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Analysis of Thermal Comfort Techniques for the Performance Conserving of Buildings and Interior Spaces

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ABSTRACT

The analysis encompassed a detailed exploration of the building's architectural, structural, and spatial configurations. Special attention was given to evaluating how these changes impacted the building's usability, overall performance, and its capacity to adapt to contemporary functional requirements. Through spatial transformation analysis, the research uncovered valuable insights into the preservation of the building's original design, its role in maintaining socio-cultural continuity, and its broader contribution to the surrounding urban fabric. This study aimed to critically evaluate and analyze the thermal comfort and functionality of ancient architectural components, specifically focusing on the traditional methods used to enhance thermal regulation and humidity control in response to heat and arid conditions. Additionally, the study investigated the spatial transformations resulting from the introduction of new functional and design interventions in both the interior and exterior of historic buildings. The results of this paper involved an in-depth investigation of the building's architectural, historical, and functional characteristics. This was achieved through a dual approach: a comprehensive visual analysis of the building's physical attributes, alongside a thorough examination of relevant written sources. Together, these methods provided a holistic understanding of the building's original design intent and its subsequent transformations enhance thermal regulation and humidity control.

1. INTRODUCTION

Throughout one of the recurrent themes defining the human Anthropocene is the continuous challenge of adapting to surrounding environmental conditions. In particular, the ability of humans not only to survive but also to form flourishing communities and developments under extreme climates was fundamental to shaping the world the way we see it today. Humans employed a wide range of adaptive techniques to be able to withstand the extreme cold near the North Pole, the hot and humid tropical climates, and the dryness of the hot-arid regions. As such, it is no surprise that such adaptive techniques clearly manifest themselves in even the most primitive of architectural trends since the dawn of civilization.

This environmental awareness in choosing architectural elements transcended the need to merely survive; humans have been striving to deliberately plan their choice of architectural elements to maximize the level of comfort in their residences and establishments. In this context, the notion of comfort encompasses several criteria that include, but are not limited to: thermal comfort, spatial factors, proper lighting, and others [1].

The notion of comfort encompasses several criteria that include, but are not limited to: thermal comfort, spatial factors, proper lighting, acoustic comfort, air quality, and ergonomic design. These factors collectively contribute to an environment that supports well-being and enhances the overall experience of the occupants, particularly in settings designed for the elderly or people with special needs [2].

Traditional cooling methods often rely on passive design principles, which leverage the natural flow of air and thermal properties of materials to reduce indoor temperatures without external energy inputs. Examples include techniques like cross-ventilation, shading, and evaporative cooling. For instance, in Mediterranean and Middle Eastern architecture, courtyards and open windows positioned strategically create natural cross-ventilation, which enhances indoor airflow and prevents heat buildup. Studies show that such passive cooling methods can significantly reduce the need for air conditioning, leading to energy savings and lower greenhouse gas emissions [3, 4].

In contemporary sustainable architecture, there has been a growing interest in adapting traditional cooling methods with modern innovations, blending vernacular knowledge with contemporary technology to enhance energy efficiency. For example, adaptive building facades that adjust to solar exposure and hybrid ventilation systems that combine natural airflow with mechanical controls are becoming increasingly common in green building designs. Research suggests that combining traditional cooling with modern insulation techniques can reduce cooling energy consumption by over 40% in residential buildings [5, 6]. This approach not only supports energy efficiency but also fosters cultural continuity in architecture, making cities more resilient to climate challenges.

Integrating traditional cooling techniques into modern building practices offers a promising approach to addressing contemporary sustainability challenges, particularly in relation to climate change and energy efficiency. Rooted in centuries-old architectural knowledge, methods such as passive ventilation, shading, and the use of thermal mass materials can significantly reduce the need for artificial cooling, thereby lowering energy consumption and greenhouse gas emissions. These time-tested strategies, including courtyards for natural airflow, high thermal mass materials that stabilize indoor temperatures, and reflective or green roof systems that reduce heat absorption, are especially relevant today. As cities grow and temperatures rise, these passive cooling techniques not only help mitigate the urban heat island effect but also make buildings more resilient to extreme weather, offering a low-energy, climate-responsive alternative to traditional air conditioning. Adapting these methods with modern materials and technology supports the development of sustainable, energy-efficient buildings that are better aligned with ecological goals.

The fact that adaptive measures in the realm of architecture and construction vary for different climatic zones is rather intuitive [7]. This paper provides an assessment of the effect of traditional architectural elements on enhancing and conserving thermal comfort in traditional middle-eastern interior spaces. Vast areas of the middle east are classified as hot-arid regions characterized by a hot, dry climate. Analyzing the prevalent traditional building techniques, common building materials, architectural elements, and traditional cooling methods, it is apparent that residents of those areas deliberately developed solutions to respond to the climatic challenges present in their immediate environment. In this region, traditional buildings feature local yet thermally effective choices of construction material [8, 9]. As will be explained in this paper, thermal comfort was also considered when determining the general orientation of these structures and the location of their natural ventilation inlets [10]. Further, traditional Middle Eastern buildings are spatially partitioned in a thermally-comfortable manner through the inclusion of private open spaces. Additional elements are also employed to enhance the level of comfortableness for building users [11].

2. TRADITIONAL TECHNIQUES OF THERMAL COMFORT

Traditional cooling techniques can be highly effective in climates with moderate seasonal temperature variations but may struggle to maintain thermal comfort in extreme heat or humidity. For instance, passive ventilation and high thermal mass may not provide adequate cooling in regions experiencing prolonged heatwaves, where air conditioning can more reliably deliver comfort. In such cases, traditional methods may need to be supplemented with mechanical cooling, reducing their energy-saving potential.

Modern cooling systems are typically more effective at achieving precise temperature control and quick adjustments to changing indoor conditions. Air conditioning, for example, can cool spaces rapidly and is effective in sealed environments, which is often necessary for certain building types like high-rise offices and hospitals. Traditional techniques, by contrast, depend on natural conditions and the building's design, making them less flexible and sometimes inconsistent in providing year-round thermal comfort. In mixed or variable climates, where temperature and humidity levels fluctuate significantly, reliance on passive cooling alone can compromise indoor comfort.

Using traditional techniques often requires architectural compromises. For example:

Daylighting vs. Thermal Comfort: Shading devices, thick walls, and small windows used to reduce heat gain may restrict natural light, affecting indoor brightness and increasing reliance on artificial lighting. This can reduce energy efficiency in terms of lighting, creating a trade-off between minimizing heat and maximizing daylight.

Ventilation vs. Indoor Air Quality: Cross-ventilation and open windows enhance airflow, but they also allow outdoor pollutants, dust, and allergens to enter, which can degrade indoor air quality in urban environments. In contrast, modern cooling systems often include filtration, helping to maintain cleaner indoor air.

Traditional cooling methods may not be feasible or cost-effective in modern high-density urban areas where space constraints limit options for courtyards, green roofs, and other large-scale passive design elements. Additionally, materials like adobe or stone, known for their thermal mass, are not as commonly used or practical in contemporary construction, limiting the applicability of these techniques in some regions and building types.

While traditional cooling techniques reduce energy use and emissions, achieving a balance between energy efficiency and comfort remains challenging. Air conditioning systems, though energy-intensive, can guarantee comfort in a wider range of conditions. Therefore, the potential for hybrid systems which combine passive techniques with minimal mechanical cooling offers a middle ground, allowing buildings to reduce energy use without entirely sacrificing comfort. Such systems could adjust to extreme conditions as needed while otherwise relying on natural methods to maintain indoor comfort.

Thermal comfort can be achieved by controlling two main categories of factors:

The first category is related to humans themselves and the other is related to the environment, the human related factors can be concluded as; the level of clothing and the level of activity. Meanwhile, the factors that are related to the environment are strongly linked to the architecture and design details which can control these factors including: the air temperature, the air velocity, relative humidity and mean radiant temperature [12, 13].

(1) Human-related factors: These include the level of clothing and the level of activity, both of which significantly influence how individuals perceive thermal comfort.

(2) Environmental factors: These are closely tied to architecture and design elements that help regulate the thermal environment. Key factors include air temperature, air velocity, relative humidity, and mean radiant temperature [14].

There were a lot of traditional design details that have been used to control the thermal performance of the buildings in hot arid regions which can control the thermal comfort inside these buildings [15].

In hot arid regions, traditional design features have been employed to enhance the thermal performance of buildings, maintaining thermal comfort inside. Below is a simplified explanation of some of these traditional techniques details.

2.1 Thermal comfort

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is subjectively evaluated (Figure 1). It is one of the most important design goals, focusing on the optimization of heating, ventilation, and air conditioning (HVAC) systems in harmony with the surrounding environment [16, 17].

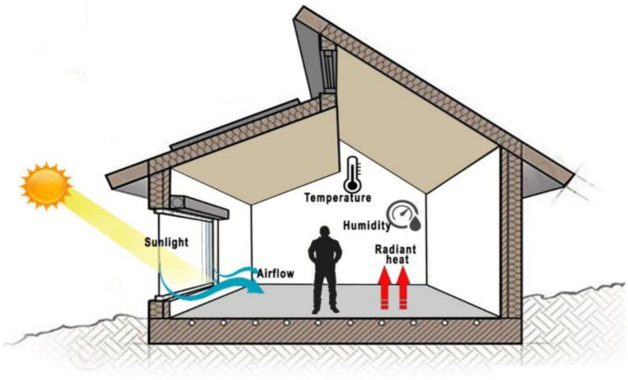

Figure 1. The environmental factors influencing thermal comfort [18]

Furthermore, the suitable temperature for the human body to feel comfortable is around 20 to 24℃ (68 to 75℉), maintaining this temperature range within interior spaces is crucial for ensuring thermal comfort, especially for sensitive groups such as the elderly and individuals with health conditions, but this may vary greatly between individuals. The main factors that influence thermal comfort are those that determine heat gain and loss, namely air temperature, mean radiant temperature, air speed and relative humidity [19].

In sustainable building design, integrating thermal comfort techniques with broader sustainability considerations such as water conservation, material selection, and waste reduction optimizes both building performance and environmental impact. Here's how these approaches intersect and contribute to a building's overall performance and sustainability [20].

Thermal Comfort and Water Conservation: Techniques for maintaining thermal comfort often affect water use, particularly in climates that rely on water-based cooling systems or vegetation for temperature regulation. Passive cooling methods, such as evaporative cooling, green roofs, and living walls, use water to regulate temperatures but can also strain resources in water-scarce regions. Thus, sustainable design often integrates water-efficient strategies, like greywater recycling systems, to support cooling needs without excessive water consumption [21, 22]. Additionally, rainwater harvesting systems can supply water for evaporative cooling or irrigation of green roofs, enhancing thermal comfort while conserving water resources.

Material Selection for Thermal Performance: Materials play a crucial role in thermal regulation, helping to stabilize indoor temperatures and reduce reliance on artificial heating and cooling. High thermal mass materials, like concrete or adobe, absorb and slowly release heat, moderating indoor temperatures without significant energy input. However, the environmental impact of such materials varies, as concrete, for example, has a high embodied carbon footprint. Sustainable design thus prioritizes materials that balance thermal performance with low embodied energy and low emissions, such as recycled or renewable materials [23, 24]. Insulated materials can also improve thermal comfort while reducing energy loss, allowing for a more comfortable indoor climate with less energy use.

Waste Reduction in Thermal Design: Sustainable construction methods, such as prefabrication and modular design, minimize waste while supporting efficient thermal performance. Prefabricated components can be precisely manufactured to reduce on-site waste and are often designed with insulating properties that enhance a building's thermal comfort. Additionally, implementing circular economy principles, where building materials are designed for reuse or recycling, supports waste reduction and sustainable thermal performance. For example, recycled materials like reclaimed wood or recycled steel can provide thermal benefits while lowering the building's environmental footprint [25].

Balancing Thermal Comfort with Sustainability: Achieving thermal comfort in a sustainable way often involves balancing trade-offs among various environmental goals. For instance, while green roofs provide thermal benefits and enhance insulation, they require regular watering and maintenance, especially in dry climates. Lightweight, renewable materials may have advantages in terms of environmental impact, but they may not offer the same thermal mass benefits as more traditional materials. By carefully selecting materials, optimizing water use, and minimizing waste, designers can create buildings that not only prioritize thermal comfort but also align with sustainable resource use and waste reduction goals.

2.2 The traditional compact urban form

The hot arid region cities consisted of buildings, yards and alleys. Buildings were protected against sun and winds, they are connected to each other by exterior walls to achieve the least absorption of solar energy. The compact urban form of the cities provided minimum sun exposure and a shaded alleys network. Those irregular alleys are narrow, high walled and covered by arched roofs which effectively help in shading, preventing the dusty wind, and reducing the exposure to sunlight, thus they can keep cool the whole day and warm during the night and ensure a comfortable air movement [26].

2.3 Building envelope materials

The building envelope thermal performance depends on heat transfer resistance, reducing heat gain and reflecting the sunrays as much as possible the thermal performance of the building envelope plays a crucial role in managing heat transfer, reducing heat gain, and reflecting sunrays in hot arid climates, hence the building envelope of the traditional houses forms an effective barrier against the harsh climate of hot arid region. Traditional buildings materials were usually local and available in the surrounding environment (Figure 2), they also are characterized by their high durability and capability to sustain, such as brick and stone which can remain for a very long time and also trunks, palm fronds and wood as they naturally exist in the surrounding [27].

Moreover, light colors of the building envelope can be very effective in reducing the gain of the summer heat compared to the darker colors. On the other hand, in such climate when the light color is used in the building envelope it could cause the problem of glare; therefore, it becomes a requirement to increase the amount of vegetation and to richen the landscape as much as possible with carefully selected colors of its vegetation. This problem can also be solved by adding different types of projection elements with darker colors to the building facades; these elements are the most exposed to the outdoors, thus they can significantly reduce the glare with their dark color while the rest of the building surfaces are kept in light colors as they contact directly with the interior space [28].

Figure 2. Example of a Mashrabiya in exterior shot (on the left) and in interior shot (on the right) [29]

2.4 Orientation of the building

The main spaces, windows and the building itself should be well oriented in such climate; to ensure minimizing the sun radiation permeation in summer and maximizing it in winter. It is also necessary to take the directions of the prevailing winds into consideration whether it was hot winds or loaded with dirt and dust [14], a suitable orientation of the building assures a lower temperature and obtains a shaded outer space [10].

Proper orientation of the building, including its main spaces and windows, is essential in hot arid climates to minimize sun radiation during summer while maximizing solar gain in winter. The building's alignment should be carefully planned to reduce excessive heat in the hotter months and ensure warmth during the colder seasons. Additionally, the orientation must consider the prevailing winds, whether they carry hot air or are laden with dust and dirt, to mitigate their impact on the building and its occupants [14]. By optimizing the building’s orientation, not only can interior temperatures be reduced, but it also enhances the creation of shaded outdoor spaces, providing comfort for occupants and reducing heat absorption [10].

3. BUILDING ELEMENTS AND PASSIVE COOLING DEVICES IN HOT ARID REGIONS

3.1 Internal and open spaces

3.1.1 Courtyard

Traditional houses used to open into an internal private open space called a courtyard, which is visually and acoustically separated from the outside to enhance the privacy of the occupants. It can be said that the courtyard is the focal point of the house and it has a very important environmental role in obtaining cool indoor spaces, that all of its openings and doors end to this connecting space between all of the house parts, as it is the main social space of the house [26]. The thermal performance of the courtyard can be more effective by increasing the shaded areas and humidity of the space with using water elements and inserting more plants in its landscape [27].

The mechanism of the courtyard is relevant to the phenomenon of the stack effect as it enhances the thermal comfort of the space by employing it to produce cool breezes and raise the dynamic movement of the air [30].

Traditional houses in hot arid regions commonly featured an internal private open space known as the courtyard. This area served as a central hub for the house, providing visual and acoustic separation from the outside, thereby enhancing the privacy of the occupants [31] (Figure 3). The courtyard not only functioned as the focal point of the house and its primary social space, but it also played a significant role in the thermal regulation of the interior. All openings and doors within the house typically lead to the courtyard, making it the connective space for various parts of the home [26].

The thermal performance of courtyards can be optimized by increasing shaded areas and humidity within the space. The incorporation of water elements and the introduction of vegetation into the courtyard landscape can help lower temperatures and enhance environmental comfort [27].

One of the key cooling mechanisms associated with the courtyard is the stack effect, which helps create natural ventilation and airflow that promotes thermal comfort. This passive cooling mechanism generates cool breezes and increases dynamic air movement within the space [30].

Figure 3. Example of a courtyard

This mechanism can be simply described in this cycle; at night the warm air rises and gets replaced by the night cool air that comes down from above. This cooled air gets inside the surrounding rooms and cools them, in the morning the surfaces of the courtyard receive the sun rays and it gets slowly heated, by the evening the courtyard becomes completely covered by the warm air as it was directly heated by the sun and indirectly by the heated surfaces of the courtyard itself as its walls and floors were absorbing the heat all day long. At last in the late afternoon, all the surrounding rooms lose their coolness and become hot again, so the cycle completes at night and repeats again [2, 3] (Figure 4).

The stack effect cycle can be described as follows:

- At night, the warm air inside the courtyard rises and is replaced by cooler night air descending from above.
- This cool air circulates into the surrounding rooms, cooling them during the night.
- In the morning, the surfaces of the courtyard, including the walls and floors, gradually absorb the sun's rays and heat up.
- By evening, the courtyard is enveloped by warm air, directly heated by sunlight and indirectly warmed by the courtyard's heat-absorbing surfaces.
- By late afternoon, the surrounding rooms lose their coolness and become warm again, completing the cycle. As night falls, the cycle restarts, providing passive cooling throughout the house [32].

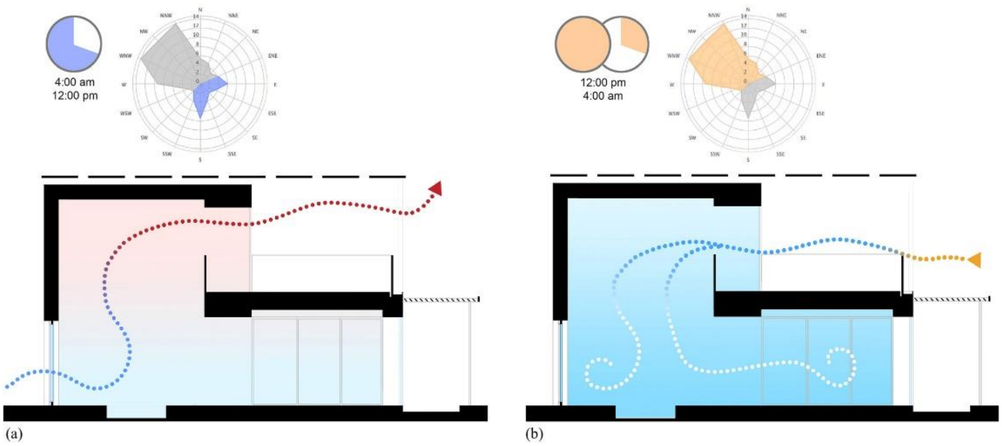

Figure 4. Impact of courtyard on ventilation [32]

3.1.2 The Takhtaboush

The Takhtabush is a covered setting area, placed between the courtyard and the back garden of the traditional house which is completely open to the courtyard and through a Mashrabiya to the back garden, this element ensures a constant air flow (Figure 5). The courtyard is shaded more than the back garden and drags the cooler air to the courtyard through the Takhtabush, as this creates a comfortable semi outdoor setting area that provides shade and increases the occupant's privacy [33].

Figure 5. Takhtaboush in Cairo, Egypt

3.2 Natural ventilation devices

3.2.1 The wind catcher (Malqaf)

The wind catcher is one of the most important passive ventilation devices, it is defined as a rising tower higher than the building roof, and it has one or more openings that face the prevailing wind to catch the desirable air and bring it inside the space, it also known as a wind tower [11], this tower is used in hot regions, middle east in particular [2].

Wind catcher has several names in different Middle Eastern countries, such as "Malqaf" in Egypt, "Badgir" in Iran, "Barjeel" in Iraq and the Gulf and "Mungh" or "Hawadani" in Pakistan [11].

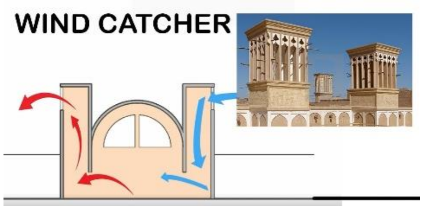

Figure 6. Example of a wind catcher

The function of the wind catcher as a natural ventilation system that uses the wind flow and the concept of buoyancy is to perform as an air conditioner or a ventilator [1], is to catch the upper cooler wind and blow it down inside the building by the effect of the pressure difference. It also helps to reduce the sand and dust because the above air carries less solid materials than the low wind, and if there were any solids in the captured air, it would be dumped at the bottom of the wind catcher (Figures 6 and 7). This tower can also be used as a wind escape in the dense cities when the air velocity is very slow at the windows level if its opening faces the opposite direction of the prevailing wind [14].

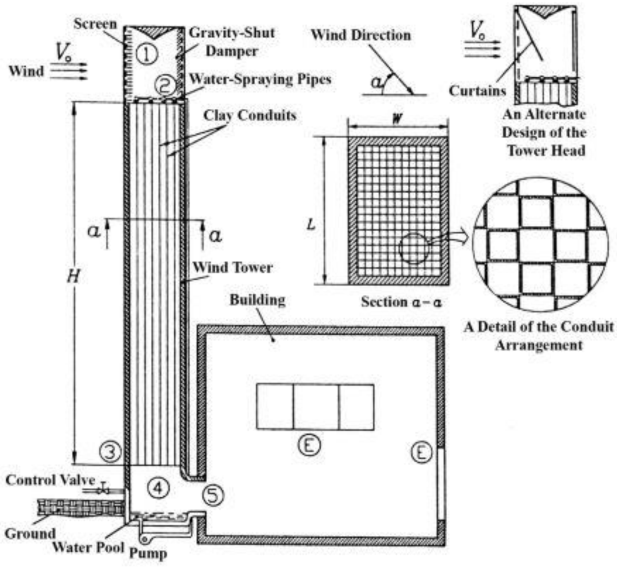

Figure 7. The function of wind catchers [34]

This cooling device consists of an air passage inside thick walls built with materials of a high thermal mass such as mud, bricks and fired bricks, this passage contains smaller passages divided by wall partitions, so the tower can pass the cool and the hot air at the same time [34] (Figure 8). In hot regions, they use the mechanism of evaporative cooling, by putting a wet surface as suspending wetted matting in its interior, a pond or a space underground, so that the air can be cooled when it passes by any of them and the air flow can be increased before it enters the building. After that, it can be directed over a water element such as a fountain or Salsabil to increase the humidity of the air [1].

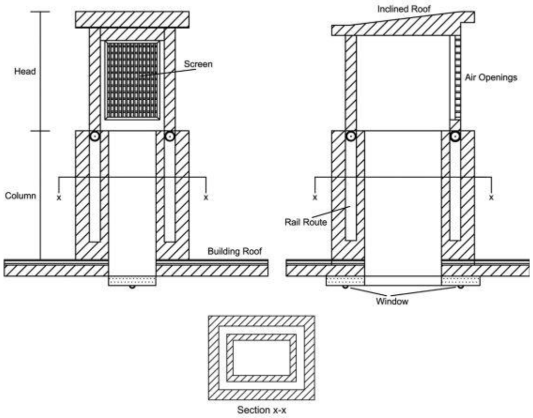

Figure 8. Composition of wind catchers [34]

Generally, traditional wind catchers are categorized into five groups based on the number of their sides (faces) including: one, two, four, six and eight-sided wind catchers, and there is also a cylindrical wind catcher as well [11]. Those faces of the wind catcher contain the openings. Experiments results show that increasing the openings number decreases the internal air flow, and the best efficient wind catcher is the two-sided type [1].

3.3 Windows and openings

3.3.1 The Qamariya

The first use of Qamariya was in Yemen 4000 years ago, it was mostly covered by colored glass, and its location was above the main door of the external window, mainly to produce colored rays of sunlight in the interior spaces. Qamariya has several shapes, it can be a semi-circular opening, or decorated as foils or leaves patterns [33].

"Taqa" or "Rusha" is a simply shaped opening (rectangular or square) placed higher than the window and facing it [14]. The main function of it is to cause different speeds of air movement and cross ventilation, and it also increases the passage of natural light. It was used in a linear, a diamond or in hierarchical arrangement (Figure 9). In some countries, it is also used above the windows and doors.

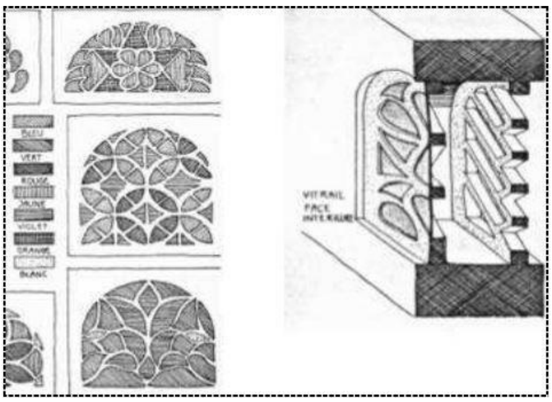

Figure 9. The Taqa and the Qamariya

3.3.2 The Mashrabiya

The name of the Mashrabiya is derived from the Arabic verb "shareba" that means "to drink" and its original meaning is "a drink place" as the Mashrabiya is a space passively cooled to store small clay water pots and cool them by evaporation effect of the air that moves through the opening.

Structure-wise a Mashrabiya can be described as a cantilevered space with a wooden lattice screen similar to a closed balcony. Mashrabiya is also known by several names such as "Shanashel" in Iraq, "Rowshan" in Saudi Arabia, "Mushabak" in Iran and "Aggasi" in Bahrain [35].

Generally, Mashrabiyas were installed in traditional houses and royal residences, and on occasions, it was used in open areas as a structure. There are a lot of types of Mashrabiya and wooden latticework designs of patterns and ornamentation were different from a region to another [36].

Figure 10. Composition of the Mashrabiya

The functions of Mashrabiya according to its design are mainly these five: to control the entry of light, control the air flow, reduce the temperature of the air, increasing the humidity of the air, and it has a strongly related role of providing and ensuring privacy that is essential in the constructive Islamic communities, the Mashrabiya allows the females to see the outside from inside without being exposed to outside men [10] (Figure 10).

The wooden screens that form the Mashrabiya mainly consists of two parts: the upper part that is made of pierced wood and the lower part or the base which is made of solid wood, both of them have Islamic ornamentations of geometrical and abstracted floral patterns [36].

3.4 Roof construction

3.4.1 The Shuksheika

This type of roofs is an open gallery covered by a combination of wood and glass (Figure 11). It was developed to do a function of the lantern, but it also helps in shading the roof and providing cool air while hot air can escape from the lower floors during the day and the cool air gets inside during the night [37].

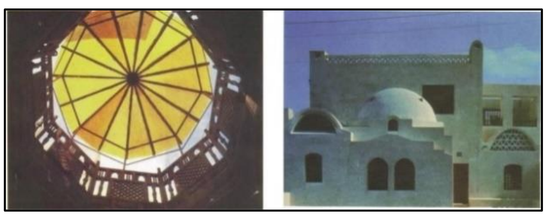

Figure 11. The Shuksheika versus the dome

3.4.2 Domes and vaults

The form of the roof is very important in hot dry climate, the curved roofs such as domes (the hemisphere form) and vaults (the half cylinder form) have many advantages (Figure 12); as they increase the height of the internal space and get rid of the hot air that rises and part of the roof is shaded from the sun for most of the day which can absorb heat from the non-shaded part of roof and the internal air, and moves that heat outside [37].

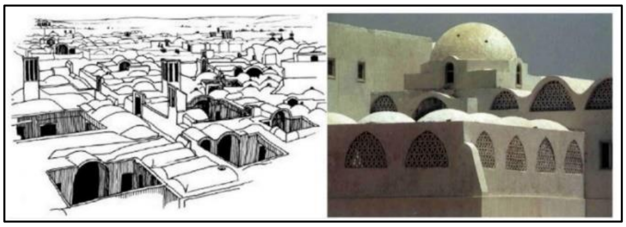

Figure 12. The domes and vaults

3.5 Evaporative cooling devices

3.5.1 The Salsabil

The Salsabil is an evaporative cooling device that used in places where there is not enough pressure to allow the water to get out of the fountainhead, so in this case the fountain is replaced by a Salsabil which is a marble plate, decorated with wavy patterns and placed at an angle inside a niche against the wall, on the opposite side of the Iwan or the setting area.

The water flows from the Salsabil into a marble channel that reaches the fountain in the middle [10].

3.5.2 The fountain

The fountain is originally placed in the middle of the courtyard, it is always shaped in a symbolic form as a squared shape, and it has an inner basin that formed as an octagon or a hexadecagon (Figure 13). The living space or the Iwan is opened onto the fountain that mixes the water with the air to increase the humidity [38, 39].

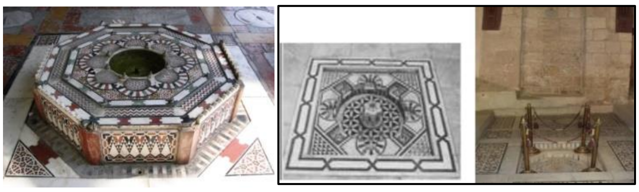

Figure 13. The fountain octagon shape and evaporation cooling devices

4. COMPARISON AND EVALUATION

The foregoing discussion demonstrates the importance and positive impact of aware architectural and building-material choices in maintaining a thermally-comfortable middle-eastern space. Despite their simplicity in terms of concept and implementation, these solutions were crucial to facilitating a comfortable and productive lifestyle in the middle-east for centuries. Moreover, the sensitivity of the people there towards the natural environment highlights the fact that their mental, physical and emotional needs can co-exist harmoniously in their daily lives. It is worth noting that all the traditional elements in Middle East architecture are not merely objects of beauty but also as means to create an environment of peace and tranquility, and this uniqueness can be clearly observed in the functions and meanings of this city's culture and practices. What dictates traditional architecture is not necessarily what is built but how it is built and how that design and build has withstood the test of time and been carried through in other building throughout the community.

Traditional architectural techniques in the Middle East such as passive ventilation, use of thermal mass materials, and strategic shading have long proven effective in maintaining thermal comfort with minimal reliance on mechanical systems. These methods, developed over centuries, are not only environmentally responsive but also align closely with sustainable principles. However, their adaptation in contemporary urban environments presents both opportunities and challenges that merit critical examination.

Linking traditional cooling techniques with contemporary sustainability challenges highlights an opportunity to incorporate historical wisdom into modern practices. By leveraging passive design, mitigating urban heat, and adapting traditional methods in modern architecture, cities and buildings can achieve higher energy efficiency and resilience against the impacts of climate change. As global temperatures rise, these techniques offer a pathway for sustainable urban growth that aligns with energy-saving goals and reduces carbon emissions.

Current waves of modernization invading the urban make-up of middle-eastern cities have been, for the most part, detrimental to the preservation of traditional structures. Further, technological advancements are increasingly replacing traditional passive measures in thermal control applications. The sustainability was a necessity and, a way of life; not just a concept. This concept is what makes traditional architecture as beneficial as a case study for contemporary design, as a template for not only practices that are environmentally friendly, but also the process of sustainable thought. That said, such technologies often come at the expensive cost of a significant carbon-footprint: a cost that our planet will soon no longer be able to afford. Global warming and environmental deterioration are real threats to us and our planet, and this leads us in the direction of drawing inspiration from and taking advantage of traditional thermal control methods as effective yet low carbon-footprint solutions to the historical problem of interior thermal comfort.

The study highlights how traditional cooling techniques such as passive ventilation, thermal mass materials, and shading offer viable, low-energy alternatives to conventional cooling systems. These methods are particularly valuable in regions with abundant solar exposure, where passive cooling can significantly lower indoor temperatures without the need for mechanical systems. By leveraging architectural designs that enhance natural airflow, such as open courtyards and wind catchers, buildings can maintain comfort in a more sustainable manner. The use of thermal mass materials, such as adobe or stone, to absorb and gradually release heat reduces temperature fluctuations, helping maintain a comfortable indoor environment over a longer period. These findings underscore the adaptability and relevance of traditional techniques, even in contemporary urban settings where reducing building energy demand is essential.

In conclusion, the discussion underscores the importance and lasting impact of mindful architectural choices and building materials in maintaining thermal comfort in Middle Eastern spaces. Despite their conceptual and practical simplicity, these traditional solutions have played a crucial role in supporting a comfortable and productive lifestyle for centuries. The sensitivity of the region's inhabitants toward the natural environment reveals a harmonious balance between mental, physical, and emotional well-being in their daily lives. Traditional architectural elements in the Middle East are not merely aesthetic; they serve as functional tools to create spaces of peace and tranquility. What defines traditional architecture is not just what is built, but how it is built and how these designs have withstood the test of time, influencing the broader community.

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