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Using Building Information Modeling to Retrofit Abandoned Construction Projects in Iraq to Achieve Low-energy

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ABSTRACT

In recent years, the Iraqi construction sector has faced many abandoned projects that have a negative impact on stakeholders, the economy, and the environment. Retrofitting existing buildings offer significant opportunities to reduce energy consumption and carbon emissions since buildings consume the largest amount of energy. The research methodology adopting building information Modeling (BIM) technology, is one of the modern techniques for retrofitting abandoned buildings to achieve low energy buildings and reduce the environmental effect. The concept of the study is applied to one of the projects in Iraq. The author finds that the use of BIM technology is very useful in carrying out various analyses and helping to find retrofitting strategies to improve the energy efficiency of the project. The results showed that the energy savings of 24% of the total improvement compared to the baseline design situation and the most efficient alternatives are heating, ventilation and air conditioning (HVAC) systems with energy savings of 71.36 kWh/m^2 .year.

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1. INTRODUCTION

Globally, the construction sector is responsible for the largest environmental impacts, consumes 32% of final energy, and generates 25% of greenhouse gas emissions [1]. Therefore, the environmental effect needs to be minimized by improving energy quality and reducing energy use in the construction sector [2]. Retrofitting an abandoned building is one of the most important strategies to reduce environmental problems associated with energy use in buildings [3]. Retrofitting existing buildings improve sustainable development, decrease energy consumption, reduces maintenance costs, and mitigates climate change [4]. Retrofit of buildings has several advantages that can be classified into environmental, economic, and social benefits [5]. The traditional method of computer-aided design uses two-dimensional viewing planning does not have the capability to perform energy simulation during the initial phase of design [6]. Building Information Modeling (BIM) is a digital representation of the physical and functional characteristics of the facility, which constitutes a shared and accurate knowledge platform for conducting sustainability measures and the analysis of energy performance at an early stage of design [7]. BIM is an innovative technology that uses several methods that can accurately measure energy efficiency in buildings [8]. BIM Technology has many tools for performance analysis (Insight 360, Autodesk Green Building Studio (GBS), Design Builder) [9]. BIM technology can create a virtual environment similar to the actual work site environment which helps in the early stages of the project to identify and solve safety problems [10]. BIM technology has the ability to effect the energy of the school building in the retrofit phases [11]. Fuzzy inference method for the indeterminacy model has the potential to solve the health and safety, and environmental risk in the construction sector [12]. In recent years, a lot of research has used BIM technology in various aspects of construction, the technology of BIM can be applied to retrofitting the building to minimize energy demand [13], identify and assess sustainable design parameters based on the tools provided by Building Information Modeling to improve sustainability in the building sector [14], use the BIM

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approach to achieve a sustainable design by using alternative waste from demolished buildings in the construction process [15], documentation using GIS and BIM data [16]. The use of the BIM technique to suggest construction alternatives to lower electricity consumption in Iraq, for example, the selection of the best construction materials for walls and roofs. It is found that the rock block is the best alternative for walls, and the Autoclaved Aerated Concrete Block (AAC block) rib slab is the best alternative for roofing [17].

In recent years, the construction sector in Iraq has faced several problems associated with an increase in the number of abandoned construction projects that have had negative impacts on the environment and increased consumption of electricity and natural resources. So, the authors of this study adopt BIM technology as one of the modern technologies to retrofitting abandoned projects to reduce environmental impacts and to improve energy efficiency in Iraq.

2. RESEARCH METHODOLOGY AND CASE STUDY

In this section, the authors present a description of the methodology for this study and also illustrate the case study.

2. 1. Research Methodology This methodology consists of two parts, the first part is the theoretical part and the second part is the experimental part, as shown in Figure 1. data collection consists of BIM data and this data includes all building information (Quantities Schedule, 2D Drawings) through interviews with specialist construction engineers at Diyala governorate and the creation of the BIM 3D case study model using the Revit Software 2020, energy analysis and simulation was performed with the plug in for Rivet, Insight 360. Finally, clarify the conclusions that the authors have reached.

2. 2. Case Study In order to achieve the objective of the study, one of the residential buildings at Diyala is selected as a case study. The work has started in 2010 project and in 2013 the construction work in the project is stopped with a total area of 2845,22 m^2, consisting of four floors, four apartments on each floor. Creating a 3D model for a case study, completion of about 55% of the work is shown in Figure 2. The benefit from the possibilities offered by BIM to complete work of the abandoned buildings is shown in Figure 3. The other information about the project is summarized as follows:

- Project location: Diyala, Iraq
- Height of Buildings12.45 m

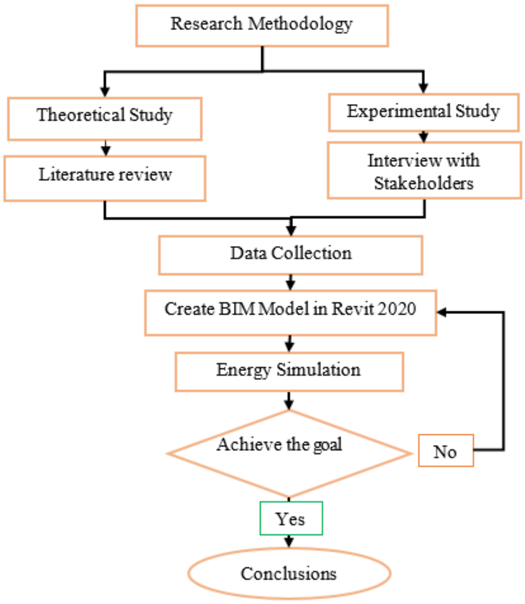

Figure 1. Research Methodology

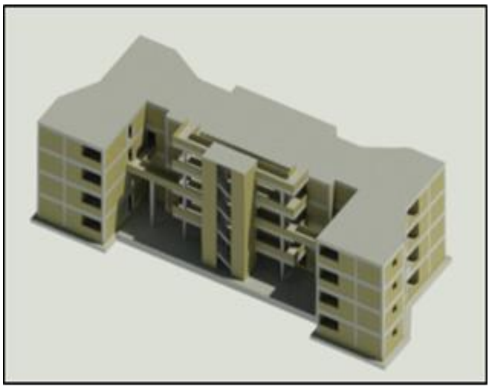

Figure 2. 3D model of the case study

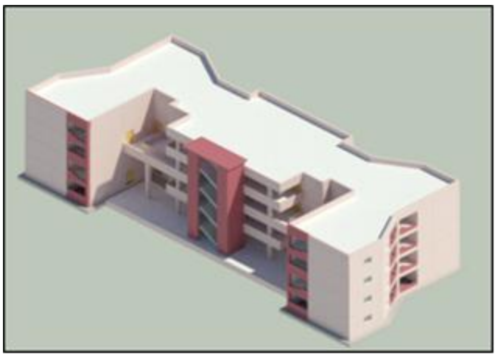

Figure 3. BIM 3D model finish work of the building

- Project supervision: engineers of the headquarters of the ministry of construction and housing at Diyala

- Type of contract: unit price contract
- The project is unfinished and is abandoned because of the country's economic crisis.
- Details of construction were used for the model building shown in the Table 1.

3. BUILDING ENERGY MODEL

Energy analysis and simulation of the building was performed with the plug in for Rivet, Insight 360. The energy analysis steps are as follows:

- Creating the BIM 3D model of the case study using Revit Software 2020.
- Selection of the building's geographical location and weather station data in Revit as shown in Figure 4.
- Creating the space and energy model of the building in Revit as shown in Figures 5 and 6.
- Select the optimizing panel in Rivet 2020 to run the energy analysis in Insight360.

4. RESULTS AND DISCUSSION

The findings of this study are based on the energy settings in Revit 2020 and retrofit alternatives which are selected in Insight 360 cloud, as shown in Figure 7.

TABLE 1. Detailed construction of case studies

Construction	Details		Conductivity (W/m k)	Specific heat J/(kg·°C)
	Materials	Thickness (m)		
External Wall	Brick	0.24	0.54	840
	Cement mortar	0.02	0.72	840
	Gypsum	0.02	0.65	840
	Oil paint	0.01	0.51	960
Interior walls 1	Brick cement plaster	0.24	0.54	840
	Gypsum	0.01	0.72	840
	Plaster	0.02	0.65	840
Interior walls 2	Brick	0.24	0.54	840
	Ceramic tiles	0.02	1.2	850
Roof	Concrete	0.15	1.046	657
	Asphalt	0.03	1.15	840
	Sand	0.02	0.335	100
	Concrete tiles	0.04	1.046	657
Floor	Concrete	0.15	1.046	657
	Mosaic Tile	0.03	0.8	850
Window	Single-glass	0.06	1.2	840

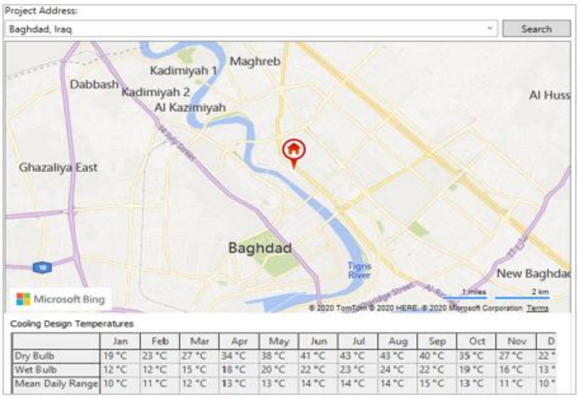

Figure 4. Building's geographical location and weather station in Revit

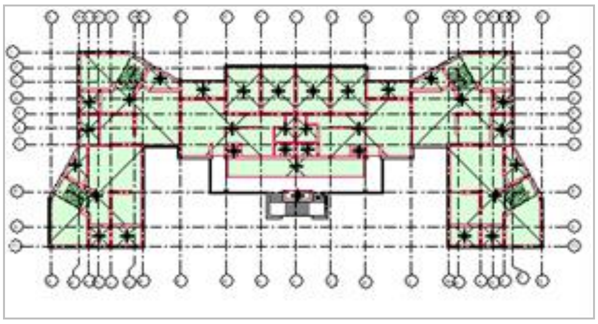

Figure 5. Analytical spaces of the building energy model in Revit

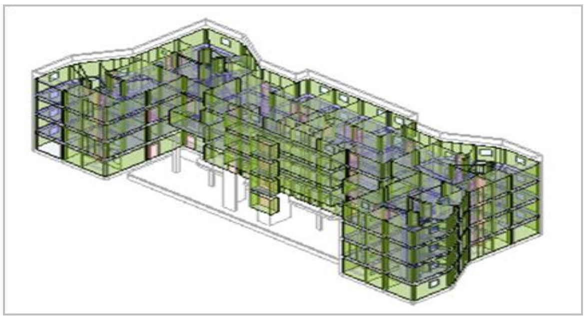

Figure 6. Building energy model in Revit

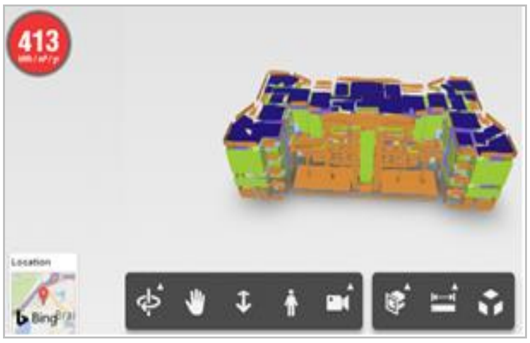

Figure 7. The building and findings obtained on platform insight 360

4. 1. Energy Simulation of Baseline Design Energy simulation uses the basic building materials of the case-study residential building. The results showed that energy consumption is equal to 413 kWh/(m^2 year) as illustrated in Figure 8.

4. 2. Retrofitting Alternatives Many abandoned projects in Iraq are designed and constructed according to criteria which do not take into account the reduction of energy consumption or sustainability. Therefore, the retrofitting of existing projects is necessary to minimize environmental impacts and to improve sustainability. Retrofitting alternatives for the case study are selected in consultation with experts and evaluated on the 360 insight platform.

4. 2. 1. Lights System The lighting system affects the use of energy and causes a large amount of depletion of energy in the building. The retrofitting consists of the replacement of existing fluorescent luminaires with another LED system. The results of energy simulation after the improvement has achieved energy consumption 397.16 kWh/(m^2 year) and energy-saving 15.52 kWh/(m^2 year), as shown in Figure 9.

4. 2. 2. HVAC System One of the key components of energy usage is the heating, ventilation, and air conditioning (HVAC) system and influences the quality of indoor air and air temperature in the building. Retrofitting consists of replacing the existing building HVAC systems with a modern system based on highly efficient heat pumps. After improving, the energy consumption is 325.81 kWh/(m^2 year) and energy savings by 71.36 kWh/(m^2 year). It should be noted that this measure has produced significant energy savings and is actually one of the main components of energy consumption and has an impact on indoor air quality and the temperature of the air in the building as shown in Figure 10.

4. 2. 3. Window Glass The type of window glass plays a major role in how much heat gain and loss in construction and its effect on energy consumption. The retrofitting consists of replacing existing single-glass windows with triple Low-E glass. After improving, the energy consumption is 303.41 kWh/(m^2 year) and energy savings of 12.47 kWh/(m^2 year) as shown in Figure 11.

In summary, as shown in Figure 12, the various scenarios examined in the applied energy simulation can be graphically represented. This section shows the various

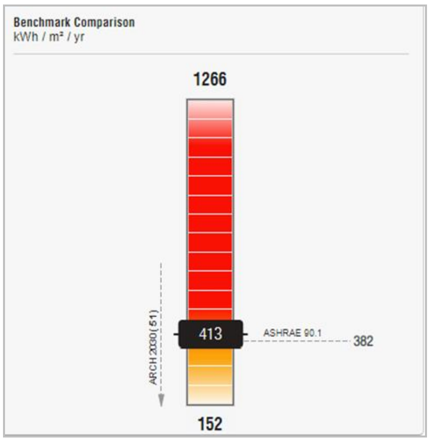

Figure 8. Energy simulation on insight 360 platform

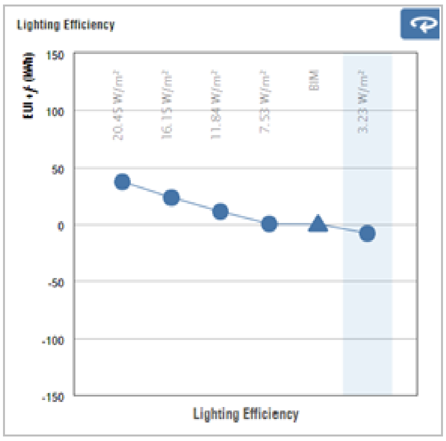

Figure 9. lighting improvement selected in insight 360

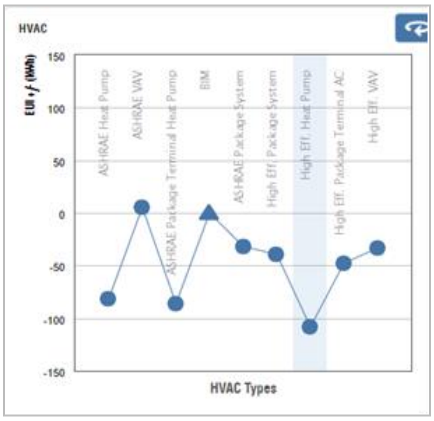

Figure 10. HVAC improvement in insight 360

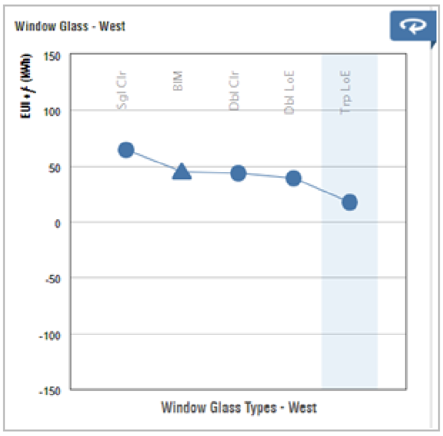

Figure 11. Window improvement selected in insight 360

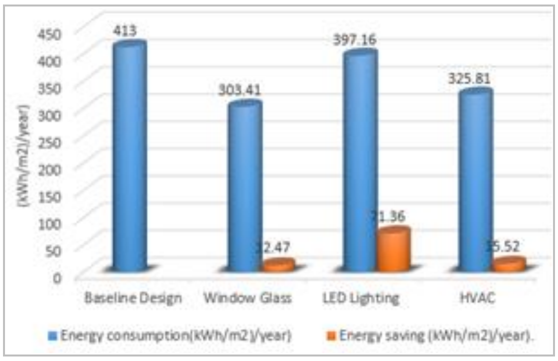

Figure 12. Various retrofit alternatives analyzed for the building

energy simulation retrofitting alternatives analyzed, where one can see the energy savings of 24% of the total improvement compared to the baseline design situation.

5. CONCLUSION

One of the largest contributors to energy use and environmental impact is the building industry. Therefore, by applying modern techniques such as BIM techniques, the authors try to renovate abandoned buildings to achieve low-energy buildings. The authors concluded that the findings are stated as in the following:

- Insight 360 is used effectively with BIM technology which is very useful to evaluate retrofitting alternatives and it enables designers and owners to the simulation of the energy efficiency of the building
- The results illustrate that the most efficient alternatives are HVAC systems with energy savings of 71.36 kWh/(m^2 year).
- The results clarified that the energy savings of the total improvement compared to the baseline design situation is 24%.

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Persian Abstract

چکیده

در سال های اخیر ، بخش ساخت و ساز عراق با بسیاری از پروژه های رها شده مواجه شده است که تأثیر منفی بر سهامداران ، اقتصاد و محیط زیست دارد. مقاوم سازی ساختمانهای موجود فرصتهای قابل توجهی را برای کاهش مصرف انرژی و انتشار کربن فراهم می کند ، زیرا ساختمانها بیشترین میزان انرژی را مصرف می کنند. روش تحقیق با استفاده از فناوری مدل سازی اطلاعات ساختمان (BIM)، یکی از تکنیک های مدرن برای مقاوم سازی ساختمانهای متروکه برای دستیابی به ساختمانهای کم انرژی و کاهش اثرات زیست محیطی است. مفهوم مطالعه در یکی از پروژه های عراق اعمال شده است. نویسنده دریافت که استفاده از فناوری BIM در انجام تجزیه و تحلیل های مختلف و کمک به یافتن استراتژی های مقاوم سازی برای بهبود بهره وری انرژی پروژه بسیار مفید است. نتایج نشان می دهد که صرفه جویی در انرژی 24٪ از بهبود کل در مقایسه با وضعیت طراحی پایه و کارآمدترین گزینه ها ، سیستم های HVAC با صرفه جویی در انرژی 71.36 کیلووات ساعت بر(مترمربع سال) است.