKELA, L., KAGIOGLOU, M., USHER, C. & O'REILLY, K. 2011. BIM adoption and implementation for architectural practices. *Structural Survey,* 29**,** 7-25.

BRÅTHEN, K. 2015. Collaboration with BIM-Learning from the Front Runners in the Norwegian Industry.

Procedia Economics and Finance, 21**,** 439-445.

BRYDE, D., BROQUETAS, M. & VOLM, J. M. 2013. The project benefits of building information modelling (BIM).

International Journal of Project Management, 31**,** 971-980.

CAO, D., WANG, G., LI, H., SKITMORE, M., HUANG, T. & ZHANG, W. 2015. Practices and effectiveness of building information modelling in construction projects in China. *Automation in Construction,* 49**,** 113-122.

GU, N. & LONDON, K. 2010. Understanding and facilitating BIM adoption in the AEC industry. *Automation in construction,* 19**,** 988-999.

KHOSROWSHAHI, F. & ARAYICI, Y. 2012. Roadmap for implementation of BIM in the UK construction industry.

Engineering, Construction and Architectural Management, 19**,** 610-635.

LEITE, F., AKINCI, B. & GARRETT, J. Identification of data items needed for automatic clash detection in MEP design coordination. 2009 Construction Research Congress, 2009. 416-425.

LU, W. W. & LI, H. 2011. Building information modeling and changing construction practices. *Automation in Construction,* 20**,** 99-100.

MASOOD, R., KHARAL, M. & NASIR, A. 2014. Is BIM Adoption Advantageous for Construction Industry of Pakistan? *Procedia Engineering,* 77**,** 229-238.

MCGROW-HILL CONSTRUCTION 2012. The Business Value of BIM in North America. *In:* BERNSTEIN, H. M. (ed.)

Smart Market Report.

PENTTILÄ, H. 2006. Describing the changes in architectural information technology to understand design complexity and free-form architectural expression. ITcon.

PITTARD, S. 2013. What is BIM. *London, UK: Royal Institution of Chartered Surveyors (RICS)*.

SUCCAR, B. 2009. Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in construction,* 18**,** 357-375.

THOMSEN, C., DARRINGTON, J., DUNNE, D. & LICHTIG, W. 2009. Managing integrated project delivery.

Construction Management Association of America (CMAA), McLean, VA, 105.

VOLK, R., STRENGEL, J. & SCHULTMANN, F. 2014. Building Information Models (BIM) for exisiting buildings - Literature Review and Futute Needs. *Automation in Construction,* 38**,** 109-127.

Impedance to Innovation Practices in the Ghanaian Construction Industry Consultancy Services: The Perspective of Quantity Surveying Firms