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The Vernacular language as a Basis for Thermal Comfort in Contemporary Architecture

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Abstract: ***Vernacular architecture takes advantage of environmental and climatic contexts to provide thermal comfort. In response to many microclimate issues, vernacular architecture has found solutions for basic human needs in residential buildings over decades. Vernacular architecture relied on locally available resources considering socio-economic factors, without relying on theories and skills gained from formal architectural education. A renewed interest in vernacular architecture has sparked in recent years because vernacular architecture can achieve thermal comfort with simple techniques. The Egyptian architect, Hassan Fathy, laid the foundations of vernacular language. In this paper, three projects of Fathy in Egypt and Jordan in the post war period were analyzed to identify the vernacular language. These projects show how Fathy achieved the thermal comfort that he wanted to obtain through detailed examination of five vernacular elements that he applied. Referring to the theories of vernacular architecture and their applications, it was found that the elements of vernacular architecture discovered and further developed in contemporary architecture. In short, vernacular language provides higher efficiency of thermal comfort. This was proven by reviewing four contemporary projects in the UAE, France and Egypt. These projects took advantage of the vernacular element that Fathy used in his projects earlier as a basis to achieve thermal comfort***
Keywords: Vernacular Architecture, Climate, Thermal Comfort, Contemporary architecture, Hassan Fathy

I. INTRODUCTION

A. Purpose Of Study

Vernacular architecture is considered as one of the fundamental bases for contemporary architecture towards thermal comfort achievement. This study attempts to prove how advanced vernacular architecture is applicable in contemporary buildings and how the efficiency of thermal comfort improved through the vernacular language. This study confirms that vernacular architecture obtains good levels of ventilation, cooling and heating making an efficient system of thermal comfort. This paper identifies vernacular architecture based on Hassan Fathy's works and its great influence on provision of energy consumption. The organizers of the Energy Program at the United Nations University chose examples of vernacular architecture as one of climate solutions in the hot regions, and they were convinced that Hassan Fathy is the most qualified person to write in this regard. Fathy believes that vernacular solutions derived from the past must be studied and developed to become usable and effective in contemporary architecture.

B. Methodology

Three case studies are taken from the works of Hassan Fathy in Egypt and Jordan. They were selected to get a detailed understanding of vernacular architecture. Four buildings in France (The Arab world Institute), UAE (Masdar Institute Research Center) and Egypt (The New American university & The Gate Residential Complex) were analyzed to show how vernacular architecture is valid and usable in contemporary architecture. Table (1) shows three projects designed and constructed by Hassan Fathy. They all were designed for the same propose of achieving thermal comfort according to their locations in arid climate areas. Fathy's goal was to provide comfortable temperature in the interior spaces considering socio-economic conditions.

II. VERNACULAR LANGUAGE BY FATHY

In arid climates, temperature is high during the daytime, while it is plummet at nighttime. Fathy incorporated courtyards, Iwan halls (three- sides walled halls), wind towers (Malqaf), vaulted-ceilings, domes, Mashrabiyyas and local building materials in the building spaces[1]. These elements are main characteristics of vernacular architecture that used to provide thermal comfort in the arid climate regions. They interact to produce balance between thermal gain and loss in the interior[2].

[1] Natural Energy and Vernacular Architecture (1986), p.25, pp.26
[2] For more information see (Leila El-wakil 2018) Hassan Fathy: An Architectural Life, (John M. Bancroft 1994) Desert Architecture III: Building

A. Courtyard

In the evening, the hot air in the courtyard, heated directly by the sun and by the radiant heat from the building mass during the day-time, begins to cool down and gradually replaced by the cold night air coming from the upper layers in the sky. The cool dense air settles down in the courtyard and spreads into the surrounding rooms. The courtyard acts as reservoir for the cold air. Courtyard It is the closed or semi-closed space formed by continuous or semi-continuous walls on its four sides in the case of a quadrilateral or more in the case of a polygonal shape. The inner courtyard overlooks the other components of the building, and no ceiling is available.

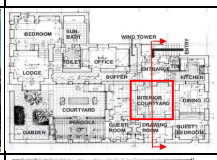
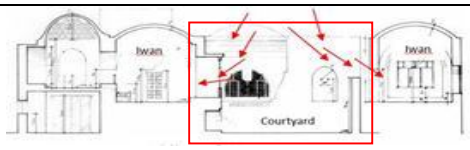
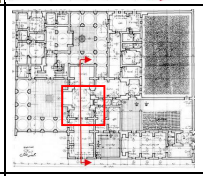
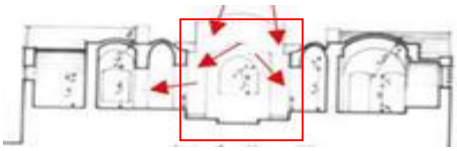
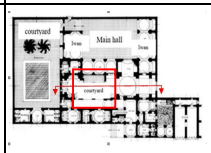
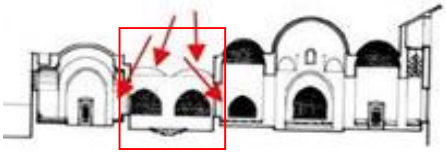
House Name	location	year	Image	Floor plan	Section
1. Akil Sami House	Dahshur - Egypt	1978			
2. Al-Sadat Rest House	Aswan - Egypt	1981			
3. Khalil El-Talhoony House	Amman - Jordan	1988			

Table 1. Analysis for the function of courtyards in the three projects of Hassan Fathy, source: An Architecture for the People: The Complete Works of Hassan Fathy, James Steel

There can be more than one courtyard in a single house that communicates with each other through corridors or iwans. The courtyard helps to provide the necessary ventilation and indirect light for the inner chambers.

B. The Iwans

Iwan is a covered hall with only three walls, completely open from the fourth side without doors[3]. Usually, iwan overlooks the inner courtyard; a corridor may connect to it and it may connect multiple halls and rooms depending on the type of building function. The use of iwans was popular in Islamic architecture. Hasan Fathy used iwan as a form of identity expression while achieving thermal comfort. How iwan works to receive air from the court lements can see through the figure 1 below.

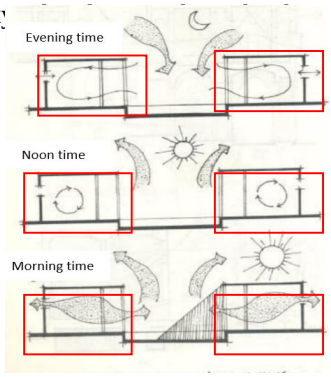


Figure 1. Diagram shows the courtyard method of achieving thermal comfort during different times of the day, source: Architecture for the poor, Hassan Fathy, Figure (74) Arabic edition

a Sustainable Future. (Salma Samar Damluji & Viola Bertini 2018), Hassan Fathy: Earth & Utopia.

[3] Iwan is commonly linked with the architecture of the Middle East. It is a rectangular hall or space, usually roofed, walled on three sides, while the fourth side is either semi or entirely open through a portico towards a yard: Dictionary of Islamic Architecture: Petersen, 1996, p 130.

Figure (1) shows the air circulation between the courtyard and the surrounding Iwans. courtyard is a space in which clean fresh air is abundant, temperatures are also lower during daytime because cool air is trapped during nighttime and retained. Courtyards are also warmer in winter due to a lesser exposure to cold air, whilst still receiving warmth from the sun which is lower during winter. lodge in the building serves to shade the building from sunlight during daytime and serving as comfortable sleeping and living spaces at night.

Figure 2. Two Iwans in Akil Sami House. Iwans are overlooking the courtyard to the left side and several small Iwans in Al-Sadat rest house to the right side, source: The Complete works of Hassan Fathy, James Steele

C. Wind Tower (MALQAF)

Wind Tower is also called Malqaf or wind catcher. It is taller than the building that the tower belongs to, and it has an opening towards the direction of the prevailing wind. The wind tower captures the air passing over the building, which is usually colder, and pass it inside the building. The wind tower is also useful in reducing the dust that are usually carried by the winds that blow on the hot regions. The size of the wind towers depends on the air temperature outside. If the temperature of the air facing its opening is low, then the horizontal cross-section must be large. On the other hand, if the temperature is higher than the maximum comfort related to the thermal environment, then its horizontal cross-section must be small, provided that the air entering through it is cooled by using wet mats or moist charcoal plates placed between two sheets of metal net. Or it can direct the air flowing over a water element such as a fountain to increase its humidity.

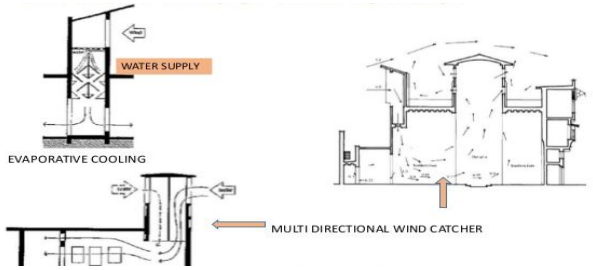


Figure 3. Drawings for different kinds of wind catchers with different methods of cooling the air, source: Natural Energy and Vernacular architecture, Hassan Fathy, edited by auther

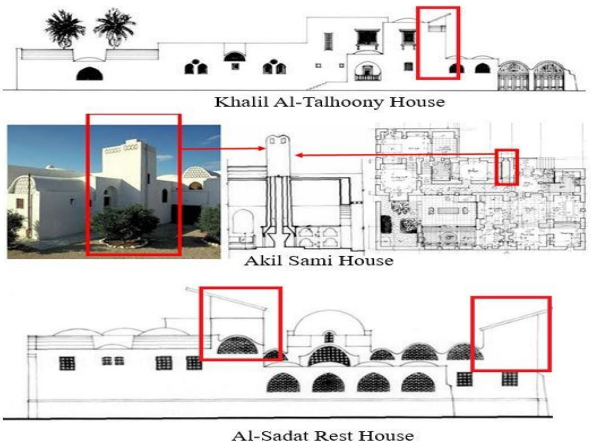


Figure 4. The wind towers drawing in the three case studies

D. Vaulted Ceiling And Dome

The shape of the ceiling has a great importance in the hot climate, as the ceiling surface receives radiation throughout the day, and then transfers it to the interior spaces and to treat it as a thermal comfort solution, the domed and vaulted shape have been used, which have many advantages such as the height of the interior space as well as allowing hot air to move upward away from individuals' heads[4].

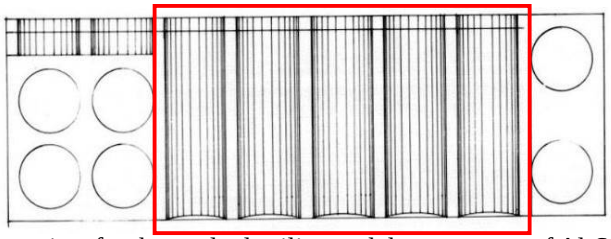


Figure 5. top view for the vaulted ceiling and domes at part of Al-Sadat Rest House

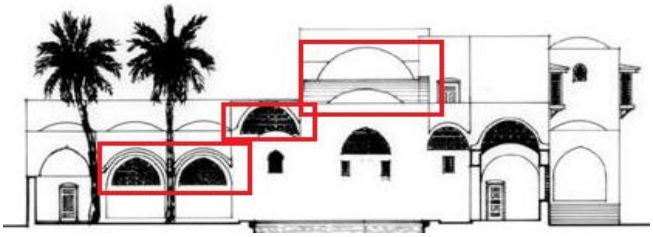


Figure 6. Elevation view shows the vaulted ceiling and domes of Khalil Al-Talhoony House

Another advantage is the increase in the ceiling area, which leads to the distribution of the intensity of the sun's radiation over a larger area, thus reducing the average increase in the temperature of the ceiling surface[5]. This effect is effective in ceilings that are in the shape of the dome, in this case the roof is always shaded until noon, and the vaulted or arched ceilings increase the speed of air passing over their curved surfaces, which increases the effectiveness of the cooling winds in reducing this temperature.

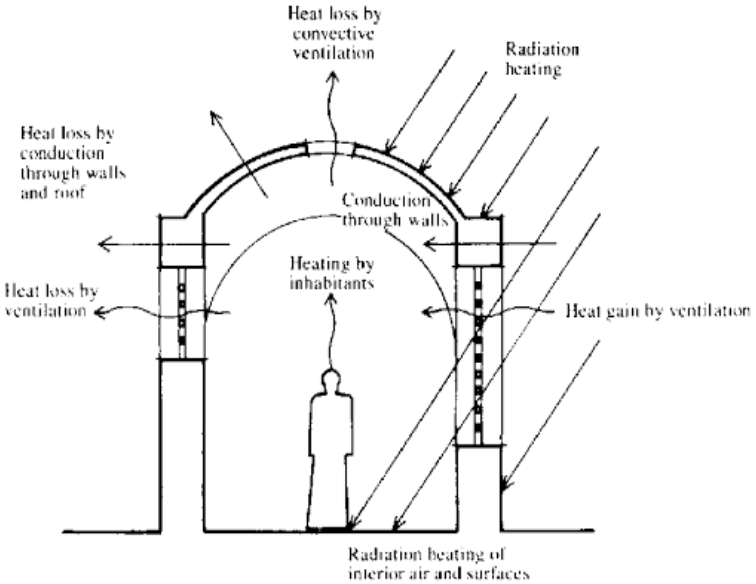


Figure 7. Diagram explains the thermal control method of vaulted ceilings and domes, source: Natural Energy and Vernacular architecture, Hassan Fathy

[4] Natural Energy and Vernacular Architecture (1988 Arabic edition), p.100.
[5] An Architecture for the people: The complete works of Hassan Fathy, Steele, James, (1997), p. 20

E. Mashrabiyya

The Mashrabiyya is a traditional Islamic screen (window) with a wooden latticework. It serves many purposes, but one of the most important functions is about privacy. The Mashrabiyya blocks the view from outside while allowing residents inside to see outside. The Mashrabiyya also effectively provides the thermal comfort.

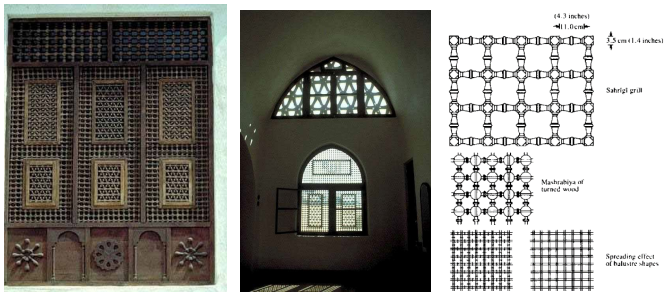


Figure 8. Different types of Mashrabiyyas in Akil Sami House

It has a shape of wooden arabesques openings with a circular cross section separated at specific junctions. The Mashrabiyya is organized in a precise geometric and ornamental form of five complex patterns[6]. The Mashrabiyya's role in thermal comfort can be explained through adjusting the passage of the light, air flowing control and reducing volume of the air.

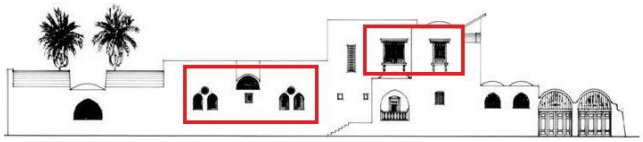


Figure 9. Two shapes of Mashrabiyya design used at Khalil Al-Talhoony House

F. Summary

As described and analyzed above upon the use of vernacular architecture vocabulary, energy saving and climate adaptation can be achieved through good ventilation inside the building, provision of shades, and improvement of air temperature.

Thermal comfort is achieved with the help of vernacular elements, courtyard, iwans and wind tower that reduce the intensity of solar radiation and providing natural light, shading and stream of cool air. Additionally, attractive urban texture has added an aesthetic touch, the difference between sunny and shaded areas creates a contrast that paints an image of unique charm and beauty as a result of the exposure of surfaces.

III. ANALYSIS OF DEVELOPED VERNACULAR LANGUAGES IN CONTEMPORARY BUILDINGS

Contemporary and Vernacular archutecture have two oposite meanings, one word defines a type of architecture that's highly progressive, modern, high tech and expressive, the other deals with traditional, simple, and local techniques, the simplest form of addressing human needs. While contemporary architecture is of the 21st century, using advanced materials and spread across a global scale. the following examples show that architects have now started embracing regionalism and cultural building tradition. With rapid technological advancements and urbanization, incorporating knowledge of vernacular construction has proved to be a step forward in terms of sustainable architecture.

A previous study of the history, social, cultural, climatic conditions, and techniques of many regional styles have shown that these low-tech methods of construction, perfectly adapt to its locale. Many vernacular structures have been established to be not just energy efficient but offering thermal comfort. The right amount of involvement of vernacular ideologies in the design of buildings for the future is what can be termed (contemporary vernacular). As a result of several architectural projects in contemporary buildings that took advantage of vernacular architecture in gaining thermal comfort, this study analyzed vernacular language as a significant issue. This study is comprised of four projects: Masdar Institute in the UAE, The Arab World Institute in Paris, The New American University in Egypt, and the residential complex in Egypt (The Gate).

[6] Hassan Fathy (1984), Mashrabiyya's Story, p.39

A. Masdar Institute Research Center

Masdar Institute Research Center is part of Masdar city in Abu Dhabi, UAE. Designed by Norman Foster, the building was completed 2011. Foster has created an exceptional shading technology as sunlight protection and provided maximum shade during the day. Windows were provided in the residential buildings with contemporary forms of the vernacular Mashrabiyya. They are mainly built of cement but reinforced with gray glass. The vernacular wind tower (Malqaf) was applied with an iron wind tower that allowed the wind flow to be diverted to the level of the roads[7].

The reintroduction of Mashrabiyyas in the facades represents advanced forms of vernacular languages to shift the architectural design from "function follows form" to more environmentally based design that is less dependent on mechanical cooling system. The integration of vernacular architecture in the building practice and modern technologies satisfy demands for style, adaptability and flexibility while keeping a sustainable footprint. Buildings are accessed via a fully shaded, atrium space that exploits thermal mass and natural ventilation to provide free cooling as a promoted vernacular courtyard. Atrium roof lights allowed daylight diffused and direct sunlight blocked.

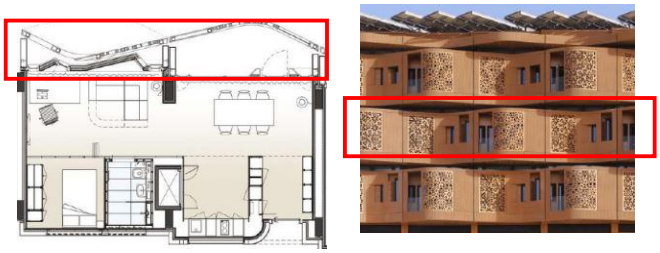


Figure 10. Plan shows the Mashrabiyya design on the left side, and the elevation on right side shows Mashrabiyya's exterior

Foster explained that buildings' design also relied on narrow corridors and openings that pass air to enter for good ventilation between the spaces in shade. Its function is similar to the Mashrabiyya windows in vernacular architecture. The adaptation of Mashrabiyya windows is protected by a contemporary reinterpretation of olden Mashrabiyya. It is constructed with sustainably developed, glass-reinforced concrete, colored with sand to integrate with its desert context and minimize maintenance. He added" the wind towers that were built in the center of Masdar city campus, which catches the wind to distribute it throughout the spaces, was inspired by the vernacular wind towers.

Figure 11. Two different styles of advanced wind towers in Masdar city.

[7] Spaceship in the Desert: Energy, Climate Change, and Urban Design in Abu Dhabi, Gokce Gunel, p. 10.

B. The New American University

The new campus of the American university in Cairo -Egypt was constructed in 1999 by the Egyptian architect Abdel Halim Ebrahim, a former student of Fathy. This project hoped to benefit from local vernacular experiences to solve environmental problems and reduce energy consumption. It took advantage of traditional environmental solutions in a contemporary manner. Ebrahim adopted in his project the idea of going to internal courtyards with water fountains to moisturize the indoor air. The courtyards were also surrounded by shaded roofed corridors to protect the openings overlooking with wooden curtains as Mashrabiyyas.

Figure 12. The New American University Campus showing the vernacular language

According to UNEP green universities toolkit, the AUC new campus is officially registered as one of the finest global examples of green sustainable educational institution[8]. The university was named also as the only higher education institution outside the United States and Canada in the 2015 Princeton Review of the Green Colleges Guidebook as "Most Environmentally Responsible". The priority for the design was to build sustainable, regional campus. We can see the sustainability in this project through many aspects such as: the plazas, courtyards and gateways between buildings were oriented toward the prevailing northeast winds and the university garden. The use of Mashrabiyyas for privacy and sun protection with ventilation control. The wind towers on the roofs to capture prevailing winds and circulate fresh air into the building. The vaulted ceiling-domes to remove hot air and replaced by cool air coming from the shaded areas. As for the water and green spaces, they contribute to cool down the air as it moves upwards to replace the warmer rising air in the center of the campus. This environmentally conscious design reduces energy and maintenance costs in the long term and also participates in the social design of the new campus.

Architect Abdel Halim Ebrahim says that "the gardens are helping to condense the cold air that collects during the night and ventilates the entire campus during the day and the walls of the buildings are constructed according to energy management systems, which reduce the costs of using air conditioning and heating equipment by at least 50%, in addition, bout 80% of the campus's exterior walls are made of sandstone, which helps keep rooms cool during the day and warm at night".

C. The Arab World Institute

The Arab World Institute was constructed in Paris, France in 1987 by the architect Jean Nouvel. The building has a modern character inspired by the Arab-Islamic architecture. Two elements of vernacular architecture were applied in the project. The first one is the inner courtyard. It is shown in the plan of the building through two masses of the building.

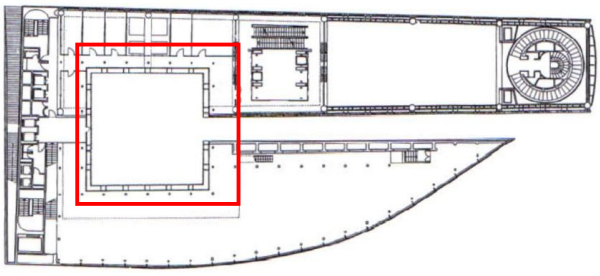


Figure 13. Floor plan shows the location of the main courtyard in the Arab World Institute

[8] Greening universities toolkit V2.0: Transforming universities into green and sustainable campuses: A toolkit for implementers (2014)

The second is Mashrabiyya: glass panels were used to cover the facades of the project, as Mashrabiyyas, but with an advanced technology, where 27,000 sensitive lighting films regulate the daylight inside the building[9].

Figure 14. Southern elevation of the Arab World Institute. The developed Mashrabiyya covers the whole façade surface

The southern façade restores the vernacular Arabian geometric motifs, consisting of 240 Mashrabiyyas with industrial and decorative character, as if it were a curtain rather than a wall. In the building, there is a delicate and highly complex mechanism like a mosaic of metallic foil that opens and closes Mashrabiyya by photovoltaic cells. The mechanism determines the amount of light entering to the building according to the volume of sunlight outside. The rhythm of this mechanism is designed to allow a maximum of eighteen movements per day.

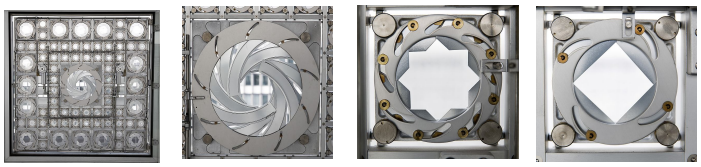


Figure 15. Shapes for the Mashrabiyyas small patterns shows the development and high complex mechanism to open and close by the use of photovoltaic cells

D. Residential Complex

This project is being constructed in Cairo, Egypt, and the project name is “The Gate”. Designed by the architect Vincent Callebaut, the project is expected to be completed in 2022. It is the first sustainable project with a green architecture system in Egypt. The architect aimed to solve environmental problems and reduce energy consumption by employing the vernacular wind towers with modern technologies. The project includes photovoltaic cells that cover the rooftop area of buildings to establish green gardens and parks that aimed to provid a natural insulating layer to reduce the sun’s heat[10].

Figure 16. Top view for the advanced wind towers of the project

Figure 17. The Courtyard from the interior of the building

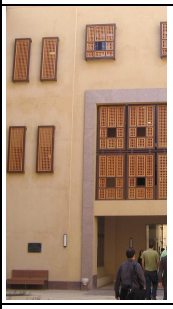
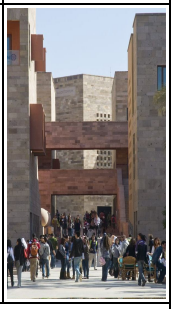
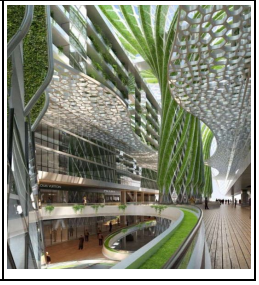
[9] Marco Casamonti, Jean Nouvel, (1st English edition 2009)
[10] Green sustainable architecture “Gate Residence”: innovative design idea of green building, Vincent Callebaut (2017)

Vincent Callebaut relied on the wind towers concept for the whole project. He designed accelerated wind towers where the large opening towards the roof area to collect the air and pass it inside the building to each floor. Due to large size of the wind towers and their locations in the center of the residential units, they not only considered wind towers but also courtyards to be built at each floor to provide natural ventilation and daylight. Callebaut used plant for the inner surface of the wind towers to help air temperature lowered and fresh air generated.

E. Summary

The following table shows the four projects of the contemporary architecture and displaying the advanced forms of the vernacular language that applied:

Table 2. The advanced vernacular language in the four projects.

Project	Advanced Forms Vernacular Architecture		
Masdar Institute Research Center - UAE	Mashrabiy-ya	Wind tower	Courtyard
			
The New American University Campus - Egypt	Mashrabiy-ya	Wind towers	Courtyard
			
The Arab World Institute – France	Mashrabiyya	Courtyard	
			
Residential Complex (The Gate) - Egypt	Wind towers	Courtyard	
			

IV. CONCLUSION

Based on the case study analysis, it was found that the vernacular architecture isn't only valid for the past, but continues to be an effective means for achieving high efficiency of thermal comfort in contemporary architecture worldwide. Vernacular language has found solutions for climate issues, and it could successfully reach to the thermal comfort with simple techniques that passed down generations after generations. The success of Fathy to achieve thermal comfort with vernacular language was an important basis for modern architects to apply vernacular language and get advantages of higher efficiency of thermal comfort. This paper showed vernacular language is valid through global cases.

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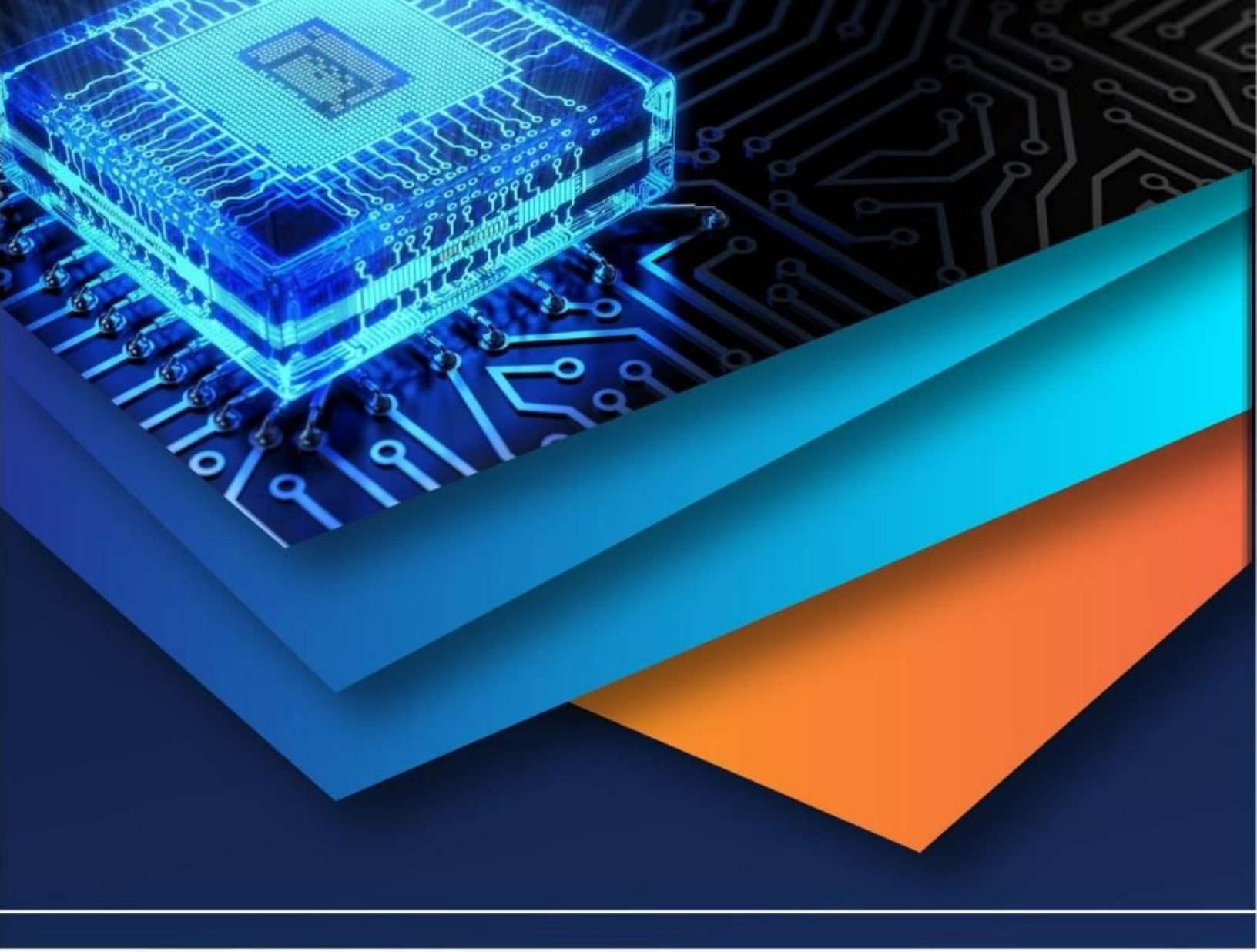

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