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Research Article

The Economic Feasibility of Sustainable Hotel Buildings Using Local Materials

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Abstract:

The trend of awareness of the importance of sustainability has developed to include many countries that contribute to sustainable eco-tourism, as the design of eco-hotels has received increasing attention in recent years, and this was from an architectural point of view, searching for an innovative idea, good design, and distinctive formation, and achieving the economic feasibility of its establishment. The research deals with the concepts of sustainability and their criteria, evaluation methods, eco-hotel, eco-tourism and their relationship to the local economy and the necessary steps that the architect follows to obtain a sustainable existing eco-hotel design with local materials in each different environment at the lowest economic cost Through the study of environmental materials in Egypt, it was found that limestone is the best environmentally friendly building material compared to other available building materials. The research concluded with positive results for the use of limestone in the construction and establishment of sustainable environmental hotels to achieve economic and environmental feasibility. The research dealt with an analytical study using the Environment Program Design builder)) to analyze differences between internal temperatures to achieve the best thermal comfort inside the hotels, through an applied model.

1. Introduction

The true measure of a project's success lies in its adherence to sustainability standards. When discussing tourist facilities in general, [1] and hotels in particular, we find that most of these projects have not achieved the required success in keeping pace with modern trends in local and international sustainability evaluation standards for hotels. [2]
Tourism in Egypt is one of the most important sources of foreign currency, as the tourism sector is considered one of the most important development sectors for any country. There is a growing interest in ecotourism, which has become increasingly important with the rise of global awareness in an effort to reduce negative environmental impacts and embrace green initiatives. This includes achieving tourism sustainability standards and increasing awareness of the concept of the eco-tourist as an attraction for increasing tourist flow [3]. Sustainability applications have evolved in recent times to encompass sustainable development and tourism activities worldwide. This has impacted the applicability of eco-friendly hotel buildings, and this type of building has been chosen as a model for other housing, whether in new cities or two- and three-story buildings. It should be noted that sustainable (mid-rise) hotel buildings that utilize locally available materials from nature and the construction site are not widespread [4]. This would save the considerable cost of transporting materials across Egypt's diverse environments. For thermal comfort and lower temperatures in spaces, achieving a naturally pleasant climate resulting from the use of environmentally friendly materials, as well as obtaining a good external design resulting from the use of local materials, [5] and achieving a distinctive architectural style desired by foreign tourists, thus increasing the marketing of sustainable ecotourism [6].

2. Literature Review

Sustainability has become one of the most important criteria for evaluating the success of modern architectural and tourism projects. The true measure of a project's success lies not only in its economic profitability but also in its ability to comply with environmental sustainability standards and minimize negative impacts on natural resources. In the tourism sector, particularly in hotel buildings, the adoption of sustainability principles has become a global trend in response to environmental challenges and the growing awareness of climate change. However, many tourist facilities still fail to fully comply with international sustainability standards and environmental evaluation systems applied in hotel design and operation [1]. The tourism industry is considered one of the most significant sources of national income and foreign currency for many countries, especially developing nations. In Egypt, tourism plays a vital role in economic development, job creation, and regional growth. With the increasing global concern about environmental protection, ecotourism has emerged as an important approach that focuses on preserving natural environments while promoting sustainable economic benefits for local communities. Ecotourism encourages environmentally responsible travel, the protection of biodiversity, and the use of sustainable design strategies in tourism facilities [2].
In recent years, sustainability applications have expanded significantly in the fields of tourism planning and architectural design. Many researchers have emphasized the importance of integrating sustainable strategies in hotel buildings to reduce environmental impacts, improve energy efficiency, and enhance the overall experience of tourists. Sustainable hotel design includes the use of renewable energy, water conservation systems, and environmentally friendly construction materials that contribute to reducing the ecological footprint of tourism development [3]. One of the key strategies in sustainable architecture is the use of locally available natural materials. Using local materials reduces transportation costs, lowers carbon emissions, and strengthens the architectural identity of the region. In desert environments, natural stone materials such as limestone have been widely used in traditional architecture due to their thermal properties and durability. Limestone walls help regulate indoor temperatures by reducing heat gain during the day and maintaining thermal comfort within buildings, which makes them particularly suitable for hot arid climates [4]. Moreover, the integration of local building materials in tourist facilities contributes to creating distinctive architectural styles that reflect the cultural and environmental identity of the region. Such architectural authenticity is highly valued by international tourists who seek unique experiences and environmentally responsible destinations. As a result, sustainable eco-friendly hotels built with local materials can play an important role in promoting ecotourism and increasing tourist attraction while supporting environmental sustainability [5]. Furthermore, sustainable hotel buildings can serve as models for other types of developments such as residential buildings and eco-tourism villages. Mid-rise buildings constructed with natural materials from the surrounding environment can significantly reduce construction costs and environmental impacts while maintaining aesthetic and functional quality. This approach supports the concept of sustainable development and encourages the wider adoption of green architecture in new urban communities and tourism destinations [6].

3. Research Questions

This research attempts to answer several questions posed by the nature of the research problem. These questions range from broad and general to more specialized and detailed, passing through several sub-questions:
A) The Central Research Question:
• What elements and criteria should be included in the improvement programs for mid-rise eco-hotels within the framework of a sustainable economic tourism ecosystem during the implementation, operation, and marketing phases?
B) Sub-Research Questions:
• What is the concept of economic feasibility and its relationship to eco-tourism?
• What is the importance of sustainable construction and its role in developing the local economy?
• What economic and environmental resources are available for establishing sustainable hotels in Egypt?
• What is the relationship between the construction method and environmental sustainability?
• Does building with load-bearing walls, modern technologies, and the use of limestone achieve economic feasibility?
• What is the impact of building with local materials on the interior quality of hotel spaces? • What is the concept of an eco-hotel, the characteristics of an eco-tourist, and the principles of sustainable design for eco-hotels?
• What are the components of ecotourism in Egypt, and what is the impact of eco-hotels on sustainable tourism?
• What environmental resources are available for establishing sustainable hotels in Egypt, and what

are the most sustainable materials available in the local market?

4. Research Hypothesis:

This research hypothesizes that applying sustainability principles, particularly the use of local materials in the design and construction of mid-rise hotels or buildings subject to regulations for two- or three-story buildings, will make them more sustainable. This will result in economic returns that contribute to increased economic viability, as well as environmental benefits through improved thermal comfort for users and reduced indoor temperatures.

5. Research Objectives:

The main objective of this research is to apply the principles of sustainability to the design of sustainable hotel buildings. This will be achieved through proposed design standards to improve hotel efficiency within a framework of sustainability and the use of environmentally friendly materials. The aim is to achieve a balance between the systems defined for these hotels through implementation, operation, and maintenance.

This will be accomplished by attempting to evaluate the performance efficiency of sustainable tourism establishments, establishing a framework for dealing with eco-friendly hotels, and developing practical standards and mechanisms for activating sustainability concepts and standards for mid-rise hotels.

Sub-Objectives of the Research:

• To study the concepts of sustainable hotels and to identify global and local sustainability assessment systems.

• To identify local and global environmentally friendly materials and how to utilize them.

• To conduct an analytical study of models and examples of tourist hotels at the global and local levels and to explore the possibility of applying sustainable hotel standards for their development and implementation in Egypt.

6. Research Methodology:

The research followed several research methodologies in its various stages. The first was the documentary method, as demonstrated in:

the research, which began with theoretical studies of sustainability and its elements, concepts of sustainable ecotourism, traditional and modern technological methods, and materials. The research then explores the various technologies.

Furthermore, it adopts an analytical approach, providing an analytical overview of local and international eco-friendly hotels. This involves studying implemented projects, recording relevant data using a proposed table of standards and their components, and then analyzing the data to draw conclusions. Finally, the research employs a deductive approach, selecting a proposed method for evaluating the performance efficiency of sustainable tourism establishments. This method establishes foundations and standards for dealing with hotels and arrives at practical standards and mechanisms for implementing sustainability concepts and standards in hotels. The research then proceeds to the applied section, presenting a real-world case study from the Egyptian market.

1. The concept of sustainability [7]:

Sustainability is one of the disciplines that connects social sciences with architecture, structural engineering, environmental and health sciences, and integrates them with technology. When we hear the word 'sustainability,' we think of renewable energy sources, reducing carbon emissions, and protecting the environment. [8] We find, through green architecture and sustainability, the use of environmental materials, canopies, domes, basements, and interior spaces of buildings to maintain the best relationship between the building and the surrounding nature. [9]

2.Standards and Strategies for Green Buildings

Site

- Evaluation of the design and implementation plan
- Selection of an appropriate site
- Project design and optimal utilization of land areas [5]

Energy

- Reducing heat islands
- Achieving optimal thermal resistance
- Rationalizing energy use, particularly in heat-rejection equipment such as cooling towers
- Rationalizing energy consumption in water-heating systems that rely on electricity [6]
- Designing heating systems that utilize gas or liquid fuel
- Reducing the annual cost of operation and maintenance
- Enhancing the efficiency of power supply
- Using central air-conditioning units instead of multiple individual units

Water

- Using the lowest possible water consumption rates during construction and operation

- Employing fixtures and sanitary installations that promote water conservation
- Provision of hot water supply
- Building drainage and ventilation systems
- Quality of sanitary works for rainwater drainage [9]
- Reuse of greywater
- Optimal selection of storage tanks

Elements for Achieving Sustainable Eco-Tourism: Sustainable Management- Sustainable Hotel Buildings- Sustainable Sites [10]

Sustainable Construction and Its Role in Developing the Local Economy

Construction activities exert a substantial influence on various economic sectors that shape the local environment, driven by the tools employed and future development requirements. The primary areas directly affected by the dynamics of the construction sector include [11]

- Preservation of resources and raw materials
- Conservation of energy
- Conservation of water resources
- Site utilization [12]
- Achievement of integration and innovation

2. The relationship of the tourism sector with the eco-hotel and its impact on the economy

Tourism is considered one of the important means of achieving the objectives of global capitalist economic policies. It has profound impacts on the economic, social, cultural, and environmental structure in tourist areas. [9] The importance of tourism as one of the strategic sectors, whose effects extend for many generations, is attributed to the rise in the real incomes of people around the world and the increase in leisure time due to the use of technology in all fields, which in turn increases the demand for tourism, especially international tourism [12].

3. The reciprocal relationship between ecotourism and local communities in Egypt [13]

Activating the participation of local community members has become a complementary part of ecotourism and nature tourism, as the goals are usually limited to preserving the local environment and utilizing local natural resources as a main element of tourist attraction. Safari tourism and eco-lodges are considered one of the main sources of income for residents of desert and mountainous areas, and the presence of an eco-lodge is of economic importance as it works to raise the material level of citizens and preserve the heritage elements of the region by preventing the emigration of original residents from their areas and ensuring environmental conservation of the area. Specialists have realized that traditional forms of economic development are limited to the exploitative use of natural resources, while at the same time causing significant environmental pressure due to the pollutants and harmful waste they generate [12]. The research addresses the importance of the economic return of eco-lodges**.**

4. The concept of the eco-hotel

It is a tourist facility that has been planned, coordinated, and designed to harmonize with the natural and cultural system of the surrounding area. It can also be defined as a new type of tourist building that provides an educational experience for the tourist about the natural and cultural life surrounding it [13].

5. The general design goals and principles of the eco-friendly hotel

The main goal of the eco-friendly hotel

1- Reduce the deterioration of natural resource [13].

2- Reduce factors that negatively affect the environment, such as importing goods and energy. To achieve this goal, environmentally renewable resources available in the surrounding environment are used in the construction process [14].

3- Obtain energy from renewable energy sources

4- Follow an environmental strategy to manage the waste generated by hotels and work on developing usable waste

5- Build the eco-friendly hotel with local materials or materials that have been reused, which leads to increasing the economic value of natural materials and cultural expertise, as well as supporting sustainable development processes[15].

6. The schematic and design foundations of the eco-friendly hotel [16].

The eco-hotel is subject to specific requirements that differ from traditional tourist establishments, where the primary goal for visitors to eco-hotels is to experience nature and integrate with it. The size of an eco-hotel is smaller than that of traditional tourist establishments due to the following reasons:

1. The small size of water, electricity, and sewage networks in these areas, which requires a smaller number of visitors and staff in such hotels [17].

2. The recreational tourism activities offered in these hotels are of a special nature and are directed at a small group of people. The following is an explanation of the components and design principles of the eco-hotel [18].

7. Planning and Design Principles of the Eco-Hotel:

The eco-hotel adheres to specific requirements that differ from traditional tourist facilities. The primary goal for eco-hotel visitors is to experience [13].and immerse themselves in nature. The size of the eco-hotel is smaller than traditional tourist facilities due to the following reasons:

1. The limited size of water, electricity, and sewage networks in these areas necessitates a smaller number of visitors and staff.
2. The recreational activities offered in these hotels are of a unique nature and cater to small groups of people. The following is an explanation of the components and design principles of the eco-hotel. [20].

8. General design goals and principles for eco-friendly hotels

The main objectives of the eco-hotel are:

1- To reduce the depletion of natural resources.
2- To minimize factors that negatively impact the environment, such as importing goods and energy. To achieve this, renewable and readily available resources from the surrounding environment are used in the construction process.
3- To obtain energy from renewable energy sources [20].
4- To adopt an environmental strategy for managing hotel waste, developing usable materials, and reusing them in other ways.
5- To construct the eco-hotel using local or recycled materials. This increases the economic value of natural resources and cultural experiences and supports sustainable development [21].

9. Locally Available Materials in Egypt:

Table 1. *Evaluation of the Sustainability of Building Materials and Their Associated Environmental Impact*

Name	Raw Materials	Standard Sizes	Production Method	Environmental Impact	Notes
 ***Figure 1.*** *Cement*	Limestone and Marl	5 kg Bags	Firing in kilns	Carbon emissions	Reinforced concrete construction requires significant water for mixing and curing, yet excessive consumption conflicts with sustainability principles
 ***Figure 2.*** *Reinforcement steel*	Iron ore	Rebars of different diameters	Firing in kilns	Carbon emissions	
 ***Figure 3.*** *Red clay brick*	Sand and clay, which represent valuable resources improving the fertility of desert soils, have instead been diverted for brick production. [5]	25 × 12 × 6.5 cm 25 × 12 × 13 cm	Firing	The manufacturing process generates carbon emissions and requires significant water consumption for preparing the mixture, which is subsequently fired to produce bricks.	
 ***Figure 4.*** *Sand brick*	Sand-lime brick is composed of a mixture of sand, lime, and water.	10*20*60 12*20*60 15*20*60 25*20*60	The mixture is dried solely by air heating, with sand as its primary constituent and lime added in small proportions.		
 ***Figure 5.****Limestone*	Calcium carbonate $CaCO_3$	30 × 15 × 15	Stone quarrying by cutting techniques	Limestone, a medium-hard sedimentary rock, is easily cut in quarries and can be readily used in construction	

 ***Figure 6.*** *Sandstone*	Cemented sand	Different depending on the application	The properties vary according to the intended application	Its color ranges from yellow to brown, and it is harder than limestone; therefore, its use in construction is limited due to the high cost of cutting and the lack of sufficient quantities.
 ***Figure 7.*** *Basalt*		11 × 11 × 3	Black in color, hard to cut, scarce; unsuitable for construction, used for cladding and decoration.	
 ***Figure 8.*** *Marble*	Natural building stones	The cutting patterns and shapes vary depending on the intended applicatio.	Stone quarrying using cutting techniques	Local and imported varieties, costly; used mainly for stairs and cladding instead of bricks.

10. Limestone offers many advantages in terms of sustainability

Therefore, limestone offers several advantages in terms of sustainability, such as:

1- Its easy availability throughout the country reduces transportation costs to construction sites and minimizes pollution from vehicles currently transporting bricks from factories and production sites to construction sites [21].

2- Limestone is obtained by cutting it using electric saws in quarries and does not require any kind of burning or heating. Consequently, there are no carbon emissions (carbon monoxide and carbon dioxide).

3- It is transported to sites over shorter distances than other types of bricks, thus reducing pollution from vehicle exhaust.

4- Limestone blocks are larger than bricks, approximately three to three and a half times the size and therefore require less cement mortar compared to other types of bricks.

5. Stone blocks provide thermal insulation due to their physical properties and wall thickness, which helps conserve energy needed for heating buildings in winter and cooling them in summer. This aligns with sustainability standards that conserve energy and, consequently, the environment, as electricity production often involves burning fossil fuels, resulting in the production of polluting gases.

6. Exterior plastering of stone buildings and parts of the interior plastering can be omitted, significantly reducing cement usage and thus lowering costs and pollution associated with cement plastering [22].

7. In cases of partial or total building collapses, the stones used in the original construction can be reused in new construction without the collapsed parts causing environmental pollution. This is not applicable to crumbling concrete, which must be completely removed and the sites decontaminated, as it is unsuitable for reuse in cases of partial or total building collapse. If this construction method were to be expanded nationally, it would rely on using limestone in building and reconstruction, leaving the stone blocks almost untouched instead of burning them to manufacture cement and cement bricks. This would protect the environment from the pollution caused by burning the same type of limestone to produce cement [23].

11. The study of limestone (calcium carbonate) as a local model

Limestone is very commonly used in architecture, from the Pharaonic civilization to Islamic and modern times.

architecture encapsulates the integration of environmental considerations and modern technologies:

in architectural practices the overarching objective is to harmonize smart technologies in a manner that is environmentally conscious, concurrently optimizing resource utilization and leveraging renewable energies with minimal ecological impact. In alignment with sustainability principles, Eco-Tech architecture operates within a smart technical framework, facilitating the creation of intelligent structures capable of interactive and responsive engagement with their ecological

This approach constitutes a holistic eco-tech system, incorporating
environmental design, technological design, and economic efficiency elements. [17].

12. Economic Uses of Limestone:

1. Building Material - A key component in concrete (Portland cement) - As a white pigment or filler in products such as toothpaste and dyes - As a chemical raw material for lime production, as a soil conditioner, and as a natural decorative stone for garden landscaping

2. Used to obtain lime for construction, and impure types are used as building stones. - It is used in the iron and steel industry, where coal and iron ore are added in furnaces
3. Used by the ancient Egyptians in building the pyramids. - Used in cement manufacturing for marble extraction - Paper manufacturing - Manufacturing some medicines

18.Locations of Limestone in Egypt:

Limestone is found in vast areas of the Egyptian desert, such as the Giza Plateau, Saqqara, Meidum, Sheikh Zayed City, Mokattam, Tora, Matrouh, and areas in Upper Egypt such as Minya, Assiut, and Beni Suef[22].

19.Limestone: A Sustainable, Local Material:

Building with local resources is one of the most important criteria for achieving sustainability. Currently used building materials such as concrete, cement, and reinforcing steel cause environmental pollution and increase carbon emissions during the manufacturing process. Therefore, sustainability is achieved with limestone. It is obtained from quarries by cutting, not burning, thus preventing environmental pollution. Limestone is of medium hardness and is cut with saws, producing thousands of limestone blocks [22]. daily, making its production economical. It also requires less water.

20.Therefore, building with local resources (limestone) is one of the most important criteria for achieving sustainability, as demonstrated by:
1. Local and environmental resources and recycling
2. High efficiency of limestone
3. High resistance to erosion and less maintenance
4. Efficient utilization of local materials
5. Choosing limestone for construction to achieve economy and avoid excessive costs.
6. Choosing materials with high moisture and water resistance and environmental friendliness (Qanater El Khayreya Building)
7. Achieving optimal thermal resistance by reducing temperatures within spaces, thus achieving the best environmental quality
8. Achieving the least harmful impact on the environment.



Figure 9. *Aqueduct Wall- Cairo*



Figure 10. *Al-Fustat Market - Cairo*



Figure 11. *Qanater El Khayreya – Cairo*

Significantly reducing reliance on manufactured materials, the delivery of which to construction sites can be delayed due to technical or economic reasons.
• This construction method is characterized by the absence of construction periods during the building phases (such as waiting periods for setting or formwork removal). Construction is completed more quickly than in a frame system. [23]. Therefore, the greater the workforce, the faster the execution rate, as illustrated in the figure.

Reduced environmental pollution rates through:

a. Reduced demand for manufactured materials, which in turn allows for a reduction in national pollution from factories.
b. Reduced pollution resulting from the transportation of manufactured materials, as well as pollution from on-site operations, such as cement dust and debris.
c. Reduced reliance on mechanization, which typically causes noise and environmental pollution, in addition to carbon emissions from its fossil fuel-burning engines.
d. Developing a spirit of community participation and creating job opportunities.
e. Using this method leads to the creation of new job opportunities in the construction sector, given its low reliance on mechanization, as it is a labor-intensive technology.
f. The use of this construction system, which is easy to train on, contributes to emphasizing the importance of community participation, as residential and service buildings can be built through community efforts.
g. New job opportunities can be created by utilizing service buildings after their construction through community efforts, such as markets, workshops, small factories, and others.

Advantages of using load-bearing walls with limestone:

Using load-bearing wall construction methods with readily available materials, such as various types of bricks or natural stones found in the region or geographical area, will largely meet these requirements. This contributes to the success of developing the desert hinterland, and this method is also suitable for building tourist villages and residential communities in remote areas.
• Significantly reducing reliance on manufactured materials, the delivery of which to sites can be delayed due to technical or economic reasons.

• This construction method is characterized by the absence of built-up periods during construction phases (such as waiting periods for setting or formwork removal), allowing for the completion of the building as occurs in a frame system.



Figure 12. *Construction using the proposed structural system*

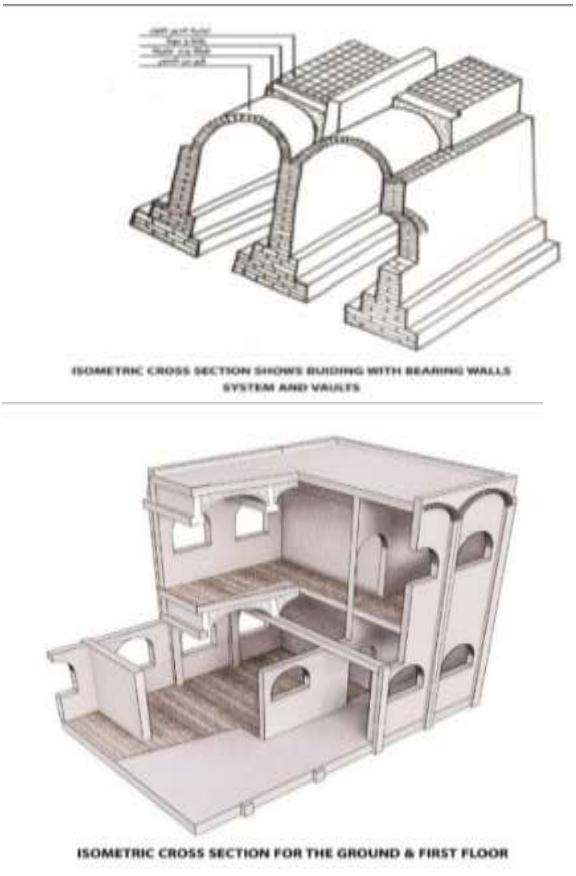


Figure 13. *This illustrates the concept of construction using load-bearing walls and vaulted ceilings.*
Source: Dr. Sami Ali Kamel, Construction Using Natural Stones: An Applied Model for a Six-Classroom School in Minya Governorate, Helwan University, Faculty of Engineering, Matareya, 2012

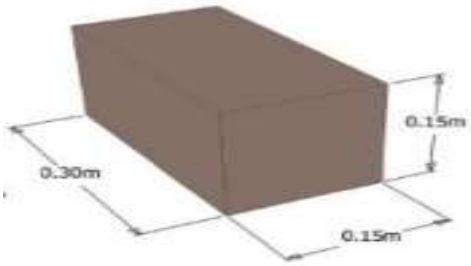


Figure 14. *It shows the dimensions of the stone used in the construction of load-bearing walls and vaulted ceilings (30*15*15)*



Figure 15. *The completion of the basement construction using limestone is shown.*

24. Roof alternatives in the proposed structural system

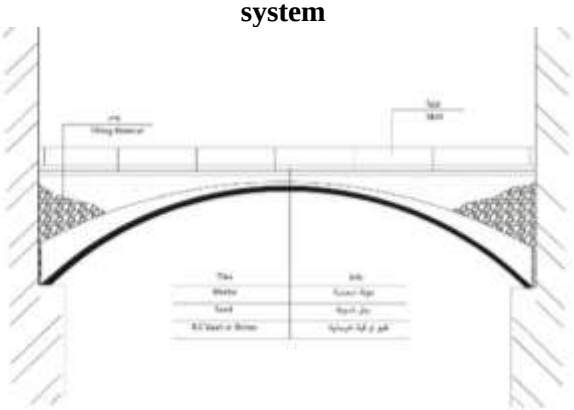


Figure 16. *The alternative to roofs is a double curved shell system, which is precast on-site.*

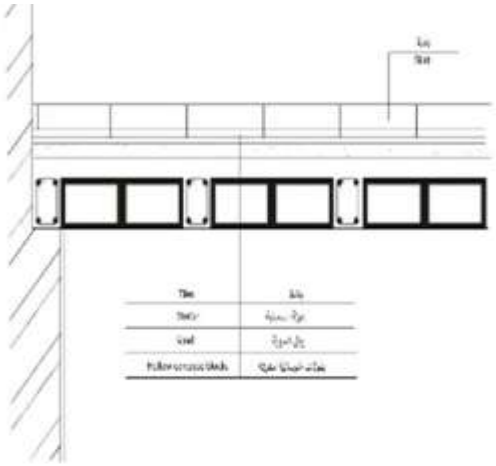


Figure 17. *The alternative to roofs is a (Concrete hollow blocks), which is precast on-site.*

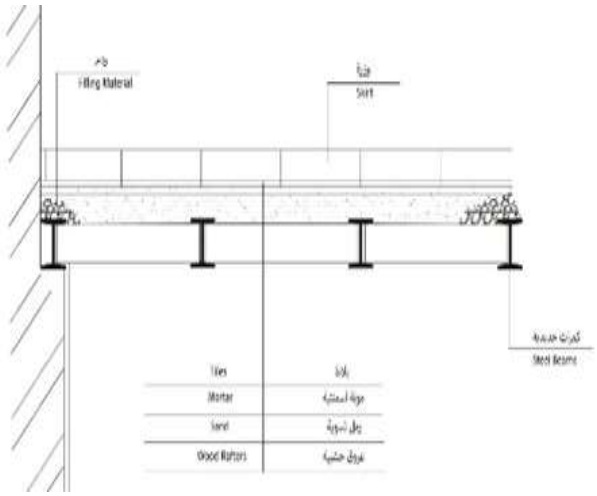


Figure 18. *The alternative to roofs is a (Main Steel beams with timber secondry beam) which is precast on-site.*

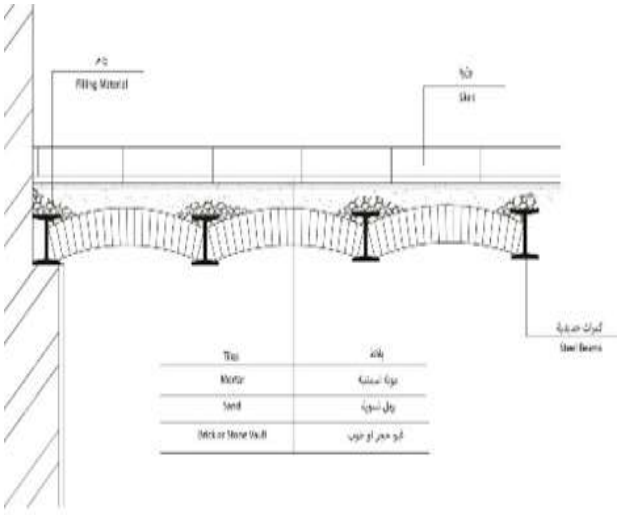


Figure 19. *The alternative to roofs is a (Steel beam&vaulted bricks)*

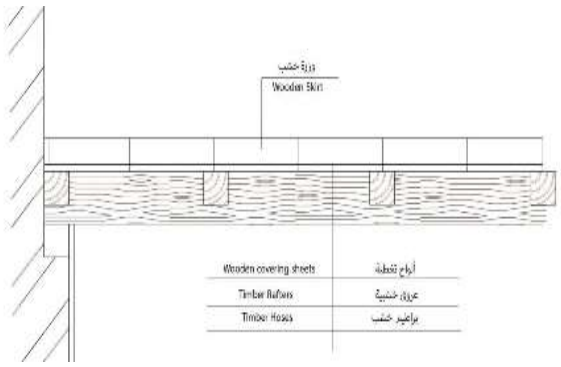


Figure 20. *The alternative to roofs is a(Timber main and secondry beam if available locally)*

Using limestone is cost-effective in transportation and manufacturing.

• Many different materials exist, such as nanotechnology, but they are not manufactured locally.

• Load-bearing walls are among the most successful and energy-efficient local construction systems.

• Load-bearing walls provide sound insulation, ensuring comfort and tranquility for residents.

• Environmental protection is achieved by replacing polluting building materials with limestone, which does not require the manufacturing processes of various types of bricks, cement, and iron that produce carbon emissions due to the burning of fossil fuels during the manufacturing stages**.**

Applied study focusing on the Laguna Beach Bay project in Ain Sokhna

Project Name: Tourist Village (Laguna Beach Bay)

Hotel: Laguna Beach Hotel, Ain Sokhna

• Laguna Bay Ain Sokhna Hotel is one of the tourist hotels in Egypt.



Figure 21. *Laguna Beach Hotel, Ain Sokhna master plan*

• Laguna Village is one of the distinguished tourist villages in Ain Sokhna, and the hotel is currently under construction.

o There are shortcomings in the application of sustainability principles to hotel design, specifically regarding cost, materials, and environmental treatments

o This study aims to improve and upgrade the hotel to make it more environmentally friendly by applying environmental sustainability standards and comparing the current situation with the proposed one.

project was constructed: Construction commenced in 2015, with approximately 20% completed so far.





Figure 22. *Laguna Beach Hotel, Ain Sokhna elevations*

Methodology of The Study:

- Analyze current reinforced concrete design of Laguna Bay Hotel.
- Propose eco-friendly design using limestone walls and vaulted ceilings.
- Quantity survey for walls and foundations to compare costs.
- Use Design Builder software.
- Simulate designs to measure indoor temperatures and assess environmental quality
- Engineering drawings illustrating the original design and the environmental alternative using natural limestone:

- Laguna Bay Ain Sokhna Hotel is a tourist hotel in Egypt.
- Tourist village operational; hotel under construction.
- Deficiencies in sustainability (cost, materials, environmental treatments).

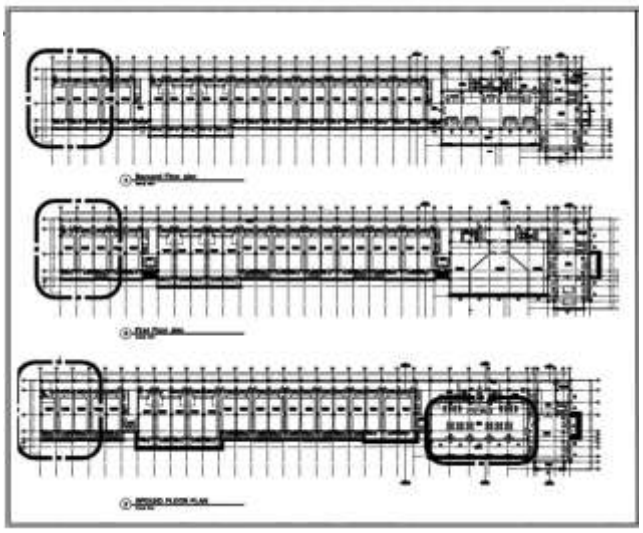


Figure 23. *Laguna Beach Hotel, Ain Sokhna PLANS*

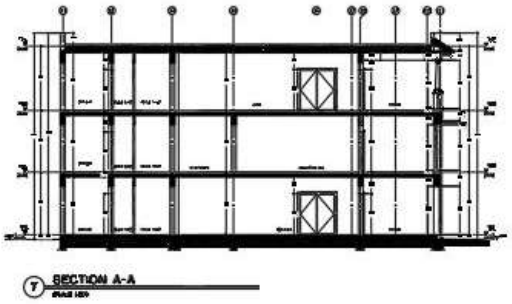


Figure 24. *Laguna Beach Hotel, Ain Sokhna SECtions*

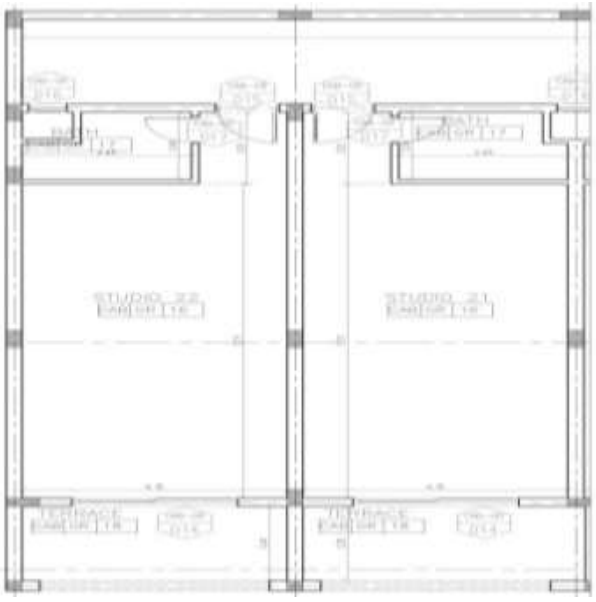


Figure 25. *Shows the floor plan of the two rooms at a scale of 1:100Room area: 42 m²*

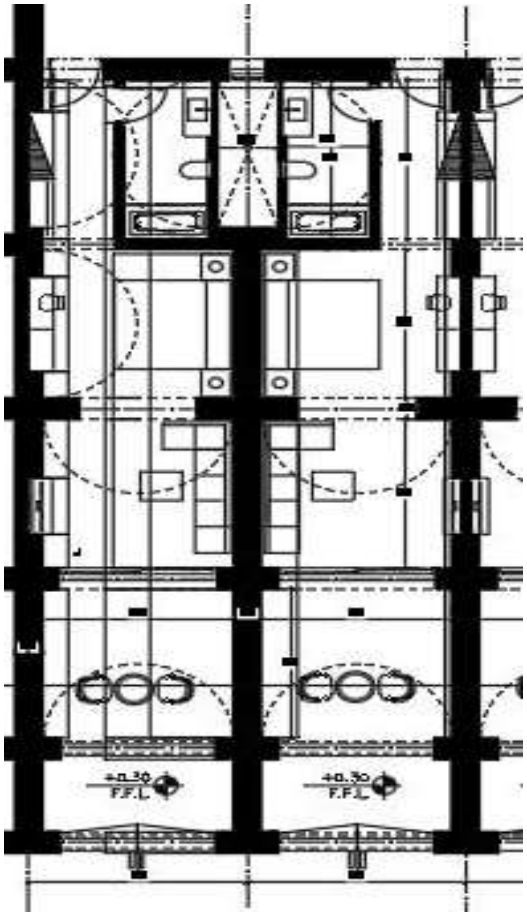
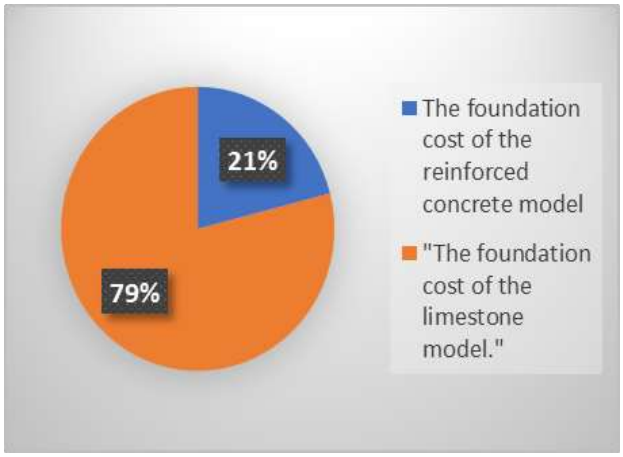
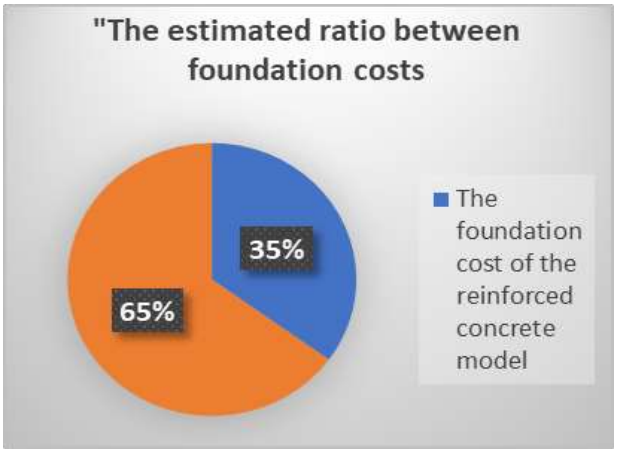


Figure 26. *Shows the floor plan of the two roomsat*

Study aims to upgrade the hotel to be more environmentally friendly, comparing current and proposed conditions.

- Orientation: Northeast
- Design: Limestone construction
- Foundations: Strip footings
- Wall thickness: 45 cm
- Ventilation: Through terrace window (180 × 210 cm)
- Ventilation is natural, reducing the building's thermal load
- Room area: 55 m²
- Orientation: Northeast
- Design: Reinforced concrete
- Foundations: Isolated footings
- Columns, beams, and slabs: Reinforced concrete
- Wall thickness: 25 cm
- Ventilation: Through terrace window (180 × 210 c





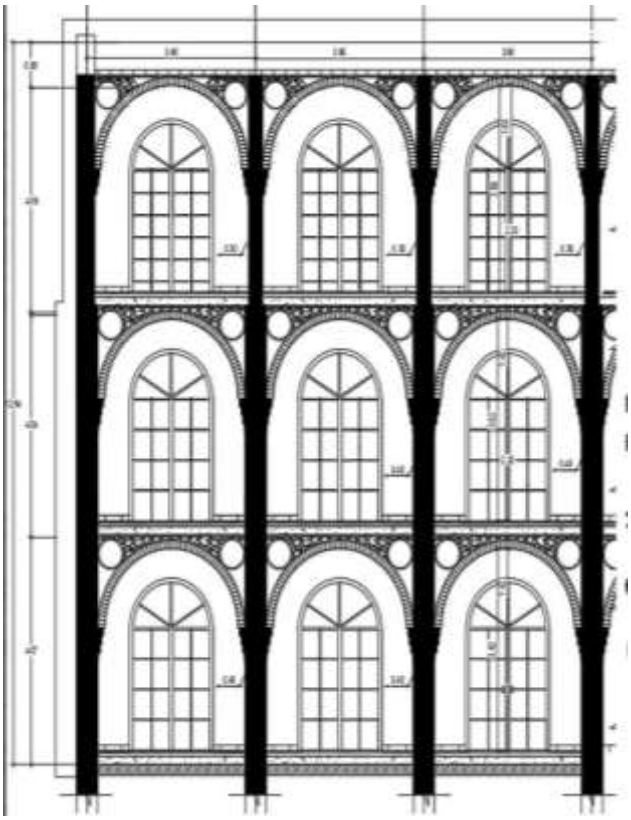


Figure 27. *Shows the SECTION*

Results and Discussions:

A comparative cost estimation of hotel room models constructed with limestone versus those built with concrete.

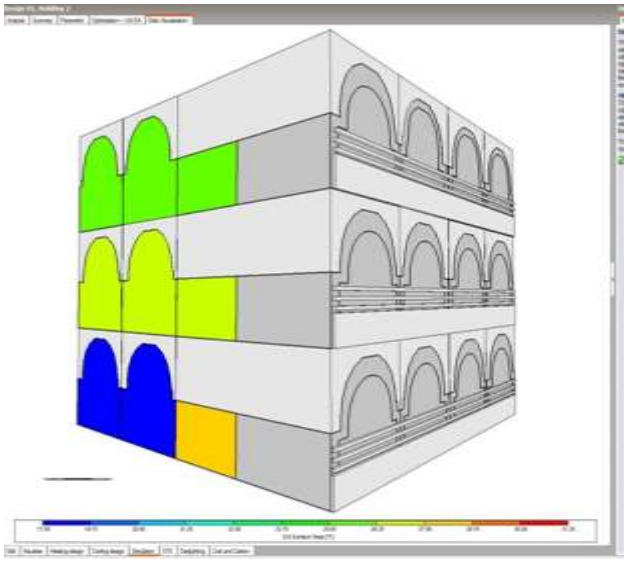


Figure 28. *This provides a comparative cost estimation between the foundation works of a limestone- based hotel model and a concrete-based hotel model, indicating a cost reduction of approximately 35%.*

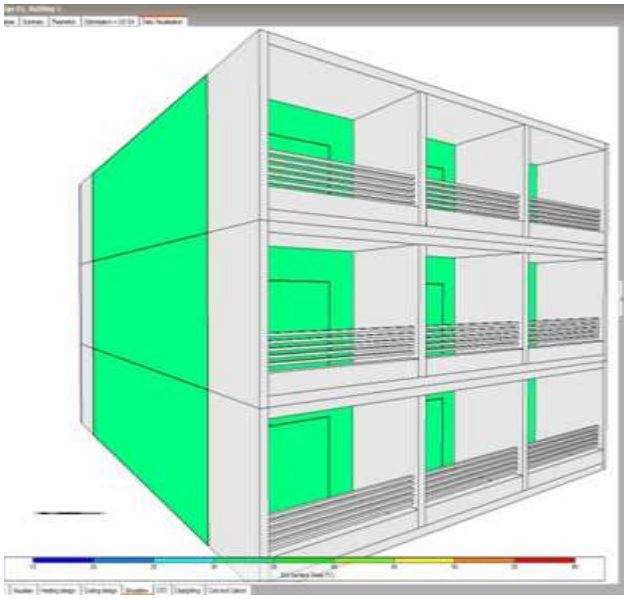


Figure 29. *Sustainable Cities & Environmental Simulation:*
"Both the current and proposed scenarios were modeled using the environmental simulation software to assess indoor temperature levels within the hotel rooms, evaluate the achievement of indoor environmental quality, and analyze the building's thermal loads on June 30th at 1:00 PM.

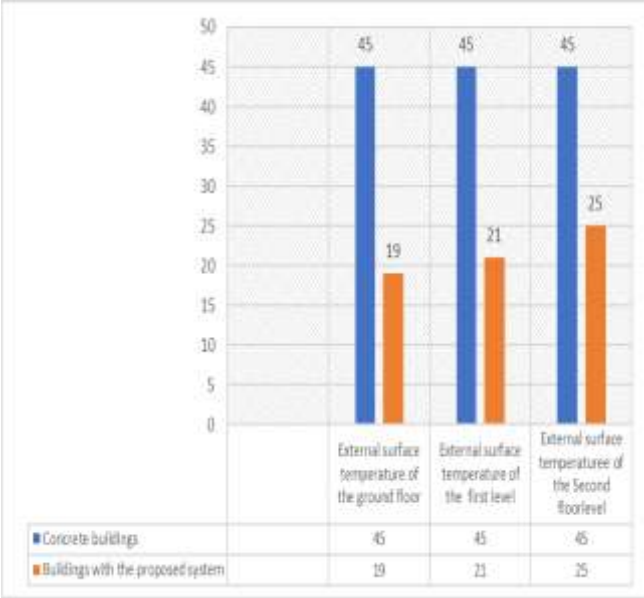


Figure 30. *Through the application of the environmental simulation software Design Builder*

The surface temperature of the building was analyzed for both the current design constructed with concrete and the proposed design. The simulation, conducted at the hotel site in Laguna Bay, Ain Sokhna, on June 30th, aimed to evaluate and compare the thermal performance of the two models under prevailing climatic conditions

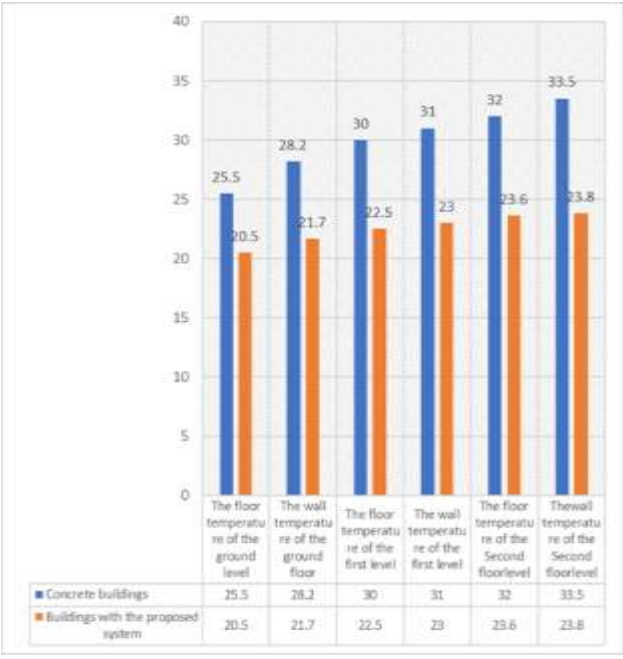


Figure 31. *Through the application of the environmental simulation software DesignBuilder*

the surface temperature of the building was analyzed for the current design constructed with concrete. The simulation was conducted for the hotel site at Laguna Bay, Ain Sokhna, on June 30th, in order to evaluate the building's thermal performance under actual climatic conditions.

4. Conclusions

The idea of the thesis stemmed from the desire to search for the causes of "tourist hotels not achieving environmental standards" in
Egypt. The clear answer came that these projects did not take into
account the application of sustainability standards, although the design of environmental hotels has found great interest in recent years, whether it is from an architectural point of view.
About the innovative idea, good design, environmental formation, or from the structural point of view, in addition to the architectural design, honest
expression of the influential forces in the facility, and an attempt to devise new methods of construction with simple material costs that
lead to the development of the building or from the technical aspects of following compatible and appropriate techniques in the methods of
implementation and the use of modern programs In solving problems of implementation, construction and environmental treatments in order to equip hotels by using local and environmental materials to facilitate costs and maintenance
Therefore, it has become necessary to pay attention to the establishment of eco-hotels and to increase their numbers because of
their great role in forming and restoring tourism and supporting the
national economy. In order to achieve this, it is of great importance To set standards for architectural and construction designs to achieve the foundations of sustainability in addition to reducing the cost of construction and maintenance, which achieves a good economic return that contributes to building the national economy of the state
General Research Findings: The results were obtained after a simulation process, which served as a model for applying the impact of using locally available materials in Egypt through various design methods on reducing the annual energy consumption of hotels. This study led to the following conclusions:
A lack of awareness of ecotourism concepts in Egypt, coupled with insufficient efforts to develop and monitor them, contributes to the problem's escalation, resulting in cost-effectiveness issues in the design of coastal and local hotels. Inadequate application of some sustainable assessment systems and standards for elements that reduce the costs of mid-rise eco-hotels in Egypt throughout all stages of implementation and marketing.

- Reducing energy consumption in all stages of implementation, operation, and marketing, and prioritizing local resources.
- Reducing carbon emissions by integrating design strategies with sustainable environmental materials.
- Focusing on natural ventilation to reduce electricity consumption.
- Relying on environmentally friendly design with local materials to provide lower indoor temperatures, thus improving indoor environmental quality.
- Utilizing natural elements on-site and incorporating them positively into the design. General Research Recommendations: • Spreading awareness and a green culture among architects and the public in this regard to address environmental problems and ensure user comfort.

The importance of materials. Local considerations and how to propose technological solutions and alternatives to achieve thermal and psychological comfort within buildings.

Explaining the importance of using local materials and manual labor, keeping up with developments, and keeping pace with modern technology, especially in eco-friendly hotels and their implementation methods, which have a significant impact on energy conservation and local heritage. Increasing interest in scientific research in general publications.

- Encouraging scientific journals and media outlets to publish on environmental conservation methods and encouraging companies that produce these systems and modern technologies to apply them in buildings.
- Encouraging businesspeople to invest in sustainable architecture to rationalize energy consumption and reduce the state's energy production costs.

Providing simulation programs and training students on their application to study building behavior and develop appropriate solutions before starting the implementation process.

- Encouraging the use of local building materials and interior and exterior finishes that reduce the heat load (taking into account thermal insulation).
- Developing curricula and intensifying courses and seminars for public and researchers in this field to keep pace with developments, intellectual trends, and modern architectural schools.

Architectural Recommendations:

- Developing and training architects in self-skills and creativity in sustainable design and construction.
- Conduct an environmental impact study for each area where the eco-hotel is to be built.

Identify local architectural styles and materials.

Construction Recommendations:

Encourage training local workers in construction.

- Encourage the use of local materials such as limestone.
- Ensure the proximity of materials to the site to minimize costs.
- Utilize local building methods to integrate the project seamlessly into the local character.
- Develop a plan for construction methods during implementation, operation, and marketing, emphasizing maintenance and post-occupancy care. This plan should employ construction techniques, such as those proposed in the applied section of the research, to achieve thermal comfort within the space and minimize heat transfer.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.
- **Use of AI Tools:** The author(s) declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

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