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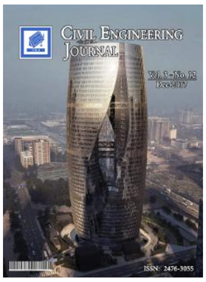

BIM as Evaluation Tool for Existing Building Energy and Quantities Takeoff

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Abstract

Information technology and its application have resulted in enormous development in the construction industry during the last decade. The main reason behind this evolution was the incorporation of Building Information Modeling (BIM) to be an inefficient construction approach. BIM is now globally considered to be the tool of transforming the construction process to new era. It is also considered as a good tool for the whole project lifecycle. The aim of the present study is to clarify how BIM can be used in after project construction within uncertainty and risky environment such as document losses and unrecorded change orders. Interviews with project team, project site photography, collecting the available schemes and documents were the approaches used in this work to re-build the projects models. The results obtained from this work show that the knowledge and expectations of BIM within existing building have an admirable achievements for construction industry. Furthermore, BIM approach used in this work made more progress in the implementation of BIM as a rehabilitation and renovation tool in civil projects. The conclusions from this study reflect high correlation between the quantities take off with what as-built constructed, more than the traditional approach. The glamorous lessons derived from BIM implementation for the case study is; working with a model in which all project team feel comfortable and harmonic, will ensure enough resources to make the model updated and ought to lead to a minimum conflict within the model or what traditionally called "project documents".

Keywords: BIM; Update Documents; Q.T.O Analysis; Energy Analysis.

1. Introduction

BIM is a smart tool for the design, production, visualization and lifecycle management of buildings. The software for BIM gathers multi-dimensional visualization with the full parametric databases. This eases the shared design and facility management among project Members [1]. Some believe that BIM is a paradigm change instead of two-dimensional representation of the design, gathering, and life cycle management of buildings [1]. Add BIM to the AEC represents a radical shift in the management of the architectural information from idea to building obsolescence [2]. The building information in many existing incomplete, abandoned or fragmented buildings is common [3]. Missing or abandoned building information might lead to ineffective project management, unclear process results and cost increases or time loss in retrofit, maintenance, or remediation processes. The existing buildings often are not updatable and lack the built documentation.

Traditional documentation method sometimes fails to serve in managing the development, rehabilitation and renovation of existing buildings. The lack of appropriate documents, change orders and built drawing of existing buildings is very common.

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In many existing buildings, incomplete, obsolete or fragmented building information is predominating [3]. Missing or obsolete building information might result in ineffective project management, uncertain process results and time loss or cost increases in maintenance, retrofit or remediation processes. As existing buildings often lack as-built documentation due to omitted updating, limitations. A traditional documentation method sometimes fails to serve in managing the development, rehabilitation, and renovation of existing buildings. The lack of appropriate documents, change orders and as-built drawing of existing buildings is very common. Many challenges occur in managing the existing buildings through their life cycle, often due to a lack of related technical information. The rework is a major factor that contributes in an unnecessary, excessive time and cost. It was found that the direct costs of the rework ranging from 3% to 23% of the contract value [4]. Construction methods with its main factors; time, cost and productivity will give the project manager or the site engineer chance of taking the accurate decision in suitable time. This means; In other words, the successful project with successful construction management [5]. This work utilized Autodesk Revit software as BIM tool.

2. Literature Review

Van Wagenen (2012), presented a study on historical building (Inland Steel Headquarters) that documented by BIM. This researcher reach to BIM contains an extensive of data about a building that can be composed graphically, numerically, or literarily. It consolidates the measurement of time to give a visual sequence of a site and a record of past work [6]. Meanwhile, Salil (2012), studied the investigation of facility management on three projects by the use of BIM and construction operations building information exchange. It is discovered that however the database created is helpful for preventative maintenance the information collection and definition process should be begun during the plan and construction stage [7]. Brandon (2011) introduced design information quality in the field of information systems, this study suggests a method for identifying information requirements collaboratively between the design and the construction team, also suggest the adoption of information delivery manuals for documentation of the information requirements [8].

Blanch (2012) proposed the redevelopment of a grocery store site at the focal point of the Rainier Beach Urban Village at the convergence of Rainier Avenue South and South Henderson Street, reusing the current general store structure, also additional building that mixed-use, and creating novel public spaces. To improve quality [9]. Mattsson and Mathias (2013), described in a research how BIM applications can be used to achieve a more efficient construction process using the case study bridge project as well as from the construction process. In addition to this, interviews have been carried out by people involved in the project as well as with other experienced people [10]. Lindblad (2013), looked at how BIM has been embraced in two distinctive construction projects. The examination intends to build up the comprehension of the boundaries ruining BIM selection so as to make it more available for the AEC-industry [11]. Nazar (2014), clarified the use of the proposed approach (Applying ArchiCAD and connecting it with Naviswork by IFC formula) and applied that on a case study of the modern building of the Ministry of Construction and Housing and to detect the vital aspects of a career in Quantity Surveying. This researcher measures the quantities accuracy for 60 item, calculated within the proposed approach with the calculated manually [12].

Panaitescu (2014), examined the intending to analyze the main challenges for BIM adoption within and engineering organization and the focusing on developing a set of recommendations addressing these challenges towards creating an effective implementation plan template relevant for the commissioning organization The commissioning organization is the engineering company Grontmij [13].

3. Case Study Evaluation Using BIM

3.1. Case Study

This project is one of the main buildings in Diyala University campus. It has a total area of 2500 m2 while the construction area of 2380 m2. The project was assigned to local company. The work was started on 10/11/2002. The construction work was stopped at 2003 (Gulf War III).The project was re-announced for bidding and assigned to another local company. The work was restarted on 3/3/2005 and the project was stopped in 2006 due to security events in Diyala Governorate, the project was assigned for the third time to a new local company in 2012.The other information about this building can be summarized as follows:

- The type of contract was a unit price contract.
- The main construction was of reinforced concrete structure followed ACI-318M-02 requirements.
- The steel truss slab for the main hall designed according to third edition of the American Institute of Steel Construction code.
- The building was carried on reinforced concrete continues strip foundation.
- Normal clay brick was used for the wall system.

- The building includes (25) space for festival facilities and different purposes.
- The building height reaches to (17.4m) and consists of three floors.as shown in (Figure 1).
- Most of the as built and design drawings and some of project documents were missed due to aging.

3.2. 3D Visualization

Visualization is a method support the customer in better understanding of the building projects and this can be obtained easily when using BIM. Traditional documentation methods, were creating 2D drawings that may not be understandable by customers because in 2D drawings the complex projects cannot be envisaged [15]. In this work, Autodesk Revit 2016 was used to create a visualization for the case study as shown in (Figure 2).

Figure 1. Case study at Diyala University

Figure 2. BIM model for the case study

3.3. Energy Analysis for the Case Study

BIM energy analysis tool in Autodesk Revit allows the easy calculations to be executed with regard to usage of the energy for case study.

3.3.1. Annual Carbon Emissions

Through the use of BIM, it was possible to create more productive building models to manage low carbon construction projects, which can ensure a comprehensive life cycle analysis, planning of the service life and optimize the life-cycle design and use of the buildings. Annual carbon emission appears in this case study was (29 metric tons/yr.) as shown in (Figure 3) according to the fuel and electricity consumption. Incorporating the carbon management during the early planning phase, provide the necessary information for this process in the design, which can ensure the positive environmental impact of the building's performance.

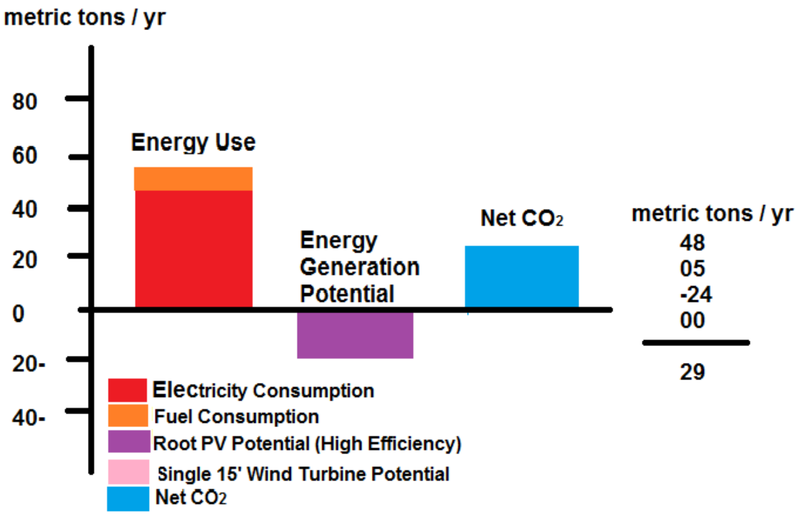

Figure 3. Annual carbon emission of case study

3.3.2. Electricity Use

Realistically, Electricity usage witnesses high increase during the summer season due to the hot climate as shown in (Figure 4). This increment was a result of the use of different cooling systems beside the traditional consumption of electric power for lighting and other domestic equipment.

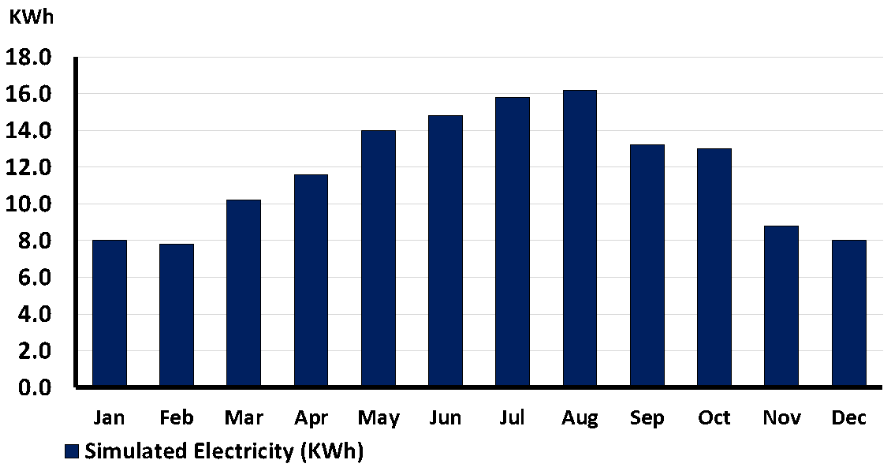

Figure 4. Monthly electricity consumption of case study

4. Q.T.O of Case Study

The quantities takeoff for the case study was calculated and illustrated in Table (1). The comparison shows the percentages of the differences between the as-built quantities and the traditional estimated quantities, also the percentages of the differences between the BIM quantities takeoff (using Autodesk Revit) and the quantities calculated by traditional methods (estimated and as-built). Significant differences were noted between the as-built quantities and estimated quantities with BIM, for example; in the item of reinforced concrete slab, the differences between the BIM quantity and as-built was (-1.1%) meanwhile it was for estimated without change order about (+4.35%) and after change order was (-2.7%) due to the Shortage and mismatch between the architecture and structural schemes as previously mentioned the part of the first floor about (325 m2) Not calculated, the difference rate for all of the fourteen items considered in this work were shown in (Figure 5).

These differences reflect the high precision of BIM quantities takeoff when compared with the traditional estimation before the correction action through the change orders.

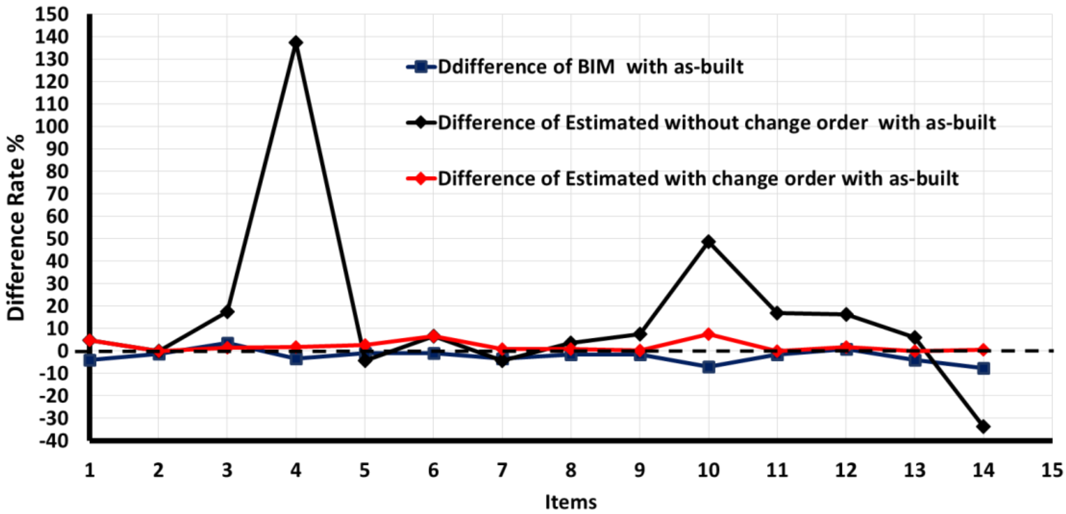

Figure 5. The differences rate with as-built quantities for BIM and Traditional Estimation

Table 1. The quantities of the case study

Item	Unit	estimated B.Q.T		As-Built B.Q.T				BIM B.Q.T	Difference (%)				
				Contract no. 1	Contract no. 2	Contract no. 3	Total		As-Built & Estimated		BIM& Estimated		BIM & As-Built
Foundation	M3	776.5		716.5	24	——	740.5	710.76	-4.6%		-8.46%		-4.01%
Columns	M3	253.5		97.3	81.2	75	253.5	250.14	0%		-1.3%		-1.3%
Beams	M3	Before change order 294	After change order 254	——	174	76	250	258.59	Before change order -14.9%	After change order -1.57%	Before change order -12.04%	After change order +1.8%	+3.4%
Domes	M3	Before change order 70	After change order 30	——	——	29.5	29.5	28.47	Before change order -57.8%	After change order -1.6%	Before change order -59.33%	After change order -5.1%	-3.5%
Concrete Slabs	M3	Before change order 345	After change order 370	——	145	215	360	356.04	Before change order +4.35%	After change order -2.7%	Before change order +3.2%	After change order -3.77%	-1.1%
Steel slab	M2	950		——	——	891	891	882.213	-6.2%		-7.1%		-0.98%
Stair	M3	Before change order 237.49	After change order 250.49	26.79	175.7	46	248.49	240	Before change order +4.6%	After change order -0.8%	Before change order +1.05%	After change order -4.18%	-3.4%
Brick under D.P.C 24 cm	M3	Before change order 322	After change order 314	297	——	14	311	306.13	Before change order -3.4%	After change order -0.9%	Before change order -4.9%	After change order -2.5%	-1.5%
Brick over D.P.C 24 cm	M3	Before change order 1223	After change order 1139	60	163	914	1137	1119.89	Before change order -7%	After change order -0.17%	Before change order -8.4%`	After change order -1.67%	-1.5%
Brick over D.P.C 12 cm	M2	Before change order 90	After change order 65	——	——	60.5	60.5	56.298	Before change order -32.7%	After change order -6.9%	Before change order -37.4%	After change order -13.4%	-0.07%
Floor (murmur)	M2	Before change order 3800	After change order 3250	——	——	3250	3250	3203.59	Before change order -14.5%	After change order 0%	Before change order -15.7%	After change order -1.4%	-1.4%
Floor of roof (98% constructed)	M2	Before change order 1050	After change order 920	——	——	904	904	910.754	Before change order ——	After change order ——	Before change order -13.26%	After change order -1.01%	——
Concrete of D.P.C	M	Before change order 470.83	After change order 444.83	189.04	181.79	74	444.83	426.388	Before change order -5.5%	After change order 0%	Before change order -9.44%	After change order -4.14%	-4.14
Package tone	M2	Before change order 2750	After change order 4160	——	——	4141.88	4141.9	3822.88	Before change order +50.61%	After change order -0.43%	Before change order +39%	After change order -8.1%	-7.7%

5. BIM Potential Expectations in the Construction Projects

Based on the experience gained from the case study, some expectation of the possible BIM potentials in the improving the construction processes were elaborated. These expectations includes; handling of drawings, visualization, clash detection, update quantities takeoff, and Knowledge about energy analysis. Many aspects of how the expectations of BIM in construction projects brightened up from the case study analysis and results were illustrated in Table 2.

Table 2: Potential expectations with BIM in the Construction projects

Expectation	Experience
Handling of drawings	Beside that a BIM model contains the whole structure details with measurements, position, and properties, infinite 2D drawings can be generated utilizing BIM tools. Also smart angle of view can be reached easily through the rotation and orientation of the 3D model to select the most useful 2D drawings.
Visualization	For the projects that are designed on BIM, There are many simulation tools which allow the designers to visualize things, quantify and walk through the building spaces. The BIM intelligent software apply rules which based on physics and best practices to provide the users with a comprehensive project environment.
Clash detection	The tools within BIM software serve in clash auto-detection of elements. Clashes will be discovered early through modeling process and warning for correction action will be generated for the designers, this will help in avoiding and reducing the costly on-site clashes. BIM modelling also ensures a perfect fitness for the parts manufactured off-site, allowing these items to be accurately installed into place rather than created on-site.
Update B.O.Q	BIM provide an excellent tools to calculate and monitor quantities and changes introduced on the project model for the next stages of work. By these options, engineers can not only determine the changes and type (adding, removing, properties change) but also they can account all quantities, calculation detailed costs and scheduling of works.know, any BOQ changes and in the cost valuation are included and corrected automatically using the data data provided in revised BIM models.
Knowledge about energy analysis	Design team can eliminate areas of energy waste through the use of BIM tools relative to project data. Smart controls can be improved by analyzing the building heat losses and energy efficiencies measures. Moreover; this will minimize the demand of building's energy, and may be result in less building services requirements. Using BIM information and energy profiles analysis will establish a reliable heat demand and building energy consumption for optimized performance.

The above expectation highlighted from the case study was complied with finding of AbuHamra (2015) in a study of construction industry and the investigation of BIM application in Gaza strip. Through this research the awareness BIM level was assessed by experts in the AEC industry. In this study, a quantitative survey was used and the results indicated that the awareness of BIM level can establish a good platform for future researchers to identify meaningful ways of providing solutions to the challenges identified and facilitate a smoother and more successful transition in the adoption of BIM technologies and innovations in the construction industry [14]. Also, Khaddaj, and Issam (2016) also Abbas and Alaa (2017) summarized in a study the recent literature on two emerging fields of research, BIM and sustainability. The conclusion was that energy seems to have gained the most momentum compared to other themes such as materials and water, also, the review indicates a significant area of overlap between BIM and sustainability in the usage of BIM to define the scope of energy-driven retrofits of existing buildings [15, 16]. Gourlis and Iva (2016) and Abd and Abd (2012) Analyzed the building performance and resources planning by update the existing facilities and energy. The results showed that the facility and resources demand could be reduced up to 52%, lead to savings the energy. On the other hand, the thermal performance against summer overheating also showed significant improvements in regard to hours exceeding levels of thermal comfort [17, 18].

6. Conclusion

The main goal of this work was to investigate the methods and techniques of reliable energy management and simulations tool using building information modeling (BIM). Current techniques of energy simulations suffer from lack in high interoperability between energy simulation and BIM. In this work and though the case study, the energy modeling leading to analyze of building project performance and this can help in the optimization of the buildings overall design with respect to energy efficiency. In term of quantities takeoff, the results show very high convergence between the as-built and BIM quantities. Very little difference were noted for the items under consideration within the case study (the average differences were below 2.38%), meanwhile the average differences between as-built and traditional estimation was 15.93%. The high rate of difference for traditional estimation was need many change orders to correct the project quantities up to the rate of 2.1% difference with as-built. This fact leads to an important conclusion as by using BIM there is a very little need for change orders (in this case study was less than 0.27%). This research highlights the reliability of using BIM as an effective tool in building energy simulation and optimization of quantities takeoff as accurate as possible.

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