A research for efficiency of using prefabrication building components in Building Information Modeling (BIM) process

Ebru Dogan,[a] Hasan Polat [b]
[a] Research Asistant—Bıngol University, Architecture Faculty, Bıngol 12000, TURKEY
edogan@bıngol.edu.tr
[b] Assistant Professor—Fırat University, Architecture Faculty, Elazıg 23119, TURKEY
hpolat@firat.edu.tr

Abstract. In process of construction activity, due to the absence of a regular organization plan, and lack of sufficient level of information in the design and conducting field,, are faced with many problems in terms of efficiency in time, quality and cost. Using Building Information Modeling (BIM) is become the main topic of the agenda because of increasingly complex structures for efficiently implementation of construction activities. BIM evaluate the models of the current situation, the work schedule, cost estimates, the sustainability analysis and building business for a building with plenty of programs supported by computer. Especially with using 2D and 3D design software program to make a building model, BIM make the model especially with building components but not with the lines. By this way, building can be simulated in computing environment before applied on a real construction area. So, all kinds of factors as defects, quality, cost and time in practice are considering to determined before building the final product constructed real construction area,. Moreover business process also predicted and make it possible to be revised the design decisions on the scale of building components and elements. In this study, was discussed the opportunities of BIM application on the efficiency of quality, time and cost issues by using prefabricated structural components and elements in the design process.

Keywords: BIM, Building Information Modelling, Prefabrication Building Component, Efficiency.

1 INTRODUCTION

The overall goals of community is development, which aims to raise levels of prosperity. To meet the needs of more better living requires more production and this forced to use more inputs. The countries limited resources, have relatively more population and the obtain theoretically unlimited needs, it is very important to use the resources efficiently to reach the targeted level of prosperity (Tigrel).

Efficiency is a very important place in design and construction, so in building construction all conditions should be examined to formed this concept. In the construction sector, works labor-intensive concept, efficiency must be addressed in terms of work plan, program and production to completed desired quality (Sorguç, 1993).

Construction projects management **consists contract, time, cost, risk, quality, procurement, human resources, communication and the management of integration process.**

From the feasibility and design phase of a construction to the end of construction and post-operational phase include time, cost and quality management which are the main body of construction project management. (İnözü, 2015).

In other words, from start to the end, the project management, it is carried out to plan, control and coordinate all resources and activities for complete a project in anticipated duration, cost and quality. For a successful project management; management skills, knowledge, experience and technological infrastructure is very important (İnözü, 2015).

At present competition has increased extraordinary and all actors in construction supply chain, architects, engineers, contractors and fabricators are under pressure to complete their project much faster and with a much smaller budget (URL-1, 2016).

In the construction sector, throughout the life cycle, building construction can be performed much easier and effectively with the help of information technology.

In this context, Building Information Modelling (BIM) concept has been developed as a system, created by the interdisciplinary working conditions, has a skill of estimate the problems will occur and contribute the solution (Akkaya & Başaraner, 2012).

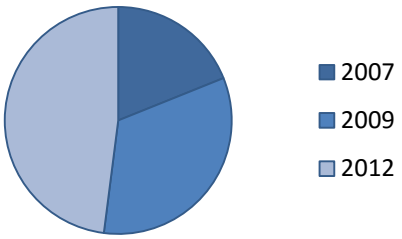
Prefabricated construction can be considered as an efficient solution to reduce the environmental impact of construction. Building information Modeling (BIM) is an important member of the Prefabrication industry due to its ability to provide an accurate virtual prototype of physical components of the building prior to manufacture at factory. Apart from the design and manufacturing process of building components, BIM will also play an important role during construction and operational stages of a building.

2 BIM

The concept of BIM is described by Charles M. Eastman in 'The Use of Computers Instead of Drawings in Building Design' published in the AIA journal in 1975.

As the technology to implement BIM is readily available with the introduction of 3D building modelling software by industry leaders such as Autodesk, adoption of BIM has increased around the world in the past few years. The usage of BIM has increased from 28% to 71% between 2007 and 2012 in North America (Table 1).

Table 1 The Usage of BIM according to the year in America,
(Mgh Smart Market Report 2013).



2.1 What Is BIM?

Building Information Modeling (BIM) is one of the most promising developments in the architecture, engineering and construction (AEC) industries. With BIM technology, an accurate virtual model of a building is constructed digitally. When completed, the computer - generated model contains precise geometry and relevant data needed to support the construction, fabrication, and procurement activities needed to realize the building (Eastman, Teicholz, Sacks, & Liston, 2008).

BIM is defined as the creation and use of coordinated, consistent, computable information about a building project in design—parametric information used for design decision making,

production of high-quality construction documents, prediction of building performance, cost estimating, and construction planning (Krygiel & Nies, 2008).

2.2 Fields of BIM Activity

There are many fields that interact with BIM in a project. They fall under three main categories as Technology, Process and Policy. This concept was originally proposed by (Succar, 2009) and is presented in figure 1.

All the categories have inputs and output to BIM in a project. There are also interactions within and between the categories mentioned in figure 1.

BIM discussed in this paper will be mainly focused on the process - technology overlap shown in figure 1. In other words it will provide a framework of integrating the process and technology fields. Policy category is not in the scope of this paper but will be discussed in the future research.

Figure 1. Three interlocking fields of BIM activity, (Succar, 2009).

3 EFFICIENCY OF USING PREFABRICATION COMPONENTS IN BIM

3.1 Prefabrication

The term prefabrication is a two word symbolizing of the pre and fabrication where pre denotes the production of the building components initially and fabrication denotes the establishment of the building components into building at the site for accelerated building construction. Where the modules are the components like walls panels and sheets comprises of a room or a bathroom utilizing the benefit of the prefabrication.

There are four different categories of Off-Site fabrication, they are component systems, volumetric systems, penalized systems, and modular systems (Chandra, 2015). In this paper will be mainly focused on prefabrication components systems.

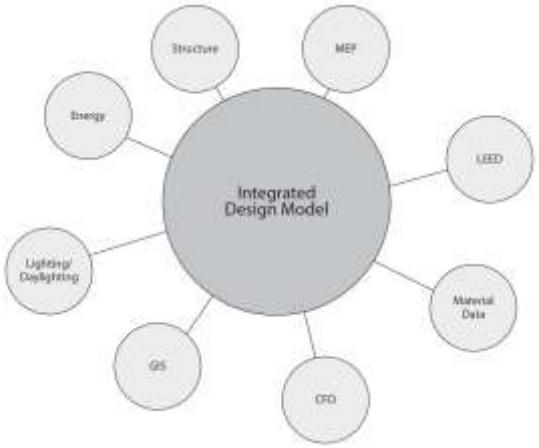
3.2 Prefabrication Component In BIM

Buildings have become increasingly complex. They are one of a kind products requiring multi - disciplinary design and fabrication skills. Specialization of the construction trades and economies of prefabrication contribute to increasingly larger proportions of buildings'

components and systems being pre–assembled or fabricated off - site. Unlike the mass production of off - the - shelf parts, however, complex buildings require customized design and fabrication of 'engineered to order' (ETO) components, including: structural steel, precast concrete structures and architectural facades, curtain walls of various types, mechanical, electrical and plumbing (MEP) systems, timber roof trusses, and reinforced concrete tilt - up panels (Samarasinghe, Mendis, Ngo, & Fernando, 2015).

By their nature, ETO components demand sophisticated engineering and careful collaboration between designers to ensure that pieces fit within the building properly without interfering with other building systems. Design and coordination with 2D CAD systems is error - prone, labor intensive and relies on long cycl-times. BIM addresses these problems in that it allows for the 'virtual construction' of components and coordination among all building systems prior to producing each piece. The benefits of BIM for subcontractors and fabricators include: enhanced marketing and rendering through visual images and automated estimating; reduced cycle - times for detailed design and production; elimination of almost all design coordination errors; lower engineering and detailing costs; data to drive automated manufacturing technologies; and improved pre-assembly and prefabrication (Eastman, Teicholz, Sacks, & Liston, 2008).

Building Information Modelling (BIM) and prefabricated construction has changed the construction industry from a costly, time consuming and a tedious process to a dynamic, professional, cost and time saving process that is more focused on design and construction of sustainable buildings. There are many benefits for the building services industry from using BIM. Involvement of building services designers from the initial stages of a project is every important in BIM. This will help to develop computation 3 dimensional models that will be used for virtual representations, information storage and analyses in a project. All the information about every element of the model and analyses conducted on the model will be stored in a central location where it can be used for future reference. Significant time and cost savings can be achieved as clash detection can be conducted prior to construction. Integration of all disciplines at the design stage of the Project (Figure 2) creates the opportunity for prefabricated construction. Many major services such as plant room, chilled water pipes, bathrooms, etc. can be prefabricated at an off-site factory and brought to site for installation. This will reduce the construction time, as most of the testing such as pressure tests and air tightness tests can be done at the factory prior to transportation. Pre-planning of services will result in excellent quality finishes as clashes and other challenges are identified prior to construction stage. Prefabrication of MEP services will reduce the risk of high workforce on site as all discipline will coordinate and produce service modules at the factory and transport it to the construction site.



MEP: Mechanical, Electrical, and Plumbing
CFD: Computational Fluid Dynamic
GIS: Geographic Information System
Figure 2 The Integrated Design Model, **(Krygiel & Nies, 2008)**.

BIM will create an opportunity for designers to carry out analyses related to building services prior to construction stage in order to get an understanding on how the building will operate after construction (Figure 3). The model can also be used to carry out energy analysis prior to construction, so that energy saving technologies can be introduced during the design stage of the project. This will also help the clients to get an idea on the operational cost of the building. 4D construction simulations can be achieved using software such as Autodesk Navisworks, which will help the Project management team as a time line and it will help the health and safety engineers to get a better insight into health and safety challenges that can ocur during different stages of construction. Building heating and cooling loads can be calculated using the model rather than using Microsoft excel spread sheets and hand calculations. HVAC duct sizing and pipe sizing can be calculated using the model. Separate reports can be generated for all computational analyses carried out using the model (Samarasinghe, Mendis, Ngo, & Fernando, 2015).

Figure 3 A model in BIM and its reality, (URL-2).

The main advantages of the prefabrication components helps in the construction by using BIM are;

- Faster assembly of units
- Factory fitted units enhances quality of the product
- Less construction time
- Its weather prone as the building units are constructed under controlled conditions
- The construction can be continued in the extreme heat and cold conditions

- The quality can be checked at any time
- Cost effective methods
- Environmental friendly like less noise and pollution at the construction site
- Low energy consumption
- Good designing probabilities
- Increased safety in the construction site
- Reduction of the constructional waste at the construction site
- Cheaper labor costs.

The main disadvantages of the prefabricated components in the building construction are as follows;

- Leaks at joints in the prefabricated modules
- Higher transportation cost for the prefabricated components to transport to the construction site
- The large prefabricated components need large cranes at the construction site for reinstalling and placing of the components in the place
- Same type of components in the set of building make the user monotonous about it (Chandra, 2015).

4 CONCLUSION

In purely economic terms, subcontractors that fabricate engineered to order components for buildings may have more to gain from BIM than any other participant in the building construction process. BIM directly supports their core business, enabling them to achieve efficiencies that fabricators in other sectors, such as the automotive industry, have achieved through the application of computer - aided modeling for manufacturing.

There are numerous potential benefits for fabricators. These include: enhanced marketing and tendering; leveraging the ability to rapidly produce both visualizations and accurate cost estimates; reduced production cycle - times, allowing fabrication to begin at the last responsible moment and accommodate late changes; reduced design coordination errors; lower engineering and detailing costs; increased use of automated manufacturing technologies; increased pre - assembly and prefabrication; various improvements to quality control and supply chain management resulting from the integration of BIM with ERP systems; and much improved availability of design and production information for life - cycle maintenance.

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Ebru Dogan is an research assistant in Bıngol University. She received her license in 2010 and her master degree in 2014 from Mimar Sinan Fine Art University. Now she has written her PhD Thesis in Mimar Sinan Fine Art University until 2014. Her main research areas are Building technologies, element design and design for deconstruction.

Hasan Polat is an assistant professor in Fırat University. He received his license in 2003 and his master degree in 2008 from Istanbul Technical University and wrote his PhD thesis Institue of Sciences, Building Sciences Program “The Development of a Computer Program That Can Be Used For Quality Control Purposes In Housing Construction” in 2013. His main research areas are Project and cost management, Construction information, Application Project, Construction elements, Redevelopment and building law, Material selection for the structure.