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The Impact of Ornamental Details of Ancient Iraqi Architecture on Building Sustainability

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Abstract

This study involves the sustainability potential of Ancient Iraqi Architecture (AIA) by assessing the thermal impact of its ornamental elements. The aim is to find whether architectural details can reduce building surface temperatures and thus improve energy efficiency. The interested buildings are from the Sumerian, Babylonian, and Assyrian periods. Using a virtual building model (12 × 12 × 5 m), five types of traditional ornamental features were simulated with SOLENE-microclimate software. The case study was conducted for the city of Mosul, with simulations focused on 13 June, representing peak summer conditions. Results show that specific elements—particularly slim vertical lengthy hollows and vertical half-circular hollows—achieved a surface temperature reduction of up to 4°C compared to plain façades. These details function via self-shading and passive cooling. This research contributes to the ongoing discourse on sustainable architecture. It shows that heritage elements can inform modern design strategies in hot-arid climates. The findings show the value of reviving vernacular details not only for cultural preservation, but also for improving energy performance.

Discipline: Multidisciplinary (Architectural Engineering (Sustainable Architecture), Heritage Study, Energy Conservation).

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1 Introduction

Architecture in ancient Mesopotamia is known as the origin of civilization. It is not just about being practical or simply decorative. It involves extreme temperature changes, constant sunlight, and limited resources. Thus, the skilled builders of Sumer, Babylon, and Assyria needed good methods to manage the heat. The decorative features of ancient Iraqi architecture are often seen today only for their beauty. Actually, they served as advanced, passive technologies for the environment. Elements like rhythmic façade relief patterns, detailed brickwork, glazed tiles, and smart geometric designs were closely linked to how well the structures performed and how they managed the local climate.

In today's world, the global construction industry is facing two major issues: a huge carbon footprint and a heavy dependence on energy mechanical HVAC systems. To address this, modern sustainable design is increasingly looking back to traditional and ancient architecture for low-energy, passive solutions. A lot of research has focused on the overall sustainability of historical buildings, like thick mud-brick walls for thermal mass or traditional windcatchers (badgirs). However, the impact of architectural decoration has not been studied much. Ancient Iraqi craftsmen skillfully shaped building surfaces. They also design for dynamic of light, wind, shadows, and moisture.

This study involves how the decorative elements of ancient Iraqi architecture (AIA) played a critical role in building sustainability. This work examines the geometric, material, and structural characteristics of these historical decorations. This research thus knows how ancient designs reduced solar heat gain/energy saving concerning the surface temperature. Importantly, this paper seeks to connect ancient heritage with modern urban design, with a local identity.

2 Literature Review

Today, the biggest hurdle for people is finding ways to lower energy use. The rise of cities, increasing population, and better living conditions have emphasized how important buildings are in energy consumption. In which the utilization of energy resources has expanded chiefly, accompanied by climate change. Studies indicate that approximately 40% of global energy consumption is attributed to the construction sector. Recent studies confirm the importance of vernacular and passive architectural strategies for reducing energy demand, especially in hot-arid climates (e.g., El Gindi, 2024; Xu et al., 2024).

Sustainable Building Concepts (SBC) has concentrated on many issues, including the limited resources, particularly energy, and the available methods to reduce their impact on the natural environment. In this regard, according to Mazraeha and Pazhouhanfarb (2018), the SBC is a helpful tool for safeguarding natural resources by using energy efficiency measures to reduce energy use. Thus, the current world must focus on sustainable urban development.

Al-Kindi (2012) discussed the architectural environment of traditional areas. It was tailored to human needs and aligned with the region's nature. It included many elements that support sustainability. This makes them useful for modern residential design (Al-Kindi, 2012).

Further, Al-Abassi (2016) pointed out that traditional architecture has effectively achieved a balance between housing and the environment. This was crucial for sustainability. Iraqi vernacular architects and researchers advocate for the use of traditional or ancient Iraqi architecture.

Sustainability is defined as a broad term that categorizes a construction approach utilizing locally sourced materials to meet the needs of residents. Examining such architecture can offer a valuable strategy for the new generation of designers to attain sustainability.

AIA represents a type of architecture abundant in architectural works, featuring various details and components, including a wide range of local building materials. All these aspects show the uniqueness of AIA and its connection to the area's environment (geographical, urban, or ecological). This contributes to a high level of thermal comfort within the buildings. Thus, it remains a relevant and effective architectural model today. Also, there are influences that give the buildings an Iraqi architectural identity. It helps rejuvenate ancient decorative details in a modern style that maintains a comfortable indoor temperature. Accordingly, the hypothesis of this study can be specified that the architectural elements, details, and fabric of the AIA can help to provide a passive design. It is a sustainable building standard that responds to local climate & site conditions.

3 Study Method

3.1 Study Scope

This study concentrates on the usage of some architectural details used in AIA and the ornamental elements, in particular in the exterior walls that are considered the most important architectural elements shared by the AIA, such as the Sumerian architecture, the Babylonian architecture, the Assyrian Architecture, and others.

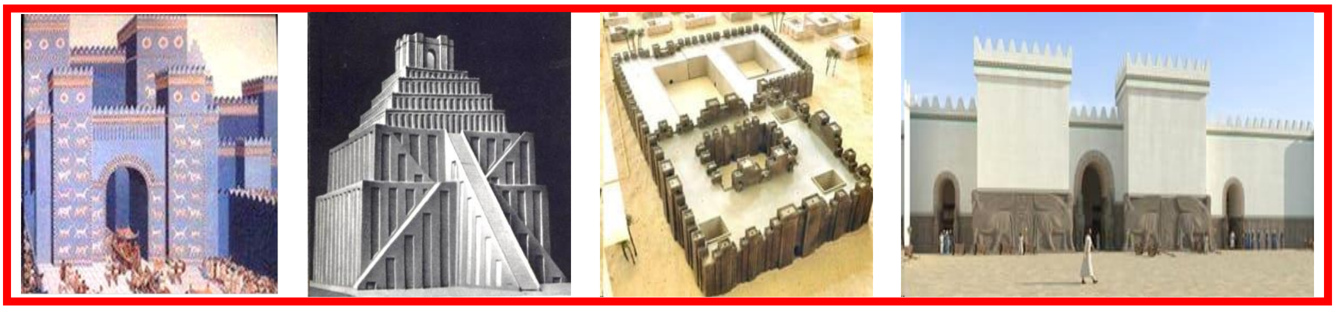


Figure 1: Samples of the Ancient Iraqi Architecture

According to the Rules of shadow and light, these details (ornamental elements) affect the nature of the falling shadows on the outer walls of buildings and thermal absorption, and consequently affect the surface temperature of the front side of the building, and so on, the amount of energy required to sustain an accepted level of thermal relief.

3.2 Study Steps

The aim of the study can be achieved via the tools of specialized computational simulation of buildings. The objectives of this study were achieved through the following steps:

1. Determining the types and shapes of the ornamental details used in the Ancient Iraqi Architecture (Table 1).
2. Applying each type of these details to a simple virtual building in the shape of a parallelogram for all sides.
3. Using the computational simulation method to get the results, and accordingly, the simulation method by the SOLENE-microclimate tool.

The usage of the method of analysis via the above-mentioned tool requires setting several requirements and files necessary to conclude the simulation process, which include:

- Determining the geographical site of the study sample, accordingly, the city of Mosul would be chosen as the site of the case study.
- Specifying the period during which the simulation would be conducted and the day on which the results of the analysis are to be collected, in line with the study of Al-Hafiz (2017).

The most suitable period for conducting the study on the ecological impacts on buildings is June, during which the results would be collected on the 13th of June, which is seen as the most repetitive day during this month (Figure 2).

- Determining the type and nature of the building materials of the study sample, accordingly, the normal concrete building material would be used, which is widely used in the city of Mosul.

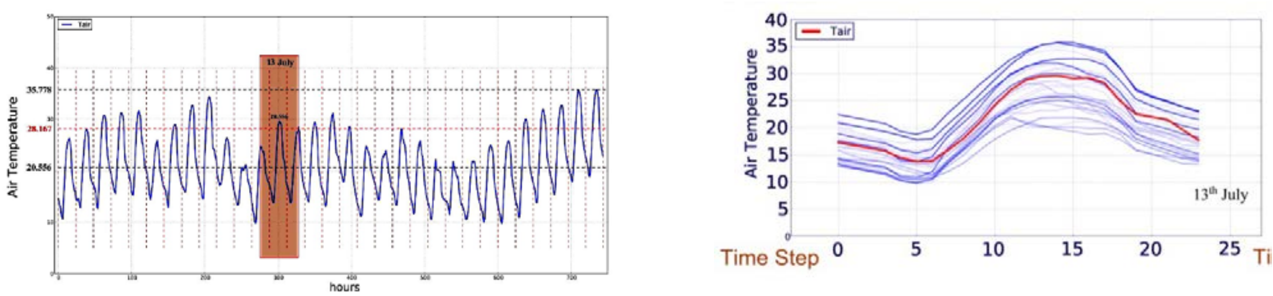


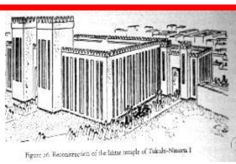
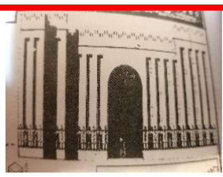
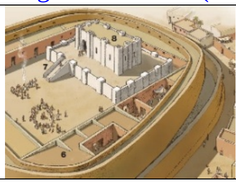
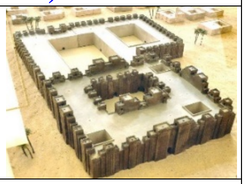
Figure 2: Select the day on which the results of the analysis are to be collected.

4 Analysis

After conducting a survey on the architectural ornamental details in Iraqi architecture, it can be divided into five main types. These are (see Table 1) (Bakr et al., 2024)

- slim vertical lengthy hollows,
- wide, lengthy hollows,
- added stones,
- vertical half-circular hollows, and
- projections on walls.

Table 1: The types and shapes of the ornamental details of the Iraqi architecture (Based on Bakr et al. (2024), Khalil and Mohammed (2023), Hussien (2023)

No.	Types	Architectural title	Shape
1.	Vertical lengthy hollows	Sumerian Babylonian Assyrian	 The white temple (Sumerian)  Karundash Temple (Babylonian)  Ishtar Temple (Assyrian)
2.	Wide lengthy hollows	Sumerian Babylonian	 Ur ziggurat (Sumerian)  Babylonia Ziggurat (Babylonia)
3.	Added Stone	Assyrian	 Nineveh City Image (Assyrian)
4.	Half-circular hollows	Assyrian	 The gate of Nergal in Nineveh (Assyrian)
5.	Projections in walls	Sumerian Babylonian Assyrian	 Palace block in Khursbak (Assyrian)  Oval temple in Khafajah (Sumerian)  Mardukh Temple in Babylonia (Babylonian)

4.1 The Case Study

To achieve the objectives of the study, the study was applied to a virtual building (12 × 12 × 5 meters) and in several scenarios:

1. A building that is without any additions, to compare the results of analysis between it and what is going to emerge later on when applying each type of ornamental detail on the four sides in a separate manner. The reason behind that is to study the impact of adding these negative and positive ornamental details for each type (see Figure 3).
2. A building containing detail (#1), (Slim vertical lengthy hollows on all sides/fronts.
3. A building containing detail (#2), (wide, lengthy hollows) on all sides.
4. A building containing detail (#3), (additional stones) on all sides.
5. A building containing detail (#4), (vertical half-circular hollows) on all sides.
6. A building containing detail (#5), (projections in walls) on all sides.

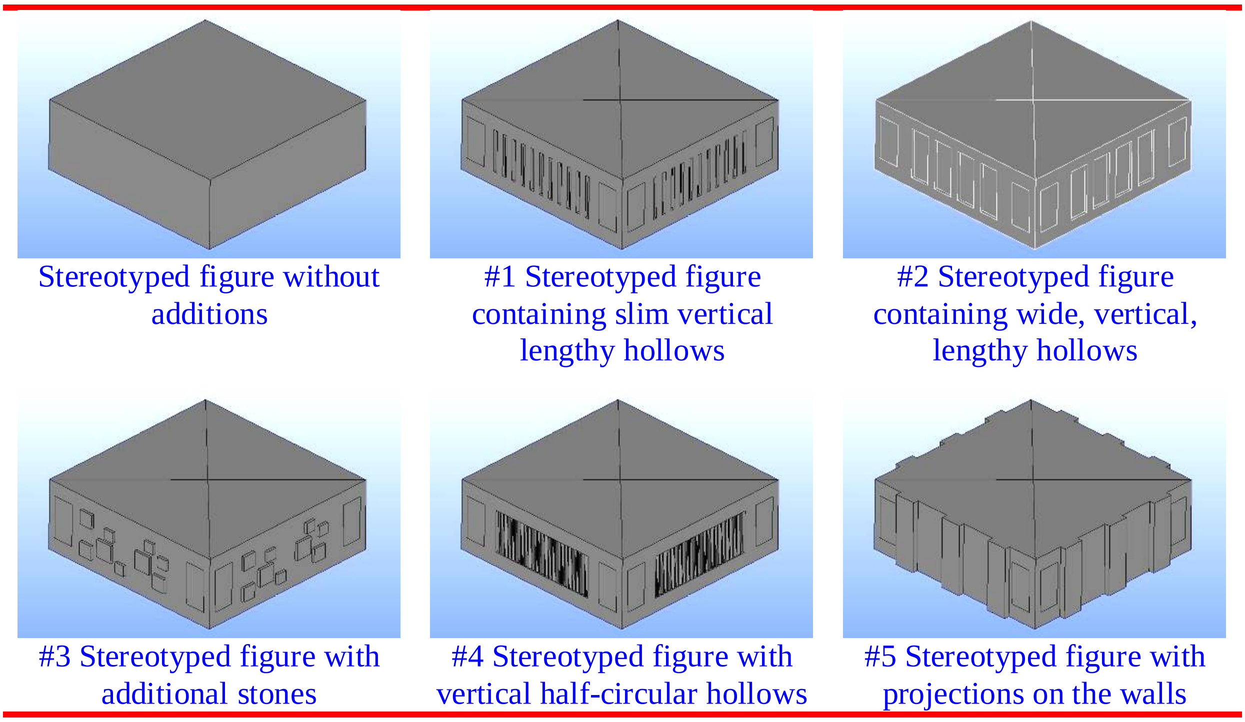


Figure 3: Virtual buildings study sample

5 The Study Results

The findings of this study are presented in several forms. Seven variables are considered, including

1). The exterior surface temperature of stereotyped geometry without additions,

2). The exterior surface temperature of stereotyped geometry containing slim vertical, lengthy hollows,

3). The exterior surface temperature of stereotyped geometry with wide vertical, lengthy hollows,

4). The exterior surface temperature of stereotyped geometry containing additional stone,

5). The exterior surface temperature of stereotyped geometry with vertical half-circular hollows,

6). The exterior surface temperature of stereotyped geometry with projections in walls, and

7). The air temperature was recorded at the weather stations.

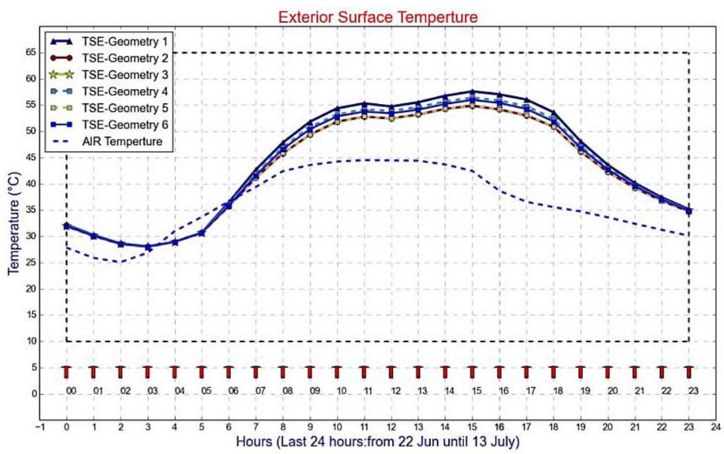
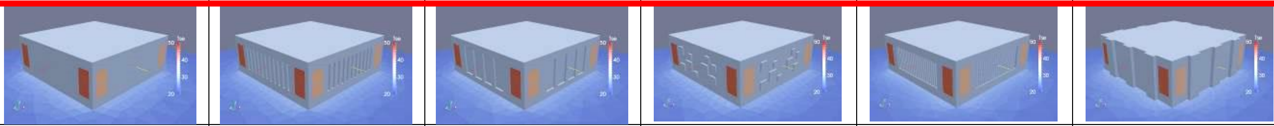
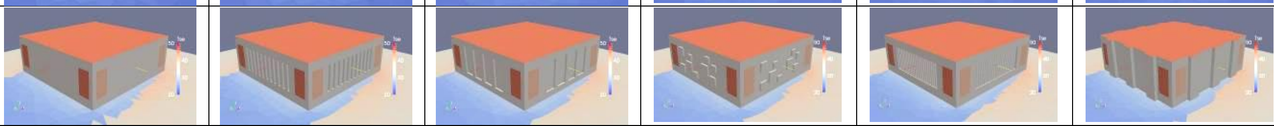
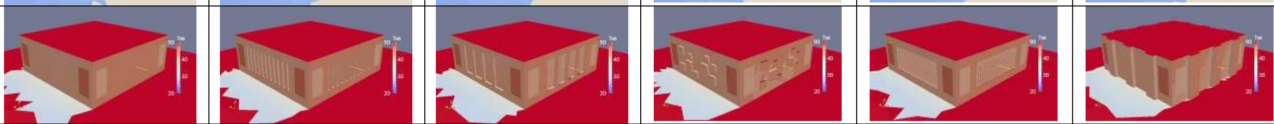
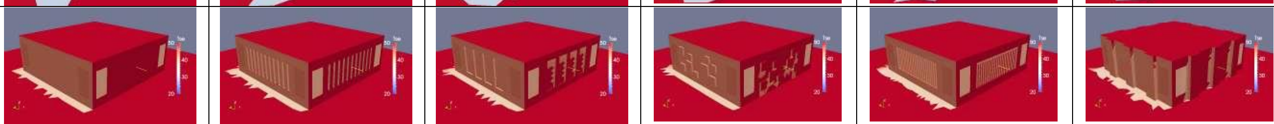
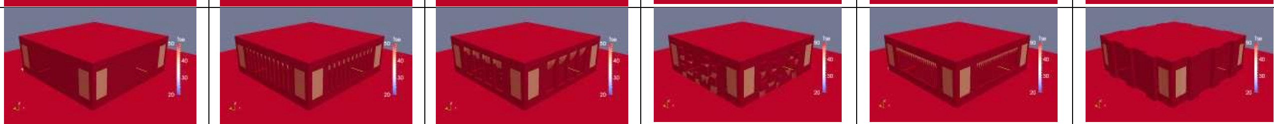
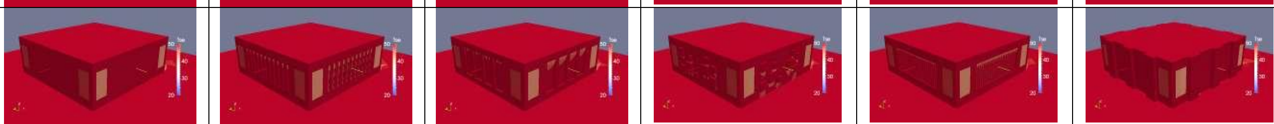
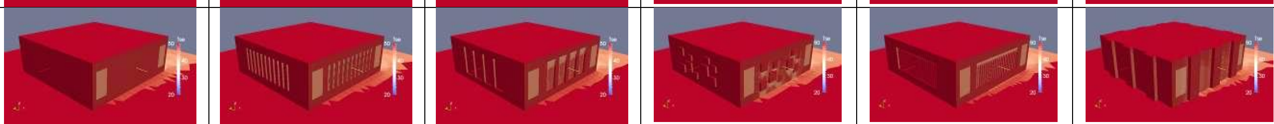
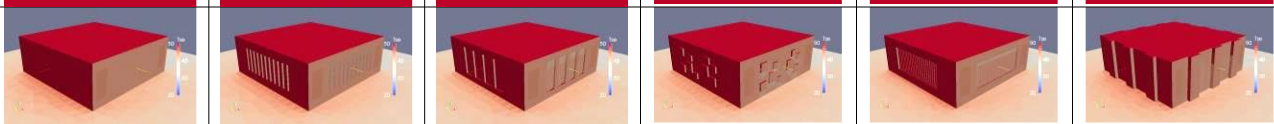
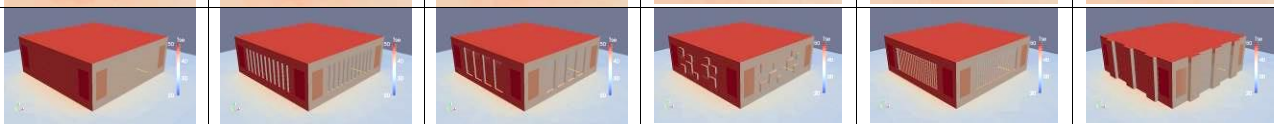
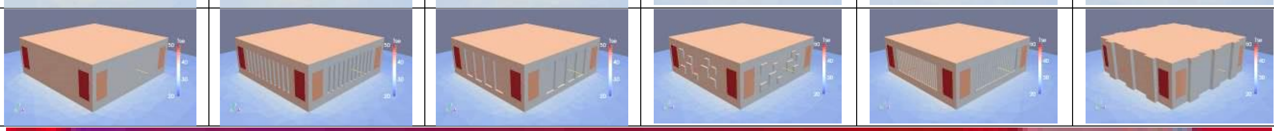
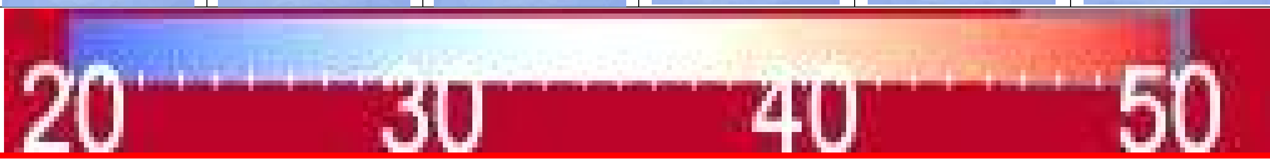


Figure 4: Simulation results of exterior surface temperature.

Figure 4 presents the complete simulation findings, illustrating how seven variables changed over time. The horizontal axis indicates the simulation period. The data reflect only the last 24 hours of the entire simulation, which ran from June 22 to July 13. A legend placed in the top-left corner explains the symbols and elements used in the diagram.

Table 2: The visual results of the case study

Time step	Sample stereotyped figure without additions	Sample (#1) stereotyped figure containing slim, vertical, lengthy hollows.	Sample (#2) stereotyped figure with wide, vertical, lengthy hollows.	Sample (#3) stereotyped figure containing an additional stone.	Sample (#4) stereotyped figures with vertical half-circular hollows.	Sample (#5) stereotyped figures with projections on walls.
h:05						
h:07						
h:09						
h:11						
h:13						
h:15						
h:17						
h:19						
h:21						
h:23						
						

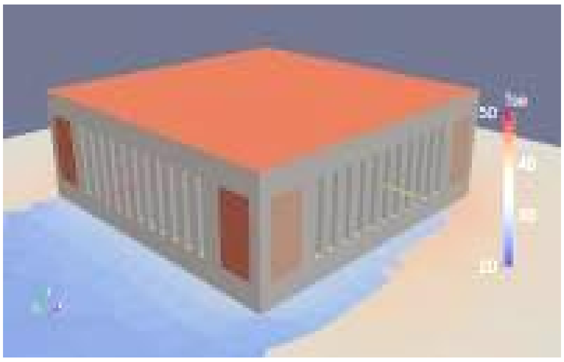
Note: Shading of colours showing the comparison among the temperatures (°C) of surfaces for all shapes.

6 Discussion

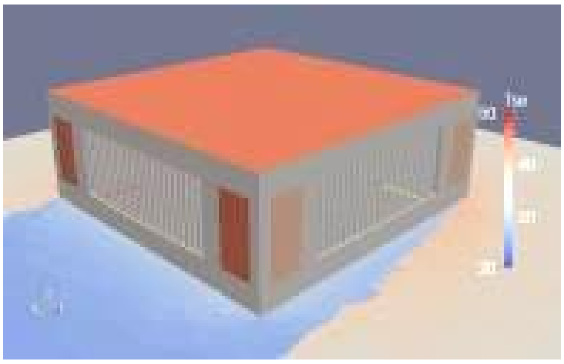
From the previously mentioned results illustrated in Figure 3, the following can be noticed.

A difference emerged in the value of the surface temperature for each stereotyped figure, and that is because of the difference in the ornamental element used. Generally speaking, all these additions participated in decreasing the surface temperature compared with the grading of these figures. According to the gains achieved in lessening the surface temperature, the following can be listed:

a. The lowest surface temperature was achieved by the addition of ornamental details (#1 & #4) (Figure 5) compared with the stereotyped figure with no ornamental details on one hand and the rest of the figures on the other hand. The surface temperature at 15:00 during the day reached about 54°C, whereas the value of the surface temperature of the stereotyped figure with no additions was about 58°C, that is a 4°C difference. The reason is that these details produced self-shadows on the wall, which worked on decreasing the temperature.



#1 Stereotyped figure with slim vertical long hollows



#4 Stereotyped figure with vertical half-circular hollows

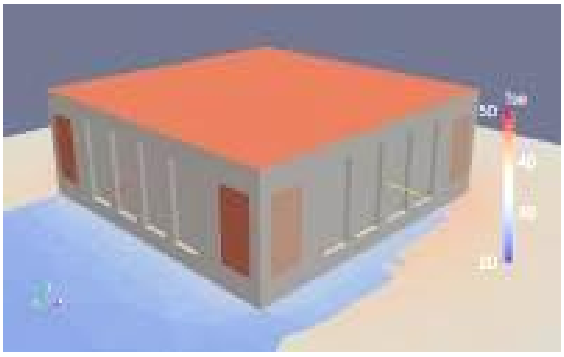
Figure 5: The lowest surface temperature at 15.00 obtained from the simulation.

b. Following that is the usage of the ornamental element number (#5), whereby the surface temperature reached about 56°C. With a difference of about 2°C between it and the stereotyped figure with no ornamental element.

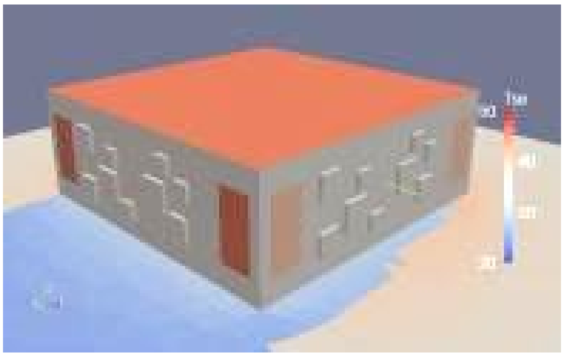
#5 Stereotyped figure with projections on the walls.

Figure 6: Simulation result for #5 at 15.00 local time.

c. For the usage of the ornamental elements (#2 & #3), the surface temperature reached nearly 56.5°C, with a difference of about 15°C between them and the stereotyped figure with no ornamental element.



#2 Stereotyped figure with wide, lengthy hollows



#3 Stereotyped figure with additional stones

Figure 7: Simulated results of surface temperature for #2 and #3 at 15.00.

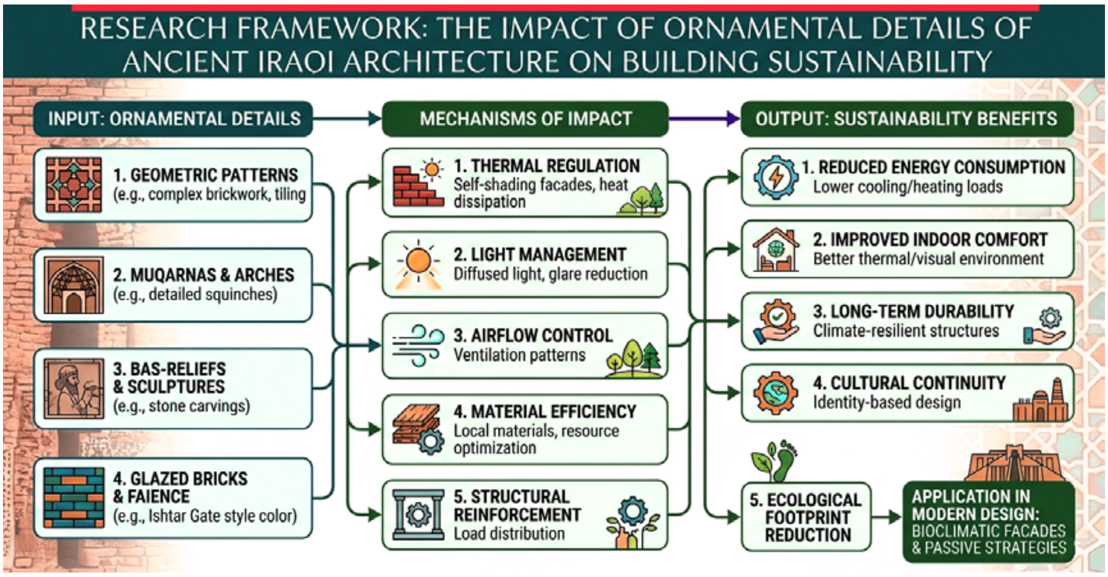


Figure 8: A framework of the Impact of Ornamental Details of AIA on Building Sustainability.

Figure 8 shows a complete framework of the impact of ornamental details of ancient Iraqi architecture on building sustainability. It can consider all characteristics of ornamental details. Then, the mechanical impact can be considered to obtain sustainable benefits.

7 Conclusion

From this study results, it is found that the Iraqi architecture is sustainable. Also, using several ornamental elements helps to decrease the surface temperature of the buildings of Iraqi architecture.

The study proves the active role of using many ornamental details, which feature the Iraqi architecture, to lessen the surface temperature of the virtual building temperatures indoors, and so affects the required energy to keep an acceptable level of thermal relief.

The amount of gains achieved by using various ornamental details, and according to the analysis of the results of the virtual samples, varied depending on the type of detail used. This could mean that there is indeed a difference in the value of what is provided by each ornamental element at the level of sustainability. So, the appropriate choice of the ornamental element increases the level of sustainability to be achieved. The results of the analysis show that the best two ornamental elements are slim vertical lengthy hollows and vertical half-circular hollows. However, all actively participate in providing a certain level of sustainability to the building.

What has been proved so far out of the results of this study coincides with those presented by Al-Kindi (2012) and Al-Abassi (2016), and aligns with global research on sustainable ornamentation and low-energy passive cooling (Abedi & Soltanzadeh, 2024). In that, traditional architecture has several factors that help realise sustainability.

8 Availability of Data and Materials

All information is included in this article.

9 Acknowledgement

Gratitude is extended to the Department of Architectural Engineering, College of Engineering, University of Mosul, for their support and for approving the inclusion of this research within their official scientific agenda.

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