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Identifying the Advantages of BIM in Structural Design

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ABSTRACT

Building information modeling (BIM) is used to support sustaining a competitive ability and surviving in competitive construction environment. Structural design is the systematic examination of the balanced firmness and hardness of a design. BIM implementations change the ordinary structural design system via application of data operating schemes. Currently, BIM implementation in structural design has been widely recognized and accepted both by construction professionals and managers. This paper explains how the use of BIM can be a significant platform for structural design. This research aims to consider the present status of BIM and analyses how architectural design, structural design and construction firms are practicing structural design phase of BIM in their design and operations. BIM and respective field in structural design literature is reviewed and analyzed to identify the benefits of using BIM. A data collection is carried out to evaluate the result of reviewed literature**.** The results of using BIM in structural design are assessed to determine if it increases the efficiency of structural design. BIM supports structural design with rational, collaborative, knowledge based models and operates the knowledge contained in the models to anticipate, encourage, and investigate task performance, display, and charge throughout the whole project life cycle. Therefore, other phases of construction project should also be examined in the future projects to address the status of up-to-date literature about BIM.

Keywords: Building information modeling (BIM), construction, structural design.

INTRODUCTION

Nowadays most of the structural engineers are using new methods and software to stay competitive. Engineers always look for new methods to increase and maintain the productivity, coordination and problem solving abilities to pace on today's economy. BIM can possibly help these goals with significant altitude. BIM is referred as a platform that supports structural engineers, detailers, and fabricators to enhance robust structural design, reduces faults, and creates collaboration between stakeholders and organizations. It also explains how designer and fabricator software supports to achieve new trades and establish projects. In various ways BIM can take place in improvement of structural engineering by maintaining all the information as correct as possible via updating models regularly [1]. The fields of creation, arrangement and flexibility of information are also analyzed with the interest that BIM shows for structural design [2].The following sections intend to assess the advantages of BIM in structural design. First of all, literature review on structural design and BIM is presented to explain and define the importance of BIM in structural design. In methodology part data sources are listed and the classification of research subjects are tabulated. In the next section the advantages of BIM are shown and finally, in the findings section, the importance of BIM and the advantages of BIM are discussed for structural design.

LITERATURE REVIEW

BIM and structural design are in the focus of literature review section. The research highlights the usage of BIM in different fields and the importance of BIM on structural designing detail.

BIM

BIM is a new process and platform used in the construction industry. Nowadays, BIM is used in many projects and is a requirement on contracts. Common meaning of BIM is: “a digital representation of physical and functional characteristics of a facility...and a shared knowledge about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.” [3] and “the development and use of a multi-faceted computer software data model to not only document a building design, but to simulate the construction and operation of a new capital facility or a recapitalized (modernized) facility" [4]. There is a general cognizance that BIM is a 3D design. In fact, a BIM model has multi dimensional information on itself. BIM is a system for initiating and organizing all of the knowledge on the building objects during all phases of a construction project including; initiating, planning, construction, closure, facilities management, and demolition. The result of this mechanism is the BIM model and the digital description of all conditions of the developed resource. Many people assume BIM as prominent design allocation and advance establishment [5]. The real value can be figured out after the handover, when the manager or the person owning the stocks gets all the correct type of knowledge. Above all, BIM integrates a lot of independent information on the model in which, items are connected to associated knowledge with it like manuals, specifications, and warranty details. This feature permits the owner or the facilitator to effectively and correctly organize the items. BIM connects all the knowledge about various parts of building design, in the same point. BIM allows everyone to reach the information for any purpose e.g. to integrate various ways of design to be more effectively, to collaborate for effective building design. In this way, the risk associated with unknowns and missing data about the building is reduced, and the cost of change is minimized.

Structural Design

Structural design is the systematic examination of the balanced firmness and hardness of a design. The main aim in structural analysis and design is to produce a structure that is able to resist all applied loads without any failure during its lifetime. It encompasses choosing of which type of structural members and materials should be used for configuration so as to carry the load in a safe way. Generally, in engineering terms, structural design refers to the engineering of stationary objects such as buildings and bridges, or mobile objects, which have a rigid shape [6]. Planning is the main stage in structural design. It involves deliberation of the different requirements and factors influencing the layout and dimensions of the structure and results in the choice of one or more alternative types of structure. This phase results in getting the best solution alternative according to data input. There are two considerations involved in this stage. The main consideration is the purpose of the structure. Law, economics and the environment are taken into account as secondary consideration in planning phase of a structural design project. Additionally, structural and construction requirements and constrains are considered, which can affect the type of structure to be designed [7]. Design is a stage that involves a thorough consideration of the substitute solutions defined in the

planning stage and results in the resolution of the most suitable magnitude, dimensions and details of the structural parts and connections for constructing each alternative structural plan under consideration [8]. Construction as the result of structural design involves mobilization of personnel; acquirement of materials and equipment, this involves their transportation to the site, and actual on-site construction. In this stage, some changes in the design may be necessary if unexpected problems happen, this can include unavailability of certain materials or difficulty in foundation problems [9].

BIM in Structural Design

BIM software support structural engineers to develop integrative allocation of structural design certification, reduce errors, and increase association between engineering and architecture departments. BIM allows structural engineers, detailers, and fabricators to improve structural design and association among professions. The BIM model is a prototype of the building and ensures the designer to realize failures and clashes before building the real structural design [10]. BIM can also create integrated design projects and can act as a dominant material as a management tool. Structural designers confront a lot of advantage of BIM in various forms, as the model can be consistently updated for achieving integrated design. BIM also changes the form that how one manage and see the items. It increases the impact on building design, structural design and engineering analysis. BIM makes possible the reduction in design efforts, minimizes errors and changes, and hence develops cost effective designs and increases the quality of production. It ensures better results both in design and construction [11].

METHODOLOGY

The origin of the research data is the compilation of BIM from different areas in structural design literature, which is reviewed and analyzed to identify the advantages of implementing BIM in structural design. A data collection is achieved to examine the outcome of reviewed literature. The consequences of using BIM in structural design are estimated to determine if it will increase the efficiency of structural design. BIM is also found to be useful in structural design in consideration of rational, collaborative, and knowledge based models and serves the knowledge contained in the models to anticipate, encourage, and investigate the performance of the project, presentation and charge throughout the whole project life cycle. These papers and articles were arranged in terms of BIM, structural design and BIM based structural design literature. A tabular system is used to represent the review studies on BIM and structural design and advantages of BIM in structural design in Tables 1and 2.

FINDINGS AND DISCUSSION

In the beginning 119 documents from various sectors like journal papers, books/book chapters, conference papers and theses were reviewed under disciplines of BIM, structural design, BIM and structural design. After completing reviews, the papers were re-checked and 33 of them are removed, as they do not contribute much to the topic. Therefore the content

analysis was done on 86 papers. Figure 1 shows keywords used in different review of papers as shown below.

Figure 1. Frequency of keywords used in various reviews.

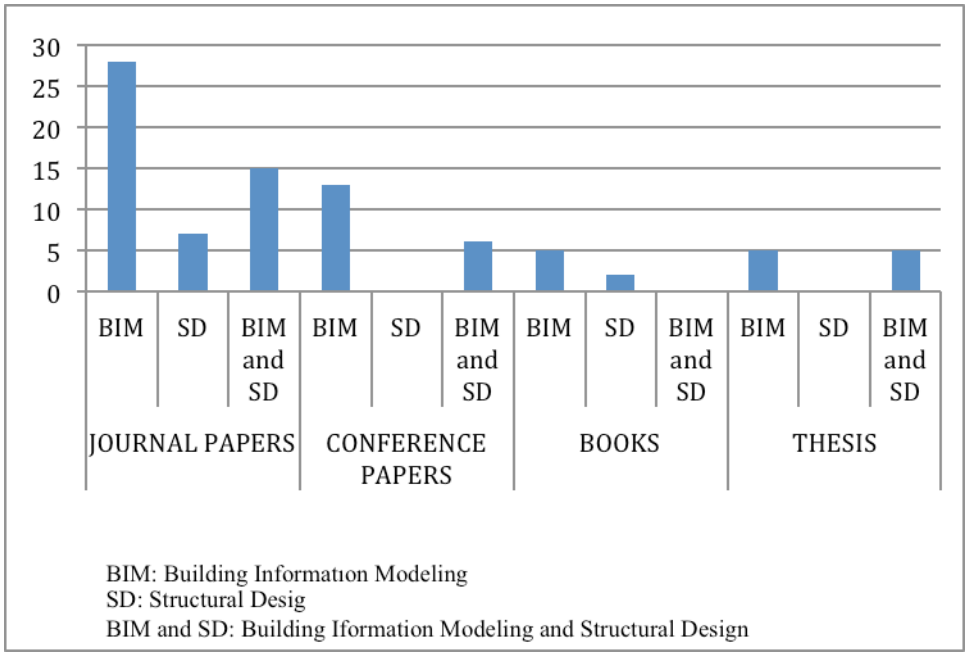

Table 1 shows the various reviews established and the keywords used in the researches. It also provides the references of each review based on their categories of journal papers, conference papers, book/book chapters and theses. Most of the reviews are from journal papers.

Table 1. The classification of keywords based on different types of documents with their respective references.

Document Type	Keyword/ s	References
Journal Paper	BIM	Yalcinkaya et al., 2015; Succar et al., 2013; Succar et al., 2015; Succar, 2008; Succar, 2016; Abdirad et al., 2016; Becerik et al., 2010; Latiffi et al., 2013; Leite, 2016; Pazlar et al., 2008; Khanzode et al., 2008; Yan et al., 2008; Han-Gu et al., 2012; Berard et al., 2012; Barison et al., 2010; Sattineni et al., 2011; Richards et al., 2010; Yuan et al., 2011; Arayici et al., 2010
	Structural Design	Arayici et al., 2012; Succar et al., 2012; Succar et al., 2013; Kaner et al., 2008; Migilinskas et al., 2103; Yalcinkaya et al., 2014 RajV et al., 2017; Mahovič, 2015; Ghosh, 2003; Kulka, 1963; Komocki, 1967; A. Yee et al., 1984; Elsner et al., 2000
	BIM and Structural Design	Qiu Liu et al., 2016; Kaner et al., 2008; Alwisy et al., 2010; Tae Song et al., 2012; Lin Chi et al., 2015; Vladimir, 2008; Azevedo,2015; Filho et al., 2016; Tae Hyeong et al., 2013; Aminu Umar et al., 2016; Bhusar et al., 2014; Nawari, 2012;

		Robinson, 2007; Czmoch et al., 2014; Nawari et al., 2014
Book / Book Chapter	BIM	Eastman et al., 2011
	Structural Design	Schlaich et al., 1987; Nageim et al., 2010; G.L. Et al., 1998; S.K. Et al., 2009; Salvadori et al., 1998
Conference Paper	BIM	F. Salazar et al., 2013; Succar et al., 2013; C. Bank et al., 2010; Watson,, 2010; Katranuschkov et al., 2010; Barison et al., 2010; Lee et al., 2013; M. Shin et al., 2011; Tangparitkul et al., 2015; Ezcan et al.2, 013; Lu et al., 2014; Tomek et al., 2014; Yalcinkaya et al., 2013
	Structural Design	Czmoch et al., 2014; Sebastian et al., 2009; Bhusar et al., 2014; Fedorik1 et al., 2016; L. Solnosky et al., 2014; Wang et al., 2013
	BIM and Structural Design	Johansen, 2013; F. Hergunsel, 2011; Succar, 2013; Panaitescu, 2014; Rancane, 2014
Thesis	BIM	J. Lamb, 2012; Bertin et al., 2011; Parrish, 2009; Hunt, 2013; Cooksey, 2011

In Table 2, the main advantages of BIM are discussed in detail on how quality, flexibility, efficiency, collaboration, productivity, scheduling, communication, estimation, lean efforts, and resource allocation are listed as major advantages of BIM. It is assumed that the flexibility of BIM leads to more satisfied clients, it is also recognized that BIM offers opportunity for companies in the construction environment and stakeholders are discussed as shown in Table 2.

Table 2. The advantages of BIM in structural design.

Advantages	**Description**
Improved Quality	One of the usual by-products of the decline in recurring data entry made possible under the BIM structure is a decrease in the errors introduced by design alterations. When a customer requires a completed set of documents to hit a delivery deadline, it's easy to envision small computational errors coming up - even in a single model; errors, time loss, and lost of status as well. BIM can be used to solve this problem by clash detection ability and by means of parametric change management capabilities.
Greater Efficiency	For structural engineering team whose responsibility long has relied on logical models that predict occurrence, the instantaneous promise of BIM and associated tools and technology can lead to a better efficiency. Structural engineering team must be particularly proficient at responding to late-stage alteration that requires compromise because it's mostly too late or too costly to alter physical design. One of the main issues with

	last-minute modification to a project is the necessity to re-enter information for those changes. By getting rid of the need to put aside large amounts of time for the tiresome redrafting and co-ordination of foreseeable changes, that time can be used for a better purpose: engineering and analytic, which add far better value to a given project.
Design Flexibility	With time and budget independence afforded by the use of BIM within the project, engineers are open to think about such alternatives – the type of job for which they have educated. Additional flexibility also leads to more content clients.
Effective Collaboration	The application of BIM in the structural engineering office provides great benefits. Regardless of how projects' designer favor to share design information, even on paper, BIM at the engineering company makes it easier to evaluate late alter and quickly return the data to the designer for examination.
Reduced Rework	Fixing problems early means fewer issues in the plans and in the end fewer hassles in the field. A bulk of contractors (57%) sees the promise of BIM to decrease rework as a huge benefit. This is the top -ranked benefit reported by expert users (77%), in comparison to fewer beginners that see it in other ways. (23%).
Improved Productivity	BIM model provides integrated database used as the foundation of knowledge of the building and the construction works which make better the accuracy and quickness of cost approximation by automation of quantity calculation therefore make better productivity.
Better Marketing	BIM offers opportunity for companies in the construction environment. As more customers start to need BIM on jobs, construction members require having BIM skills to capture that business. On the other side, companies can also present the technology to new clients who do not require BIM and use this as a marketing aspect to get an opportunity in their bid to get a job.
Better Project Outcomes	Almost half of the construction companies claim that BIM's influence on the general project result is a high advantage. Companies, which are less experienced in BIM, consider this as their highest advantage, while expert companies rank it slightly lower.
Reduced Errors	Virtual design and construction with BIM create the potential to recognize problems earlier in the construction process. Most of all users see this as an important advantage, mostly contractors. More experienced users recognize its value compared to others.
Time Saving	Structural analysis software is seen as a time saver by most of the professional engineers, contractors and architect. BIM can be used to double-check calculations as well as do difficult functions with increased precision. Building codes are pre-programmed, and values

	such a load limits and deflection are produced automatically, giving you time for other task of the project.
Improved Communication	BIM gives a source of comprehensive combined information that becomes a trusted repository of combined correct data and measurements to make sure consistency, as every trade construct their own models. The entire project team profit from speedier, easy communication and enhanced organization.
Estimated and Material Accuracy	Creating a comprehensive, structural model that is rich with information allows structural engineers to obtain correct material quantities to create more economical bids with much lower contingencies. Besides giving structural engineering company a competitive edge for securing business, constructible models allow materials to be sequenced and prearranged with confidence to decrease material waste and the cost of fixing error come across at the job site.
Reduced Waste	Information is coherent with the use of BIM. Designers can then make well-informed conclusion that can help decrease the environmental effect of buildings, in which factory built assemblies can be used. In that case the information can be managed better and factors such as waste-on-site can significantly be reduced.

CONCLUSIONS

In this research paper, the importance of BIM in structural design concept and the advantages of BIM in structural design are emphasized. The tables are used in this study to represent the research intention of BIM in structural design has grown in large number of fields in education and research. All the data obtained in this research indicates the use of BIM in a project that provides a number of visible advantages in terms of material, budget, time, quality and business cooperation. BIM enables integration of the roles of all stakeholders in a project. In the classical structural design, it is very difficult and time consuming to establish a cooperation among project stakeholders, which leads to excessive loss of resources. The use of BIM in projects increases the structural design process' quality and results in minimum risk in projects. The advantages of using BIM are not only project-oriented but also business and organization oriented with global perspectives. The design company of many engineering firms and manufacturing industries are always needed to obtain efficient work, with minimum cost and also improves high quality with good collaboration. It is claimed that BIM enables structural design to work better and increase the efficiency of the process through saving time, reducing errors and risks. In this paper, the possible benefits and the advantage of BIM on structural design are discussed. The findings of this study provide useful information about BIM and its advantages considering the structural design. The advantages of BIM in structural design is reviewed and presented in this paper. However, the advantages of BIM in other phases of a construction project should be researched to analyze mutual benefits of BIM usage and to picture a holistic view of BIM advantages.

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