

Role of BIM - Technology in quality assurance of construction and energy analysis of buildings

Shaimaa Ghanim Hakim Alamedy

Peoples' Friendship University of Russia, Russian Federation; (RUDN)

Abstract: This article described in detail the visualization of 5 case studies in Iraq with two important subjects; The first subject is construction quality control using BIM-compliant construction projects employing Autodesk Revit software; The second subject is quality assurance using BIM and energy analysis, which evaluates the energy usage in accordance with BIM utilizing Autodesk Revit software, and Autodesk Green Building Studio (GBS) Cloud. There are several causes that lead to the selection of these case studies. These case studies are applied models or examples executed by many Ministries such models exist in other governorates in Iraq. Despite the fact that the research topic of quality improvement utilizing Building Information Modeling (BIM) technology was not used in the chosen models, these buildings had several challenges throughout the execution phase. This research will be more valuable when implementing government agencies and private sector companies specialized in construction. wants to use BIM technology to improve the execution quality for future buildings.

Keywords: energy analysis of buildings, construction project, Building Information Modeling, quality, quality control, quality assurance.

Introduction

BIM technologies make work on the project much more quality active and easier, however, the start of using BIM is rather complex. Many researchers have examined the privileges of BIM in the countries of the world, but there are no recommendations about its execution [1]. Before opening the working in BIM, it is necessary to make a clear integration plan: select the departments that will be first; choose the project; choose the person who would be BIM Manager; Provide tools and training in the basic disciplines; practice a team work; create content libraries and templates; enter instruction and specifications, BIM-company standard; choose the professional who would be quality [2].

Building information modeling (BIM) refers to the digital representation of a building's structural features. It is a digital 3D model that includes all of the spatial and functional features [3]. It enables the building industry to share input on buildings with all related entities, including builders, technicians, and managers, throughout its existence. This strategy aids in overcoming the many problems of

coordination and harmonization across planning, development, and management teams [4].

Autodesk Revit Software 2022

Revit software is widely regarded as the most well-known Building Information Modeling (BIM) software in the architectural design market today [5]. Autodesk released this platform to the market in 2002 [6]. This platform is a product family that consists of Revit architecture, Revit structure, and Revit MEP [7].

Revit, as a tool, has an easy-to-use interface with drag-over tips for each step and smart cursor. It has the most connected apps as a platform, including Facility Management: Autodesk FM Desktop [8]. The Revit software is classified as a building information modeling application. One of the benefits of BIM models is that a single drawing file connects all of the drawings. Unlike other Computer-Aided Design (CAD) tools, Revit employs parameters to regulate the size of features, such as doors, windows, and walls [9]. The two-dimensional illustrations are based on the three-dimensional model of the building. When modifications are made to the design file, this guarantees that the changes are applied to the whole model as well as the appropriate 2D views, such as floor plans, parts, and elevations. This considerably speeds up the model revision throughout the design phase and aids in building maintenance during the building's lifecycle [10].

Plan Practical Study Workflow

The workflow plan of the practical study was as follows: The five separate projects were selected as pilot projects that distributed in different governorates in Iraq; Collect the 3D plans and paper documents of a case study selected; Modeling the case study using Revit software (ver.2022). BIM's usage in building quality assurance, the BIM concept, building performance analysis technology, and leveraging the usage of REVIT software as a source of new materials for energy analysis improves the data input and makes the existing data

more reusable. The most significant advantage is that the findings of energy analysis materials can be displayed immediately and building alterations may be directly integrated, allowing for more building repetition to be studied to improve the efficiency and achieve quality objectives.

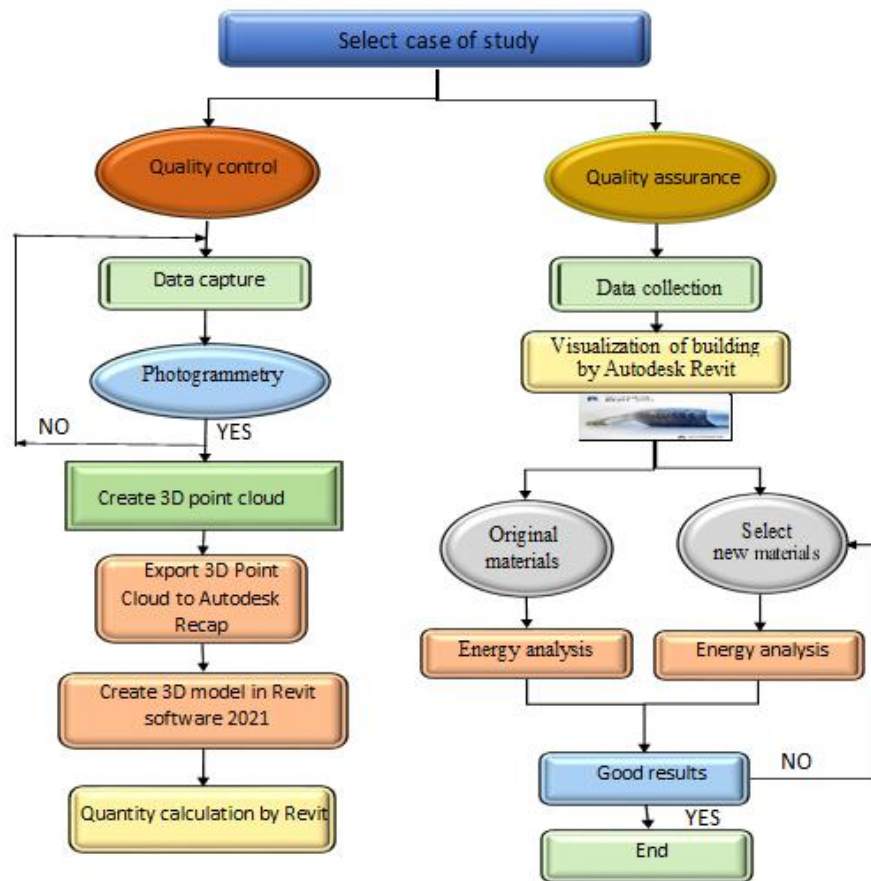


Figure 1. – Plan practical study workflow (author).

The outcomes of each validated process demonstrate that the approach used generates informative and visual data products that enable the user the mobility within the scope of building inspection and monitoring, as shown in the Figure 1.

Description of selected study cases

Project No. (1): Al Damin Medical Complex

This private sector project is considered as one of the most important projects in Babil Governorate - Iraq, the building is shown in Figure 2. Its total

area is about (650 m²). The project was assigned to the local company at an estimated cost of (1,050,000 USD). The height of the building is 23m and it has 7 floors. This building contains 42 clinic rooms.



Figure 2. – Al Damin Medical Complex

Project No. (2): Babylon Health Department

This project is considered one of the public sector projects, the building is shown in Figure 3. Its total area is about (2250 m²). The project was assigned to the local company at an estimated cost of (2,700,000 USD). The height of the building is 14m and it has 3 floors with 38 clinic rooms.

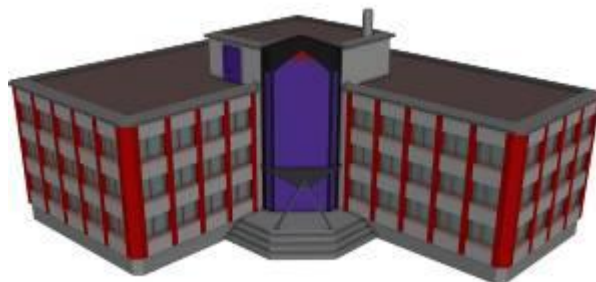


Figure 3. – Babylon health department.

Project No. (3): Computer Engineering Department

Department of Computer Engineering at the University of Technology in Iraq. This project is considered as one of the public sector projects, the building is shown in Figures 4. Its total area is about (400 m²). The project was assigned to the local company at an estimated cost (1,800,000 USD). The building is 30m high

and has 10 floors. Each floor contains 15 offices, 5 Large classrooms with 120 seats and 3 health facilities.

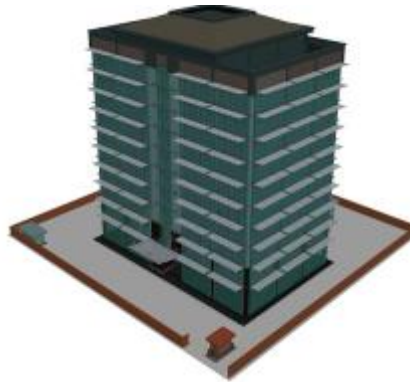


Figure 4. – Computer engineering department.

Project No. (4): Al-Salam Apartment Building

Al-Salam apartment building in Basra Governorate, Iraq. This project is considered as one of the private sector projects, the building is shown in Figures 5. Its total area is about (750 m²). The project was assigned to the local company at an estimated cost of (1,650,000 USD). The total height of the building is 12m and it has 3 floors.



Figure 5. – Al-Salam apartment building.

Project No. (5): Al-Noor Resident Building

Al Noor Residential Building in Baghdad Governorate, Iraq. This project is considered as one of the public sector projects, the building is shown in Figures 6 (a-b). Its total area is about (5000 m²). The project was awarded to the government company at an estimated cost (3,000,000 USD). The height of the building is 58m

and it has 16 floors. Each floor is 3.5m high and contains 20 apartments in addition to other facilities.



Figure 6. – Al-Noor resident building.

The design of the selected buildings contains a diversity of constructional details, such as slabs, beams, columns, finishing, floors, steel doors, wooden doors, aluminum windows, etc. These projects are currently under construction, which provides an opportunity to show the BIM's capacity to keep up with the changes during construction.

Quality Control

Effective quality control for BIM-compliant construction projects using Autodesk Revit software utilizing these techniques in the Iraqi projects reduces the likelihood of modifications, mistakes, and omissions, resulting in fewer conflicts and disagreements and improving the construction project execution quality [11]. There are various stages that must be taken in order to get a 3D modeling of the building and integrated it with BIM. The first phase is the planning procedure, which determines the coordinate system as well as the needed distance for imaging and the size of the coded target if local coordinates are employed. In terms of fieldwork, the end result is that photographing of the appropriate building are taken, and data is processed. The point of origin and orientation has been modified before being exported to Revit, where it is built upon, and the data and quantities are extracted, as shown in Figure 7.

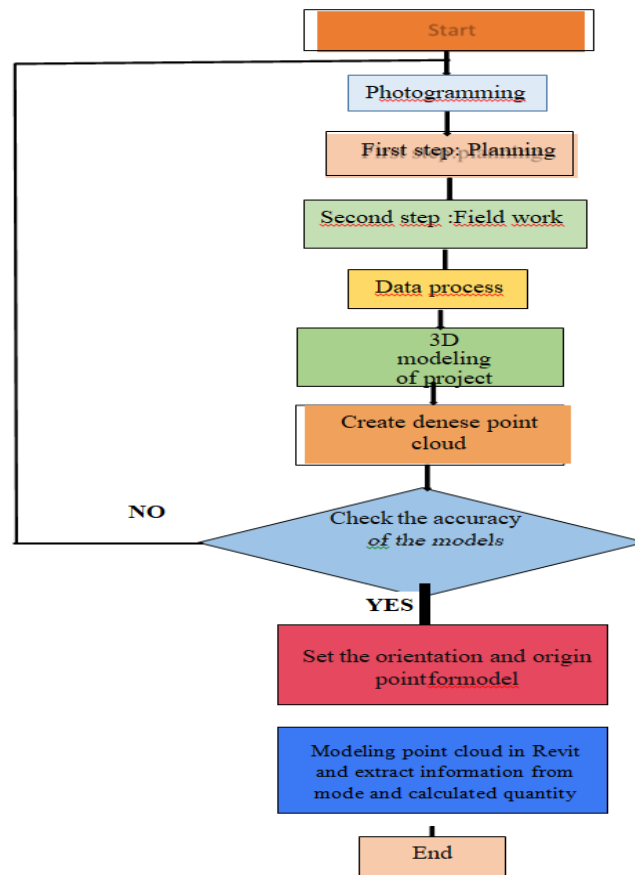


Figure 7. – Flowchart for creating a 3D model and integrating with BIM (Author).

Method Improving Execution by BIM Model

After completing the 3D modeling in Revit 2022, the process of BIM model improving with building performance analysis (BPA) tools starts to green building studio, and this improving process is very important in the projects execution stage .

To create a 3D BIM model, the 3D BIM model can be worked through the use of 3D AutoCAD plans and using the most important software in BIM packages called Autodesk Revit software (ver.2022). The actual quantities that were used to pour the foundations, columns, beams, slabs, staircase, flooring works, secondary ceilings works, tile works and stone works of the building from reinforced concrete, will be calculated.

When one wants to improve the quality of the building that must last high-quality materials, where the author interviewed several project managers and private offices for the sale of construction materials for the purpose of inferring materials that include quality and resistance to weather conditions in Iraq. The selection of new materials was based on the availability of the materials in the country and their insulation properties to minimize additional construction costs in addition to quality assurance construction projects and increasing thermal insulation for buildings and providing a good environment for the occupants doing buildings.

BIM was used to simulate the buildings and provide the power consumption cost, and BPA was used to analyze the results and suggest new building alternatives which can help in improving the quality of the building and increasing thermal insulation for the building by suggesting new building materials. Also, BIM has been utilized effectively in numerous projects in recent years to achieve quality execution [12].

It is dependent on three factors: Modeling the building, processing information, and providing data that can be used to assess the efficiency and quality of the building [13].

Table 1 shows the new material and components used in the selected case studies. To construct quality projects of rising structures by Revit software, the author must first bring new materials to the Revit environment by exploiting their properties to develop new materials by making a special new library in the case studies.

This includes using foam material, Sandstone, granite, Glass Fiber, double glazing, and Cellulose Insulation discovered in Revit Select Manage as the initial step in creating new materials. menu, Settings panel, and then clicking on Materials from Revit software.

Table №1. – The used new materials and components.

| Building Element | Material/components | Thickness (m) | Thermal conductivity (W/m.K) |
|------------------|----------------------|---------------|------------------------------|
| Wall | Sand Stone | 0.15 | 1.5 |
| | Granite | 0.18 | 3.0 |
| | Fiber glass | 0.15 | 0.03 |
| | Cellulose Insulation | 0.16 | 0.08 |
| Roof | Foam | 0.18 | 0.19 |
| windows | Double glazing | NA | 1.1 |

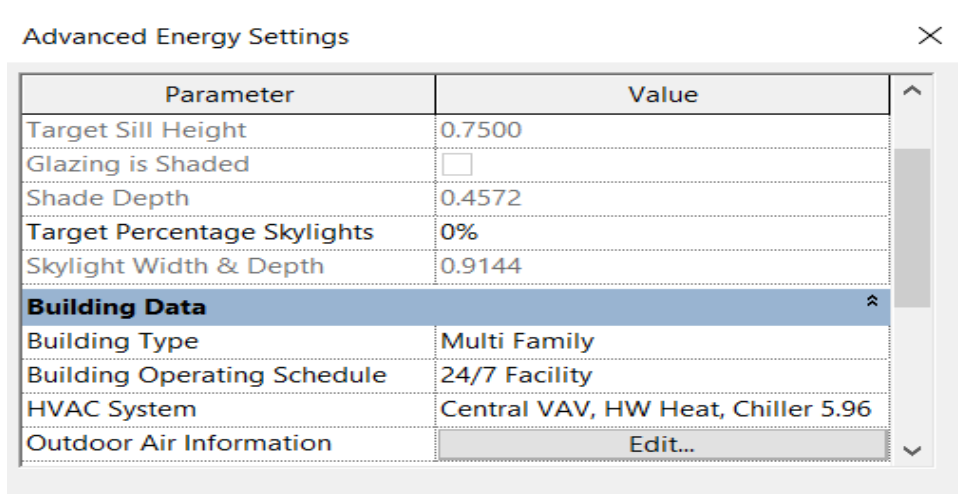
To use the new materials in the model, the author must first import the specifications and related attributes of the materials into Revit by accessing the Material Browser and establishing a collection of materials assets that includes:

- (A) Identify, provides descriptive information about the new materials, product information, and Revit annotation information.
- (B) Graphics: This category covers the shading, surface pattern, and cut pattern.
- (C) Appearance: It comprises information, general, and other data, as well as the appearance of materials in a rendered view, realistic view, or realistic view.
- (D) Physical characteristics are used to input information, such as compressive strength, shear strength, density, and shear modulus.
- (E) Thermal characteristics include energy-related qualities such as thermal conductivity.

Energy Simulation

Energy Simulation is assessing by analyzing the building in green building studio to Revit 2022, the energy auditing in this analysis is according to ASHRAE, and this analysis is done through following steps: Create 3D BIM model of Project by using Autodesk Revit 2022; Create spaces for all rooms; Change energy setting

and import some information, like location of the project, type of project and type of Havac System, such as shown in Figure 8.



| Parameter | Value |
|-----------------------------|------------------------------------|
| Target Sill Height | 0.7500 |
| Glazing is Shaded | <input type="checkbox"/> |
| Shade Depth | 0.4572 |
| Target Percentage Skylights | 0% |
| Skylight Width & Depth | 0.9144 |
| Building Data | |
| Building Type | Multi Family |
| Building Operating Schedule | 24/7 Facility |
| HVAC System | Central VAV, HW Heat, Chiller 5.96 |
| Outdoor Air Information | Edit... |

Figure 8. – Energy settings.

After finishing the 3D BIM model in Revit 2022, the model will be optimized to the website Green Building Studio (GBS) for detailed energy consumption analysis, and then from the website of (GBS) cloud, find the information of model and save it directly when optimizing the model to insight cloud. After that create energy model, calculate the heating and cooling and optimize 3D model to Autodesk Green Building Studio (GBS) as shown in Figures 9-13.

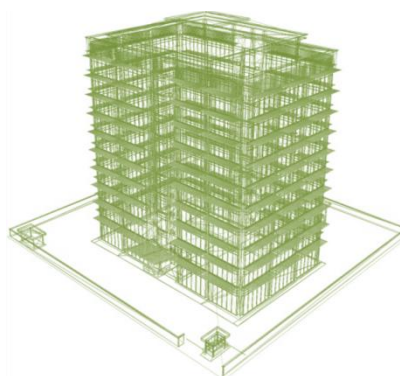


Figure 9. – Energy model for Project No (1)

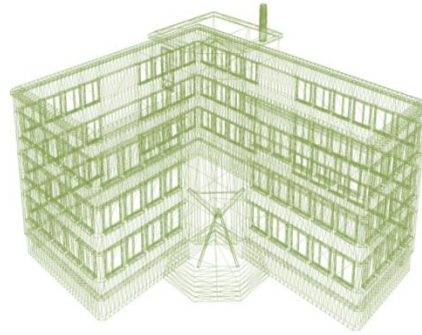


Figure 10. – Energy model for Project No (2)

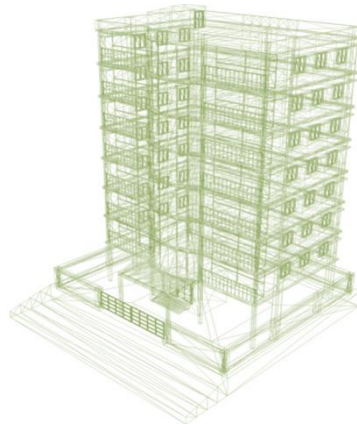


Figure 11. – Energy model for Project No (3)

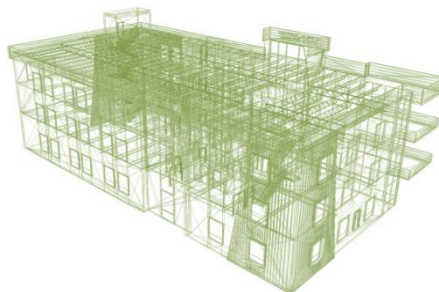


Figure 12. – Energy model for Project No (4)



Figure 13. – Energy model for Project No (5)

The results of the analysis as seen in Figure 14 is to give the annual consumption of energy useintensity (EUI).

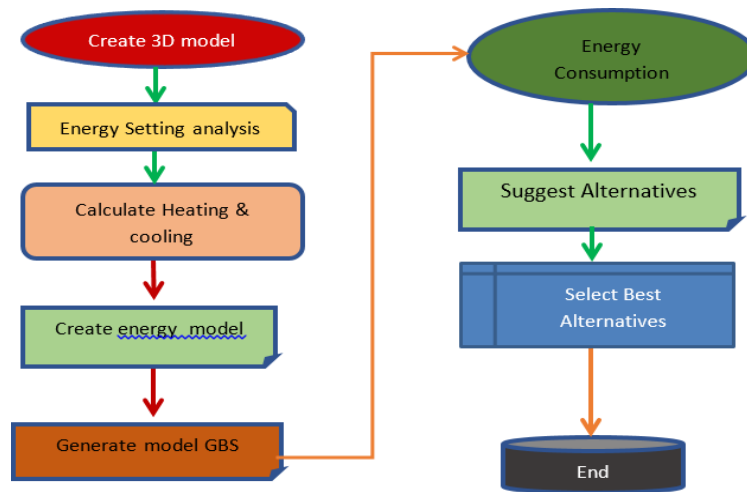


Figure 14. – Framework to evaluate energy performance.

Conclusion

This article discussed the methodology and detail the visualization of 5 case studies with quality control using building information modeling for BIM-compliant construction projects and utilizing Autodesk Revit. Also, the quality assurance was debated employing building information modeling and energy analysis with original materials and using new materials to improve the performance quality of the building. For the primary building activities of the case study (98.6), it was found that the precision of the amounts taken off using the BIM technique has an error rate of (1.4 %). The previous estimating 55 method, on the other hand, had error rates of (5.1%) for the identical jobs. This is clear proof of increased BIM correctness. BIM is a very helpful technique for carrying out various analyses that aid in discovering various strategies for improving energy consumption efficiency. Relying on the GBS tool as a useful tool that can aid engineers in energy performance assessment and the selection of the most appropriate options, the researcher comes to the conclusion that the best options were chosen. Granite for completing walls, cellulose insulation, and foam material

atop roofs are utilized to boost quality assurance using BIM since they reduce energy consumption. Using quality principles like quality control and quality assurance throughout the execution phase, as well as embracing continuous process improvement techniques, the programme received a 95% approval rating on the questionnaire to evaluate the quality improvement system.

References

1. Vysotskiy, A., Makarov, S., Zolotova, J., & Tuchkevich, E. Features of BIM implementation using autodesk software. *Procedia engineering*. 2015, 10 p.
2. Egan J. *Rethinking Construction. The Report of the Construction Industry Taskforce*. London. 1998, 38 p.
3. Kaner, I., Sacks, R., Kassian, W., & Quitt, T. Case studies of BIM adoption for precast concrete design by mid-sized structural engineering firms. *Journal of Information Technology in Construction*. 2008, Pp. 303-323.
4. Chantawit D., Hadikusumo B. H., Charoenngam C., & Rowlinson S. 4DCAD-Safety: visualizing project scheduling and safety planning. *Construction Innovation*, 2005, Pp. 99–114.
5. Eastman, C. M., Teicholz, P., Sacks, R., & Liston, K. *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*. John Wiley & Sons, 2011, 626 p.
6. Xu, H., Feng, J., & Li, S. Users-orientated evaluation of building information model in the Chinese construction industry. *Automation in construction*. 2014, P.p.32–46.
7. Whyte J., Lindkvist C., Ibrahim N. H. Value to clients through data hand-over: A pilot study. Summary Report to Institution of Engineers (ICE) Information Systems (IS) Panel. 2010, 150 p.
8. Dao, D., Rizos, C., & Wang, J. Location-based services: technical and business issues. *Gps Solutions*. 2002, Pp. 169-178.

9. Love, P.E., Skitmore M. Earl G. Selecting a suitable procurement method for a building project. *Construction Management and Economics*. 1998, Pp. 221–233.

10. Chen, J. K., & Ho, H. H. Transformation and Impact from the Software Ecosystem Perspective: Case Study of Autodesk Inc.'s Ecosystem Roadmap. In *2021 IEEE International Conference on Social Sciences and Intelligent Management (SSIM)*. 2021, Pp. 1–7.

11. Sepasgozar, S. M., Costin, A. M., Karimi, R., Shirowzhan, S., Abbasian, E., & Li, J. BIM and Digital Tools for State-of-the-Art Construction Cost Management. *Buildings*. 2022, 396 p.

12. Wang, J., Sun, W., Shou, W., Wang, X., Wu, C., Chong, H. Y, Sun, C.. Integrating BIM and LiDAR for real-time construction quality control. *Journal of Intelligent & Robotic Systems*. 2015, Pp. 417–432.

13. Naji, H. I., Mahmood, M., & Mohammad, H. E. Using BIM to propose building alternatives towards lower consumption of electric power in Iraq. *Asian Journal of Civil Engineering*. 2019, Pp. 669–679.