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Adoption of BIM in achieving environmental sustainability in existing residential buildings in hot and dry areas (Iraq as a case study)

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Abstract

Seeing that Iraq is located in hot, dry areas throughout the summer, and in era of emerging warming, rising temperatures, and growing environmental concerns, demand for sustainable residential buildings is one of the first and most important factors to consider. With the rise in greenhouse gas emissions and the rising cost of energy around the world, a demand toward sustainable designs that preserve the environment while also being pleasant to individuals has emerged. The early knowledge of sustainable methods and designs through available architectural technologies (BIM), where modeling can help in Building Information) to conduct complex building performance analysis to ensure the sustainability required for building design. It is hoped that this research project will achieve the feasibility of BIM-based proposals and sustainable solutions according to technical analyses. The objectives in this research were as follows:

1- determining the current condition of an existing residential building and showing the benefits of analysis based on the use of BIM.

2- Modeling a building though the architectural rift program.

3- Studying the direction and of the sun and the amount of light in Revit Insight.

4- Studying the Carbon emission level and the thermal mass in Design Builder.

5- Giving Sustainable Architectural solutions based on the previous studies using the BIM technology and then extracting and developing the methods to clarify the benefits of using BIM for sustainable studies. The results of the research were as expected; Useful for architecture and construction organizations that are interested in using BIM technology for sustainable design

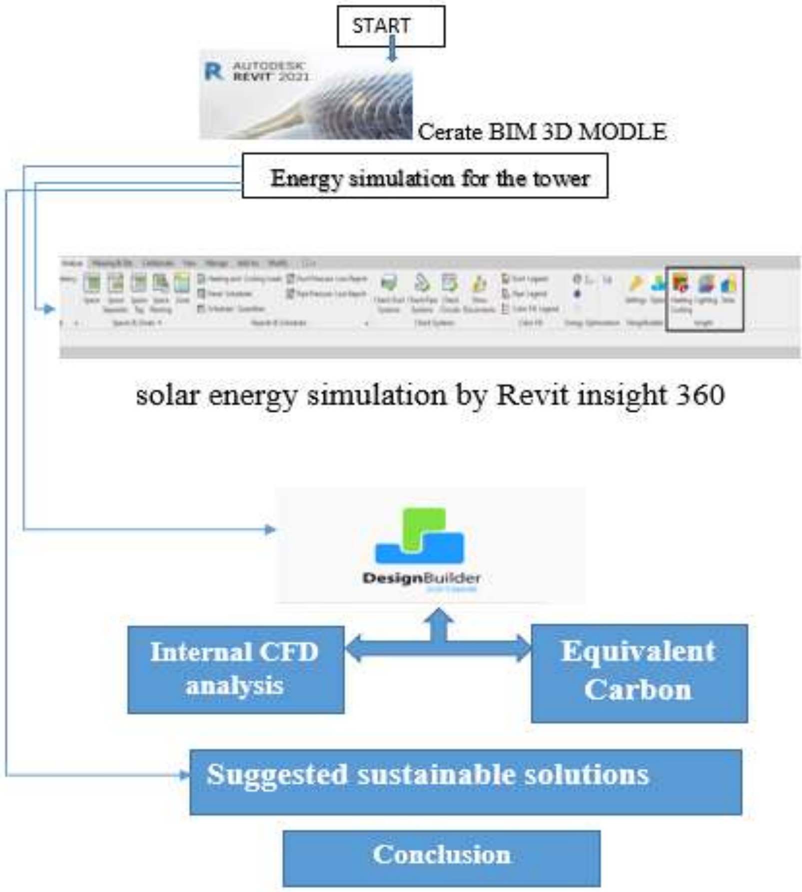
Key Words : BIM, environmental sustainability, Sustainability analyses

Introduction

Architecture is the result of the interaction between environmental factors and human beings. The translation of the interaction between these two qualities is represented through architecture. [1] As a result, we discover that residential structures acquire varied features depending on the areas and climatic environments to which they belong, leading to the term "environment-responsive buildings" (sustainable). [2]However, because of the hot and dry climate in summer and the cold and dry climate in winter, some of the consequences of technological development, such as total reliance on mechanical conditioning regardless of surrounding environmental conditions, have reduced the importance of the building's role as a filter between the environmental specifications of the external and internal environment, especially in hot and dry areas. These are structures with low construction costs but high operating and maintenance expenses, assuming unlimited energy sources. However, due to the limited energy sources available today, different designs must be adopted in order to create a stable indoor environment that meets human comfort requirements, as well as the use and employment of designs that are primarily based on responding to daily and seasonal variations in climatic conditions. [3] As a result, any building's successful design performance (as a measure of individual comfort in the building) will necessitate a complicated relationship involving the external environment and internal environment features, mediated by the building envelope and mechanical systems. [4] The role of BIM technology here appears to be in discovering sustainable building solutions or anticipating problems caused by passive design, with the difficulty stemming from the enormous number of options and design choices provided as answers to these challenges. [5]

.**Research Objectives, Scope and Methodology**

The objectives And Scope were: 1) to determine the current status of an existing apartment building and the benefits of sustainability analyzes based on it using BIM, 2) Making 3D model of the building By REVIT , 3) Studying the condition of the sun, direction and lighting By Revit Insight program, 4) Studying carbon emissions and thermal mass By Design Builder program, 5) Giving sustainable architectural solutions based on previous studies using BIM and then extracting the study and developing a framework Conceptual to Demonstrate the Using BIM for Analytics for Sustainable Residential Buildings The results of the research are expected to be useful to companies and educational staff In the study of applications in architecture and construction, as well as people interested in using BIM technology for appropriate sustainable residential design.



Software utilization evaluation BIM in the field of sustainability:

Some research has discussed the issues surrounding the use of BIM along with sustainable design practices and associated problems as an attempt to assess,[6] the benefits in a purely quantitative manner, and discuss the limitations of previous research and studies on BIM in measuring[7] the extent of benefit, and propose a broader framework that includes both measurements quantitative and qualitative for a deeper understanding of the process of integrating BIM and sustainable design to measure[8] what BIM can offer for sustainability, present it as a system to facilitate change in prevailing sustainable building concepts and practices, and establish performance determinants that require more than a separate technical performance assessment; In order for BIM to become meaningful and beneficial to both organizational performance and construction performance.[9]

literature View

We discovered that sustainable design treatments that accomplish the goals of environmental strategies appropriate for hot and dry areas are distinguished by their variety and impact on design. [1]These environmental treatments must be combined with the architectural product in a thoughtful, practical, and aesthetic manner that is consistent with the designer's ideas and the basic design requirements, which necessitates that these treatments (in whole or in part) be considered during the design stages[10]. The design process (from an environmental standpoint) goes through numerous stages since it directly influences a building's degree of thermal performance and overall efficiency, as well as levels of thermal comfort and occupant performance. [2]Phase. It was extracted in four phases in this study and they are as follows:

- the design phase of the site plan
- The construction phase.
- The design phase of the construction plan.
- The building envelope design stage. Building openings design stage

With regard to the most important high-frequency design treatments, they were as follows:

- **First:** at the level of treatments related to construction site and block design, the most common treatments were related to collective building guidance, design of building blocks, and shaping and design of building surfaces. The external spaces of the port. [1]
- **Second:** the most typical treatments at the level of building outline design were related to shading areas of the building, employing air traps and projection activities to match the sun's movement. [10]

- **Third:** the most typical treatments connected to the design of the building envelope were related to the use of insulating materials, such as high-heat-capacity materials, wall and ceiling shading, and designating colors and materials for internal and external finishes. [11]
- **Fourth:** the most typical treatments connected to the design of building openings were related to the building's ventilation, the control of the openings' area, the orientation of the openings, the shading of the openings, and the use of different types of insulating glass[12].

The role of BIM is to take advantage of these theoretical studies in evaluating them according to scientific and engineering strategies that rely on analysis tools and information extracted from technology according to the site and the mass designed within[5] it to give analytical studies that can be compared with theoretical studies and consider whether the design can be used or re-analysis again according to the site and the mass designed within it to give analytical studies that can be compared with theoretical studies and consider whether the design can be used or re-analysis again according to the site and the mass Many scenarios in the design[13], and building designs can be monitored and studied through BIM to aid in early detection of intersections and outlines during the presentation to begin construction, and control to reduce energy consumption in residential buildings by studying the benefits of materials and studying the design of the residential building, especially that Iraq suffers from Large consumption of electrical energy. [14]

Case Study

Figure (1) Ground floor plan for tower type c

Figure (2) Typical floor plan for tower type c

Creating 3D BIM Model for Case Study:

Revit is a building information modeling and design program for architects, civil engineers, structural engineers, and contractors. Because the program makes it easier for designers to obtain the idea of 3D structural diagrams using basic tools and procedures, it aids in the analysis and extraction of building information, it helps to maintain the design process semi-automated.

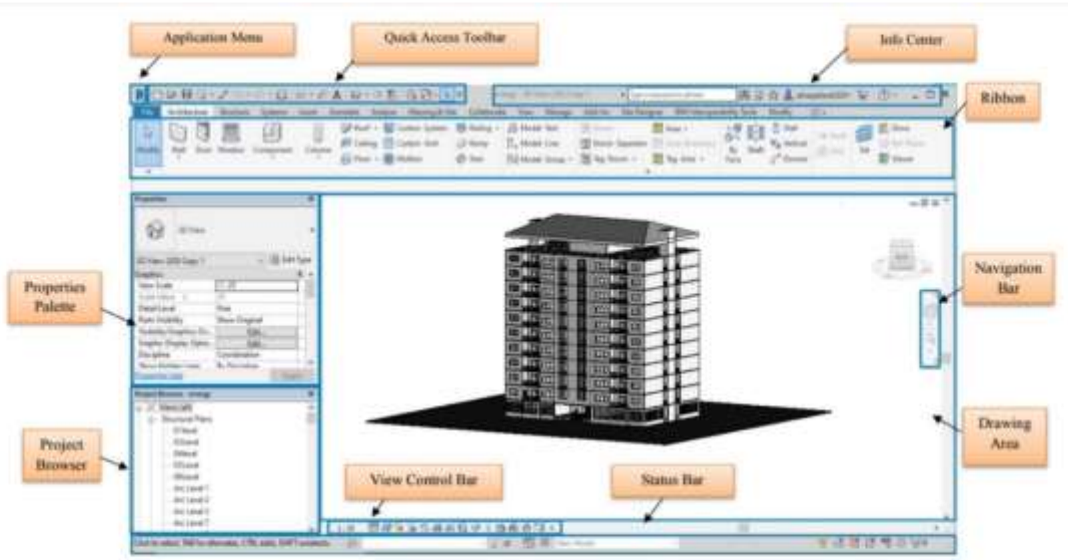


Figure (3): Interface of Autodesk Revit2020 software

Energy simulation for the tower.

1- Revit insight 360: A plug-in added to Revit that helps architects and engineers analyze designs and design more energy-efficient residential buildings with advanced simulation study engines and high-performance building analysis data integrated into Revit. [15]

Figure (4): insight 360 plug-in work path.

a) solar energy simulation by Revit insight 360:

is a type of modeling that uses the results of solar radiation analysis to track solar energy. Surfaces are used as a model in solar analysis. Standard architectural elements (walls, ceilings, floors, and ceilings) or conceptual blocks can be used to generate solar analysis. Many types of families (such as generic models), grouped objects, components, associated objects, imported surface geometry, and power analysis model surfaces are not supported by detailed geometry object types. These geometric forms frequently produce incorrect results that are close to zero.

Figure (5): Method for creating custom solar analysis.

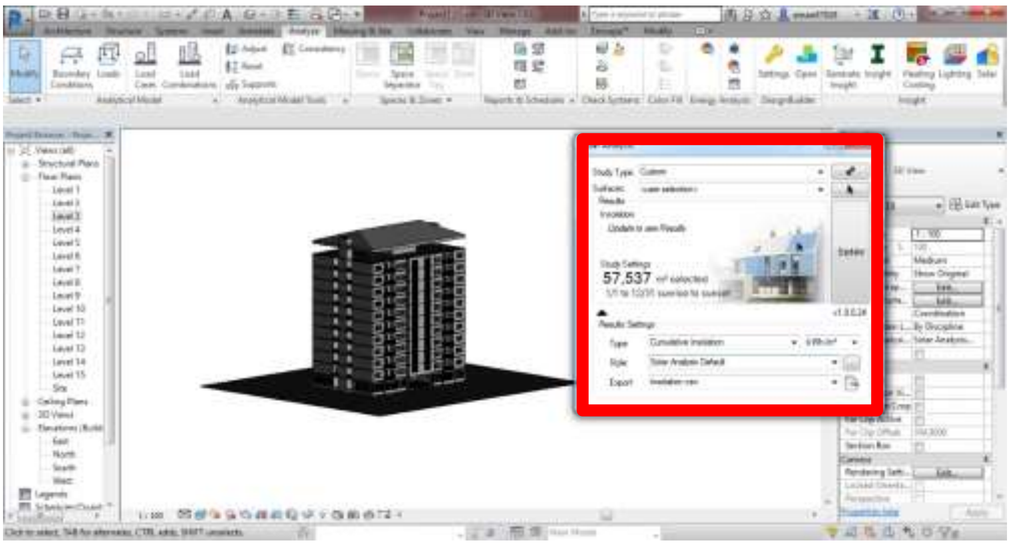


Figure (6): Setting of solar analysis.

After select roof of building, the figure (6) shows the settings that must be adjusted before solar analysis, the researcher clarified it as follows: Weather data, the location must be specified (Iraq), Building area: The building area must be entered.

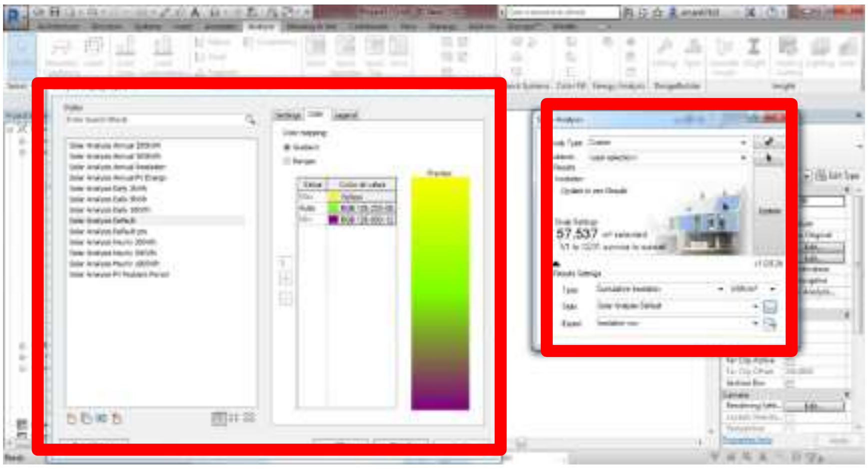


Figure (7): Setting of solar analysis.

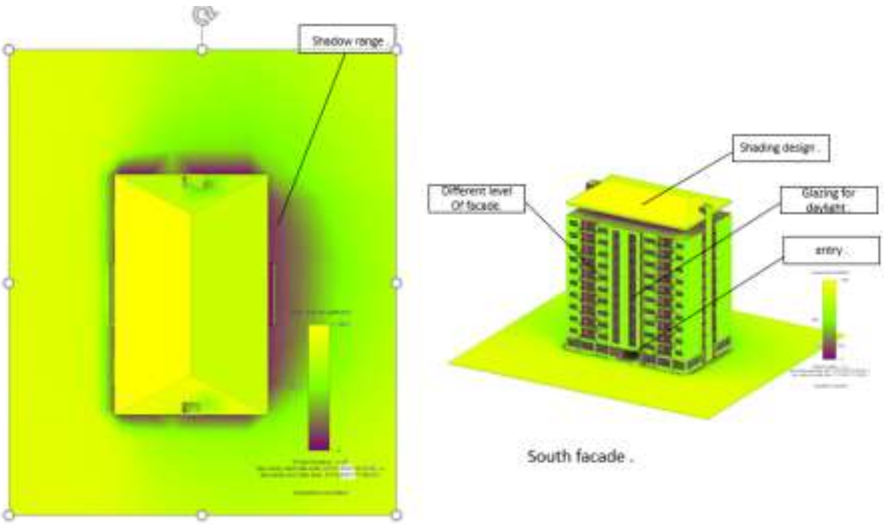


Figure (8): solar analysis results for the southern façade and site.

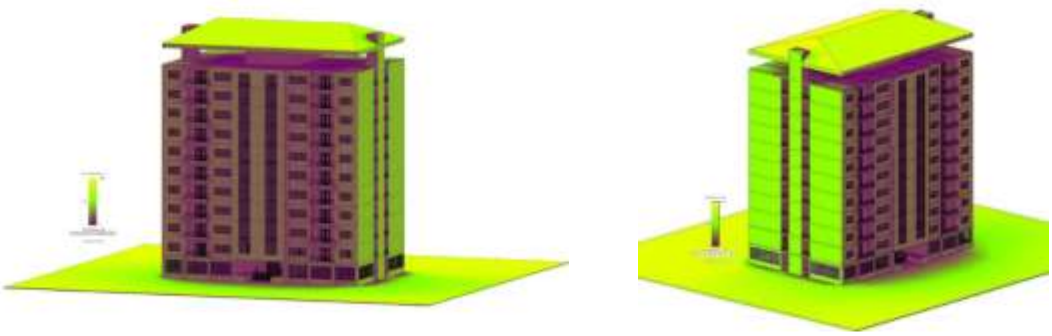


Figure (9): solar analysis results for the tower (c).

2-design builder: The Design Builder program is used to study the residential model through simulation to conduct several tests on it and then display the results obtained and thus suggest the most important solutions that lead to achieving thermal comfort inside the building.

b) Internal CFD analysis by design builder software:

CFD is an acronym for Computational Fluid Dynamics in Software (Heat Transfer). The information it provides can be used to analyze the impact of building exhaust design on the environment, forecast smoke and fire hazards in buildings, study indoor environmental quality analysis and design, and design manifolds for natural ventilation ecosystems.

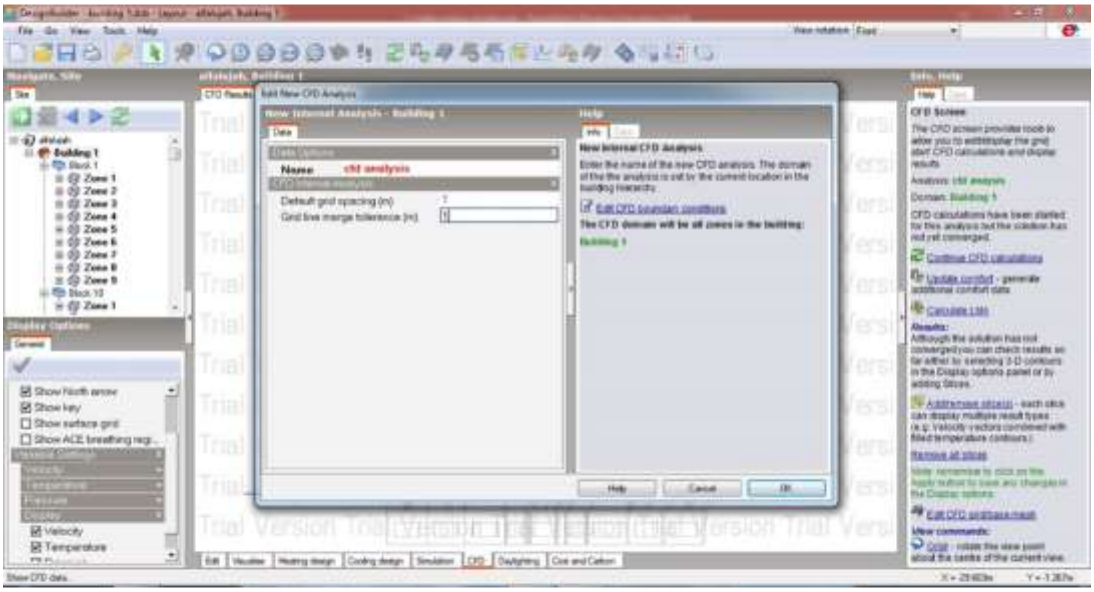


Figure (10) cfd setting in design builder program.

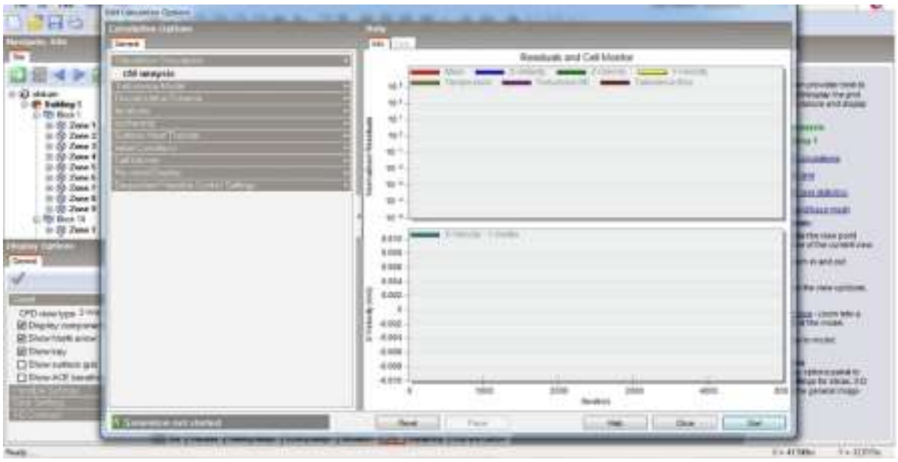


Figure (11) cfd setting in design builder program.

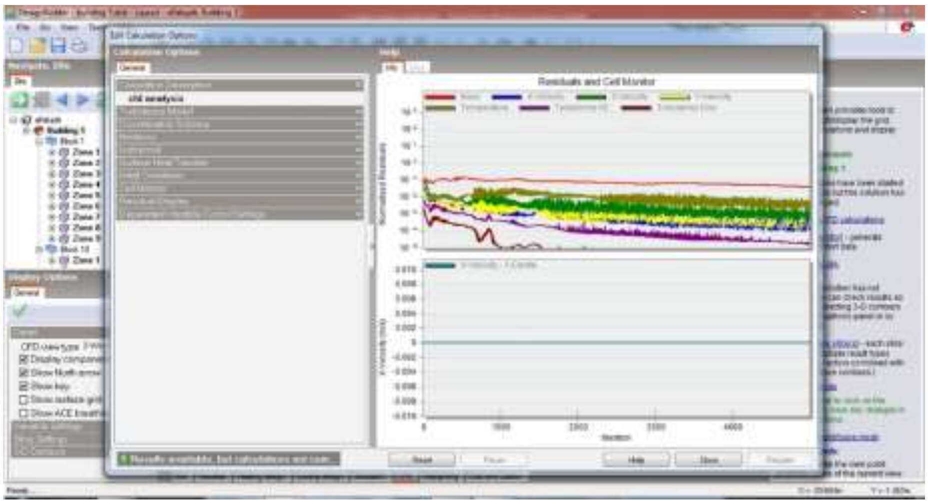


Figure (12) cfd calculation charts.

The indoor environmental analysis provides information about how air velocity, pressure, temperature, etc., are distributed throughout the building's interior courtyards. It helps in controlling the internal ventilation of the building through the given information

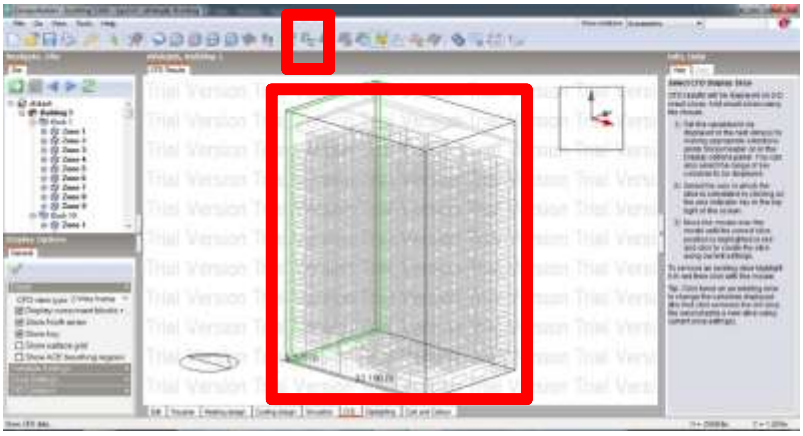


Figure (13) creating cfd slices .

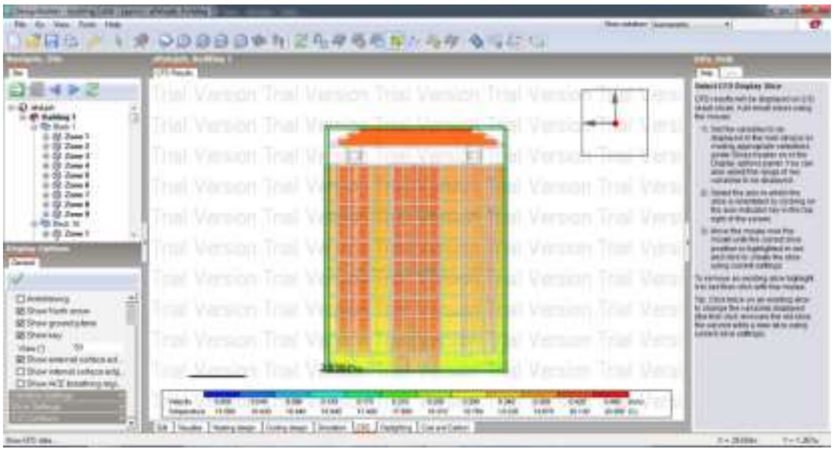


Figure (14)cfd slice result .

C)Embodied and Equivalent Carbon:

The data shown below are based on the analysis of bulk data obtained from BATH ICE The embodied carbon that is relevant to building services such as light, heating and ventilation machines is not covered in these results. You should make sure that all of the building materials and glazing systems used in the project have this data defined on the 'Embodied carbon' tab of the materials and glazing dialogs.

The results are indicative only and it is the user's responsibility to ensure that input data is checked and the basis for the calculations is understood.

Materials Embodied Carbon and Inventory	Area (m2)	Embodied Carbon (kgCO2)	Equivalent CO2 (kgCO2)	Mass (kg)
Timber Flooring	1470.1	6768.9	6916.1	14715.0
Clay Tile (roofing)	736.6	16942.9	17679.6	36832.4
External Rendering	858.6	2790.5	2790.5	27905.1
Floor/Roof Screed	611.5	8218.7	8218.7	51367.2
Plasterboard	778.0	10760.8	11327.1	28317.8
Gypsum Plastering	3429.7	16942.9	17834.7	44586.6
Gypsum Plasterboard	24480.1	66096.3	71604.4	550802.8

Urea Formaldehyde Foam	611.5	1444.4	1558.0	811.5
MW Stone Wool (rolls)	1595.3	9630.7	10272.8	9172.1
MW Glass Wool (rolls)	778.0	2063.9	2266.3	1349.0
XPS Extruded Polystyrene - CO2 Blowing	3429.7	27484.6	91424.4	9543.3
Concrete Block (Medium)	3429.7	38413.1	38413.1	480163.9
Cast Concrete	611.5	9784.2	9784.2	122302.8
Cast Concrete (Dense)	7400.0	124320.7	124320.7	1554008.6
Brickwork Outer	3429.7	128272.4	134102.9	583056.2
Roofing Felt	736.6	3394.5	3394.5	3535.9
Asphalt 1	778.0	816.9	816.9	16337.2
Sub Total		474146.4	552724.8	3534807.3

Constructions Embodied Carbon and Inventory	**Area (m2)**	**Embodied Carbon (kgCO2)**	**Equivalent CO2 (kgCO2)**
Project pitched roof	736.6	25959.8	27071.3
Project external floor	858.6	8082.4	8377.5
Project flat roof	778.0	13641.6	14410.3
Project wall	3429.7	211113.0	281775.1
Project partition	12240.1	66096.3	71604.4
Project internal floor_Reversed	7400.0	124320.7	124320.7
Project ground floor	611.5	24932.7	25165.5
Sub Total	26054.6	474146.47	552724.74

Glazing Embodied Carbon and Inventory	**Area (m2)**	**Embodied Carbon (kgCO2)**	**Equivalent CO2 (kgCO2)**
Project external glazing	1263.3	23624.2	23624.2
Local shading		0.0	0.0
Window shading		0.0	0.0
Sub Total	1263.3	23624.2	23624.2

Suggested sustainable solutions

1-green roof: are excellent solutions for improving the environment since they may not only generate new places to utilize but also rehabilitate urban areas, as well as minimize building energy needs, mitigate pollution effects, and control climatic conditions (eg rainwater flows and storms). Ceilings are one of the sources of thermal increase inside buildings, because they absorb heat and transfer it to the interior. Due to its relatively large surface compared to the facades of medium and low-rise buildings, and its exposure to almost vertical and direct sunlight during the day. Therefore, protection from radiant heat must be provided, especially in summer.

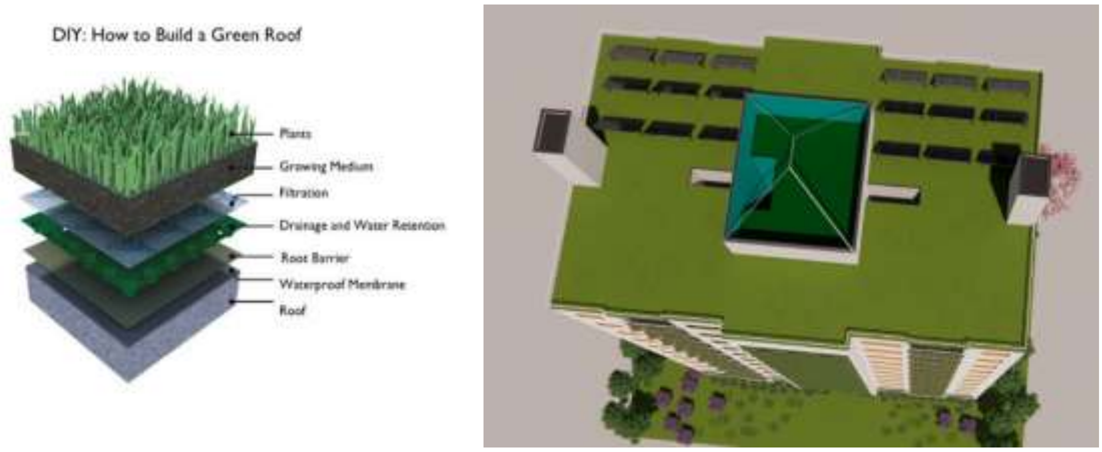


Figure (15) green roof for the building.

3- Green facades:

1- Helps to mitigate the effects of extreme heat. Plants on the facades will also assist absorb a considerable amount of heat created, resulting in a pleasant microclimate and protection from high summer temperatures and direct winds.

2- Improving the building's indoor and outdoor air quality by reducing oxygen generation and so ensuring pure air. As a result, vegetation should be included into places where oxygen emissions are nearly zero.

3- The individual's psychological influence as a result of the use of green walls Green walls, in addition to its aesthetic qualities, give a high level of comfort, particularly for the building's internal atmosphere.

Figure (16) green façade solution.

4- solar panels:

Solar panel, or photovoltaic (PV) module

1 - Sustainable energy: Solar energy has the advantage of being a renewable alternative to fossil fuels, which is one of its most significant advantages. Fossil time can come to an end at any time, while the Sun, on the other hand, can last at least a few billion years.

2- Protecting the Planet: Solar energy is a clean energy source, which means it does not emit any harmful carbon emissions to the environment, unlike coal, which is used by many facilities and facilities to generate electricity, so its use can help reduce the amount of greenhouse gases emitted and emitted. For the most part, nonrenewable energy sources.

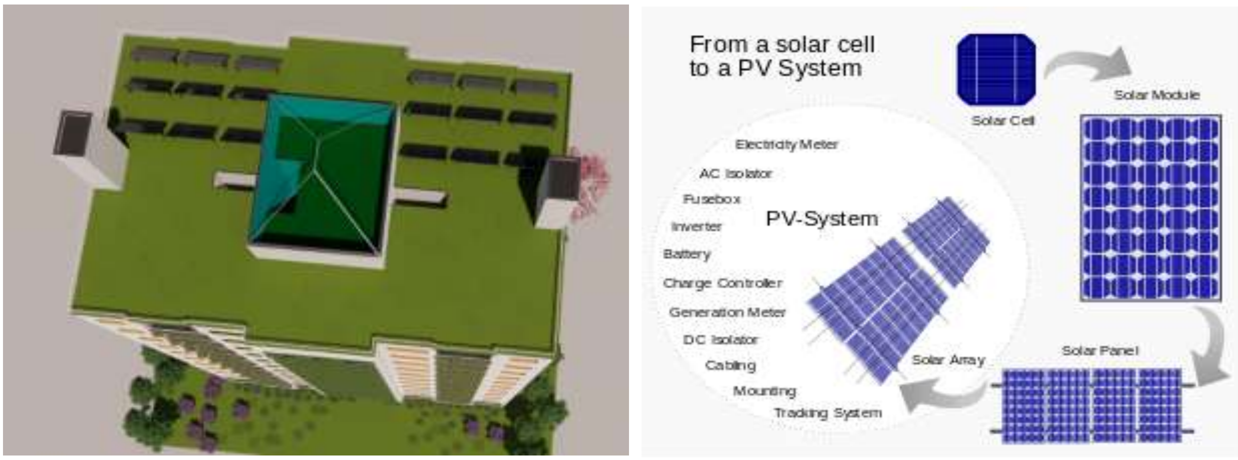


Figure (17) solar panels on the roof.

Conclusion:

The current issues that Iraq is facing, such as rising housing demand and the stage of reconstruction, necessitate the adoption of innovative solutions to address them. Sustainable development is one of the most appropriate strategies for the development of society, the economy and the environment. It is necessary to promote sustainable practices and develop ways that fit our reality in order to achieve sustainable development in construction projects. Through building performance analysis and assessment tools, Building Information Modeling provides flexible and simple techniques for enhancing design decisions. REVIT and Design Builder has proven its effectiveness in integrating with sustainability goals. The INSIGHT 360 extension has proven its effectiveness in facilitating the design decision of the building with the aim of improving its performance through its interactive interface. The GREEN BUILDING STUDIO platform has demonstrated its great ability to give statistical data that aids in bettering building design decisions, selecting equipment, and projecting energy needs in order to obtain flexibility in controlling energy supplies during the operational stage.

Recommendations and Suggestions:

1- Imposing strict laws, as well as improving them to be compatible with sustainable development ideals.

2- Developing a government program to support and encourage sustainable projects by lowering taxes and fines, as well as providing infrastructure.

3- Launching a government effort to develop a method for assessing building sustainability by examining climatic conditions and the local environment, then adopting and promoting it at the national and regional levels.

4- Increasing academic research on sustainable construction project management strategies and tying these methods to building codes.

5- Increase academic research on the convergence of BIM and sustainability.

6- Expanding research towards the development of performance analysis tools, as well as promoting and encouraging their use in academic settings.

7- Compulsory submission of a building life-cycle assessment report with the file of any project to be undertaken in order to examine potential environmental implications. Launching promotional projects that support the trend towards sustainable development.

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