Passive sustainability strategies in traditional Gaziantep residences: a critical report on historical development

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Abstract

In recent years, the increase in the need for energy and the rapid depletion of energy resources have revealed that energy control in buildings is of vital importance. This situation requires energy efficiency not only in new buildings but also in existing building stocks. For this reason, passive strategic measures affecting thermal comfort and energy efficiency in historical buildings built in Gaziantep in the late 18th and early 19th centuries have been evaluated in this study. First, the cultural, technological and natural images of the region that are effective in the development of these strategies were identified. The reflection of these images on architectural design and the parameters affecting energy use as a result were revealed. In order to examine the effect of passive strategy measures in the spaces, a field study was carried out on a selected Gaziantep traditional residential building. For the field study, measurements were taken from the selected building and the street every hour during the day. These measurements have been made under the following conditions: sunny inside the courtyard, sunny outside the courtyard, shade inside the courtyard and shade outside the courtyard. Afterwards, all measurements have been compared. As a result, it is concluded that the courtyard systems that form the cultural, technological and natural image of the region have a great effect on thermal comfort.

Keywords: traditional Gaziantep residences; thermal comfort; passive strategic measures; energy saving

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1 INTRODUCTION

The building industry assumes a vital role in fulfilling societal requirements, enhancing the quality of life and mirroring social and economic attributes. However, it also causes carbon emissions, environmental degradation and an increase in global warming due to the use of natural resources and energy consumption. The construction sector utilizes approximately a third of the world's resources, around one-sixth of its freshwater, a quarter of its wood and roughly 40% of all raw materials. Moreover, construction contributes 40–50% of total energy consumption and greenhouse gas emissions [1]. As a result, researchers have focused on alternative energy sources, heat conservation strategies, renewable energy solutions and sustainable design [2]. In fact, it is remarkable that such issues were taken into consideration centuries ago [3], and designs were created according to different climate zones, but the designs made today ignore these issues. Passive energy measures taken in historical buildings and structures symbolize the cultural legacy bequeathed by earlier generations and ought to be conserved to serve the well-being of generations to come [4].

Gaziantep Province, where such historical structures are frequently encountered, is only one of the important cities in Turkey. In scrutinizing the conventional architectural style of

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Gaziantep, it becomes evident that the selection of construction materials, arrangement of facades, spatial orientation and even the configuration of spaces have been significantly influenced by the area's inherent natural resources, cultural attributes and technological potentials. These factors collectively exert a discernible influence on the energy efficiency aspects of the building. However, these parameters could not be transferred to later structures for various reasons.

Nevertheless, the construction industry in Gaziantep has witnessed a rise in demand due to a significant influx of immigration to the province. Therefore, building production has overgrown in this region. However, in addition to problems such as energy consumption and rapid consumption of limited resources, there are also design defects caused by quick and urgent building production due to increasing building demand. Passive energy measure decisions taken for the traditional residences of the region could not be transferred to the later buildings since, in subsequent buildings, cultural requirements and the use of natural resources are ignored, and a drastic change is made in the construction system with the developing technology. Alterations in these design decisions and ignoring various parameters have increased the amount of energy needed in buildings.

When modern houses are compared with the traditional Gaziantep houses built in the 1800s, it is seen that the traditional Gaziantep houses have a higher level of thermal comfort. This situation has attracted attention in the academic community, and there has been a tendency towards the research of technologies based on renewable, clean energies. Since the historical characteristics, climatic characteristics and geopolitical and geographical locations of the city are influential factors in terms of thermal comfort in the evaluation process, these issues are mentioned in detail in the study. Within the scope of this study, the design decisions and operational measures taken to achieve energy efficiency and thermal comfort of the accommodation structures designed between 1800 and 1900 of the historical Gaziantep houses are analysed.

Due to developing technologies and changing living standards, transferring all these parameters to modern buildings is impossible. However, these parameters will be important criteria for the design of new buildings. By modernizing these parameters, it is thought that energy usage can be mitigated in newly constructed buildings. The uniqueness of this study is that the parameters arising from natural resources and cultural and technological benefits of traditional Gaziantep houses have yet to be analysed in previous studies.

Over the past few years, the growing population has led to a heightened requirement for energy. In response, the International Energy Agency (IEA) has undertaken research endeavours focused on achieving net zero energy emissions by 2050 [5]. Roughly 32% of this demand can be attributed to the global construction sector [6]. Plenty of work has been done to make buildings sustainable regarding energy performance [7]. In the literature, research on the energy efficiency of buildings is listed as follows; innovative research on the building envelope aiming to optimizing the heating and cooling loads of the building [8, 9] research on regulating heat transfer through elements such as doors and windows [10], [1] and novel approaches and enhancements concerning the roof [11]. However, these investigations can only be implemented for new constructions. Given that historical buildings hold a distinct and esteemed status, they are subject to oversight by multiple institutions and organizations, and diverse steps are taken to safeguard their originality and prevent degradation.

Historical buildings have exceptional qualities in terms of aesthetic understanding of a certain period, sociocultural structure, construction methods, design and manorial importance. Historical buildings are recognized as an integral component of contemporary society. In addition, throughout history, architects have consistently employed diverse strategies and techniques in architectural design endeavours to achieve buildings that provide comfort and suitability in accordance with the specific climatic and environmental characteristics of their respective regions. Within this framework, historical structures are frequently perceived as reservoirs of energy conservation potential [12]. According to Godwin [13], the whole emphasis in the production of new buildings in the UK is on minimizing energy consumption. However, he also emphasizes that there is a linear relationship between the construction of historical buildings and sustainability.

In their study, Moran *et al.* [14] put forth the implementation of photovoltaic panels (PVs) as a means to curtail energy consumption in historical buildings and ultimately deduced that PV technology indeed proves effective in diminishing energy consumption. Nevertheless, it should be noted that these practices are typically restricted in certain countries, as interventions on historical buildings necessitate special permissions, and any alterations that might compromise the authenticity of the structure are strictly forbidden. Nevertheless, upon scrutinizing the conventional building systems across diverse regions, it becomes evident that intriguing passive energy conservation measures are already in place.

Literature research shows that various methods have been developed to provide thermal comfort in historical buildings in different climates and cultures. Dormohamadi *et al.* [15] examined the windcatcher elements used for passive cooling in Iran, which is located in the hot climate zone. Windcatcher elements have become a traditional architectural element in Iran and have been effectively used to reduce cooling loads. Alwetaishi *et al.* [16] conducted a study examining the impact of windows on the thermal comfort of historical building facades in Taif, situated at a relatively elevated position in the Arabian Desert. The study reveals that the size and characteristics of windows play a substantial role in influencing indoor air temperatures and overall energy usage within the buildings. In Taif, with a warm climate, it is possible to obtain thermal comfort in autumn, winter and spring without the need for additional energy, while air conditioning is necessary due to the high temperature in summer.

According to Al-Sakkaf *et al.* [17], the concept of sustainability in historical building research should be evaluated from a much broader perspective in terms of environmental, economic and sociocultural aspects so that sustainability concepts can be

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considered holistically while preserving historical values. The literature review in the framework of sustainability actually shows that traditional Gaziantep houses take various traditional and passive measures to conserve energy. Furthermore, Wu *et al.* [18] emphasized that thermal comfort in historical buildings is influenced not only by architectural spaces and elements but also by human actions. Consequently, when assessing the sustainability of historical structures, the significance of human activities within these spaces should not be disregarded.

Within the context of this research, the study will evaluate the cultural characteristics of the region and the behaviours of its inhabitants while examining the proposed solutions aimed at mitigating passive heating and cooling loads in traditional Gaziantep houses. Therefore, within the scope of this study, the effect of the correct architectural design measures on thermal comfort in historical buildings is investigated.

2 RESEARCH METHODOLOGY

The efforts undertaken by the IEA to achieve a state of net zero energy by the year 2050 are also relevant to preexisting architectural structures. Nevertheless, in the analysis of heritage edifices, it becomes imperative not only to optimize energy utilization but also to duly recognize and account for the cultural, technological and environmental imprints inherent to a specific era. These manifestations, encompassing cultural and climatic influences, along with their intricate interplay, necessitate a comprehensive standpoint. Thus, a holistic methodology must be embraced, wherein these manifestations are meticulously contemplated in all endeavours aimed at the preservation and modification of historical constructions.

As depicted in Figure 1, the sustainability framework for the historical building has been defined to encompass cultural, technological and natural aspects. In this study, passive strategy parameters will be revealed by examining the decisions taken in the design, implementation and use of Gaziantep traditional houses in the context of sustainability. Then, the materials, facade design and orientations, environmental design and courtyard systems of traditional Gaziantep houses will be examined, and passive measures will be determined in the context of sustainability. These specified parameters are both crucial data that should be considered in historical building intervention processes and critical data that can be used in new building production.

2.1 Sustainable architectural concept

It is possible to divide the images of sustainable architectural concepts into various titles. Within the scope of this study, images are analysed as natural, cultural and technological images. In addition, the harmony and unity of these images with each other are evaluated.

2.1.1 *The natural image*

People cannot design their living spaces independently from the spatial and environmental context. Design considerations must encompass the living elements as well as the non-living elements that coexist in the environment. When examining traditional architectural structures, it becomes evident that they harness the inherent advantages of nature. For instance, they make use of the sun's warmth and the cooling effects of trees' shade and breeze. Traditional building materials like wood, stone and straw, which are region specific and obtained from nature, are employed. However, with contemporary buildings often being multi-storeyed, even with advancements in solar and wind energy utilization, trees alone cannot sufficiently control the climate. Moreover, local materials may not provide the required structural stability for multi-storey constructions. As a result, modern buildings use concrete for their structural systems, whilst natural materials such as stone and wood are often used only for decorative purposes (e.g. cladding), ignoring their functional properties.

In traditional buildings, it is known that building materials in the region are used in the construction of buildings. In the construction of traditional Gaziantep residences, the stones extracted from the parcel where the building will be built are used in the construction of the building. The cave formed by the material extracted from the ground is shown in Figure 2. These caves are used as cellars where supplies will be stored during the use of the building.

The geometry of the caves is irregular. There are small chimneys inside the cave that will provide natural ventilation. These chimneys provide the moisture balance inside the cave and ensure the long-term storage of the provisions to be kept inside. It is a remarkable feature that these caves are pretty cool, especially in the hot summer months, and that no energy source is needed for this coolness. On the other hand, when modern buildings are analysed, it is seen that energy-demanding refrigerators and deep-freezer cellar systems have replaced these natural air-conditioning features used in traditional buildings.

One of the natural images of Gaziantep is the system called 'livas and kastel', which were built underground to carry water to the city. The water flowing through the livas merges in the kastels, and the kastels are used as public spaces [19]. Livas establish a physical relationship with wells in the earth. There are wells in the gardens of many houses in the region. These wells take water from the livas and are used for garden irrigation, filling the water of the pool called gane, and for various daily needs. This is considered a passive strategy of the structures in the use and utilization of special resources such as water.

2.1.2 *Cultural image*

Cultural image is an approach that delineates distinct and meaningful local architectural characteristics [20]. Design criteria include not only climatic conditions but also other life-affecting factors, such as religion. Different space sizes and connections are required to accommodate privacy, the number of occupants and internal circulation scenarios. Culture stands as one of the most significant influences on building an organization. The choice between directly opening the house's outer door to the street or courtyard or creating a transition space (e.g. yard or narrow alley) between the street and the house exemplifies the impact of culture.

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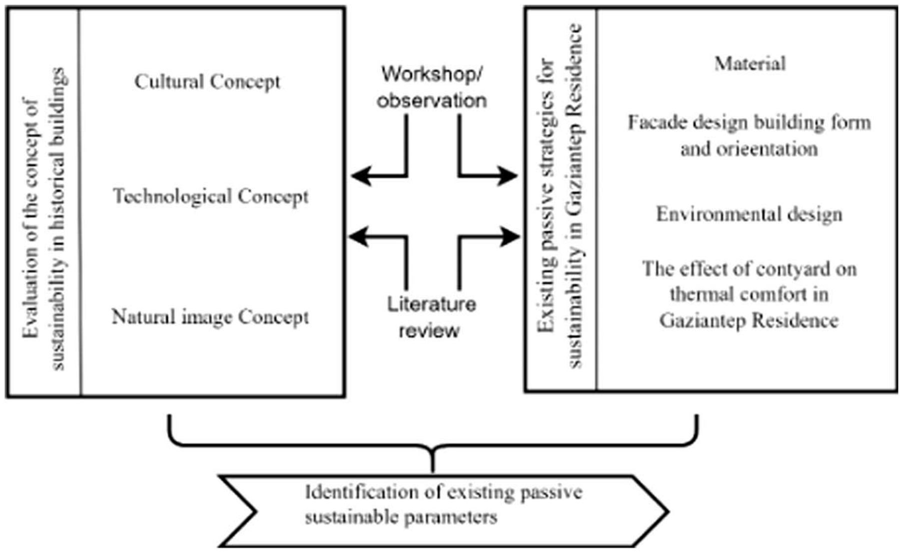

Figure 1. *Graphical presentation of research methodology.*

Figure 2. *Cave in traditional Gaziantep residences.*

This spatial arrangement plays a crucial role in addressing privacy needs while also adapting to climatic conditions.

Gaziantep region culturally has a large family structure rather than a nuclear family structure. For example, when the number of children of the residents of the house increases or when the children grow up and get married, they live with the family. In this case, new spaces are needed with the increase in the number of family members living in the residence. In this case, new spaces are added right next to the house and put into use. As a result, elevation differences exist between the added and existing spaces, as shown in Figure 3. The spaces between these elevation differences can be accessed by wooden or stone stairs.

The fact that rooms can be added for the needs in traditional construction systems allows flexible design. However, this adaptable design arising from cultural requirements is not possible for modern buildings. Gaziantep modern residential buildings are multi-storeyed, and the design is completed at the initial stage. Hence, even if the needs alter, changing the space design is impossible due to static requirements.

2.1.3 *Technological image*

The technical perspective relies on science, technology and management to offer solutions for environmental challenges. This approach employs quantitative calculations, such as energy efficiency, and emphasizes a human-centred approach [21]. In traditional architecture, climate control solutions were devised based on the technological possibilities of their time. These solutions encompassed elements such as relatively thick walls, limited use of glazed areas with narrow dimensions and designing spaces to serve multiple functions.

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Figure 3. *Level differences between spaces.*

Figure 4. *Passive ventilation system.*

In the context of traditional residences in Gaziantep, the construction technique predominantly involves the utilization of masonry stone. This approach gives rise to a set of regulations that govern its implementation. Among these regulations, specific constraints pertain to the dimensions of windows and doors within walls constructed using the masonry methodology. This limitation is a direct outcome of the masonry technique's fundamental characteristics. Given that all walls within masonry structures bear significant loads, the prospect of creating sizable openings becomes unsuitable from a load-bearing perspective. Nevertheless, the need for additional windows arises to ensure sufficient interior illumination. These windows tend to be smaller, particularly in spaces proximate to the ceiling. This particular scenario has consequently evolved into a distinctive technique employed to facilitate interior ventilation, as illustrated in Figure 4. This method is a passive natural ventilation system that does not impose additional costs.

Nonetheless, owing to advancements in technology, contemporary constructions can now incorporate larger windows. While these windows offer notably elevated levels of illumination, they need to address diverse factors such as optimal natural ventilation and effective heat permeability. Given Gaziantep's location within a hot climatic zone, extended periods of intense summer sunlight prevail. Consequently, the cooling of interior spaces becomes imperative, resulting in a significant challenge pertaining to cooling loads for occupants. In addressing these challenges, solutions have arisen, including sun shading components capable of adapting their angles in response to the sun's orientation, as well as the implementation of double glazing techniques. Nevertheless, it is vital to bear in mind that these innovations are not sustainable due to supplementary construction expenses and the requirement for ongoing maintenance over extended periods.

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2.2 Sustainability in building design

To achieve sustainability in building design, it is essential to ensure comfort conditions, offer self-sufficient solutions and maintain harmony with the natural and artificial environment. During the design process, factors such as orientation, climatic data, geographical features, building form and space organization, landscape, environmental design, facade features, materials and construction systems are carefully considered. In this section, in order to examine the thermal regulation on the facades of Gaziantep houses, the buildings are analyzed under three main categories: firstly material selection, secondly facade design, building form and orientation and environmental designs, and finally the effect of traditional courtyard systems formed by the form on thermal comfort.

2.2.1 *Material*

Material selection in Gaziantep region consists of local materials. There are various stone types such as Keymık, minaret stone, Havara stone and black stone in the region. The mechanical characteristics of Keymık and Havara stones, both sourced from the same geographical area, exhibit discernible disparities. Keymık stone demonstrates greater hardness, lower porosity and enhanced strength than Havara stone. Conversely, Havara stone possesses porous and breathable attributes, rendering it more amenable to processing. This inherent quality facilitates its incorporation into construction practices [22].

The prevalent construction technique in this region involves erecting walls in a dual-layer configuration. Keymık stone finds application in the external layer due to its minimal water absorption and heightened resilience against external forces. In contrast, Havara stone finds utility within the internal region. As depicted in Figure 5, the interstice between these two layers is filled with rubble. This design culminates in the creation of walls that are not only breathable but also conducive to comfort.

2.2.2 *Facade design, building form and orientation*

The building form, facade elements and the ratio of full and empty elements on the facade are the parameters that affect the energy use of the building. With technological advancements, numerous strategies have been implemented to regulate thermal conditions and, consequently, energy transfer in building exteriors. Several approaches can be employed to mitigate heat transfer on building facades during new construction. In the study by Hosseini *et al.* [23], one such approach involves the utilization of kinetic shading elements to prevent heat dissipation from building facades. Correspondingly, Anaç's thesis [24] demonstrates that kinetic shading elements present an efficacious means of heat preservation on building facades. Cuce *et al.* [1] proposed a new glazing system to control this heat flow. In the literature, excessive novel products and proposals exist to block heat transmission from facades. Nevertheless, employing these systems in historical buildings poses significant challenges [25]. Historical buildings embody cultural heritage owing to their unique aesthetic value and construction techniques, necessitating utmost care and precision in any interventions. It is also noteworthy that these measures impose an additional cost during the manufacturing phase.

When the historical buildings of Gaziantep are examined, it is seen that measures have already been taken to prevent this heat and energy transfer. The dwellings in this region feature a double-layered window design, wherein a single-walled glass constitutes the outer layer, while the inner layer is a cover section (Figure 6). These covers are crafted from wood and represent a traditional Gaziantep architectural element known as 'nacar workmanship'. The nacar workmanship is an artisanal practice prevalent in the region, adorning all interior walls and serving as window covers. These covers effectively regulate indoor thermal conditions by preventing excessive heat gain during summer and minimizing heat loss in winter. Consequently, these elements not only ensure energy control but also contribute to a distinctive architectural aesthetic within the interior spaces. Through experimental methods, the study carried out by Kim *et al.* [26] provides evidence that incorporating wood in the walls of architectural spaces has a positive impact on thermal comfort. Moreover, the traditional nacar workmanship of Gaziantep is also shown to contribute to thermal comfort positively.

Gaziantep is in the continental climate zone and has dry air, so making designs by creating wind in buildings is one of the passive strategies of the region. Increasing the air quality in the interior of the space and determining the wind speed and direction have been important data of architectural designs. Generally, the narrow facades of buildings in Gaziantep are orientated east-west. According to Darçın and Balanli [27], the narrow facade is shaped in the direction of air movement, and the strong suction effect occurs as a result of the negative pressure on the wide facades of the buildings. In this case, the ventilation effect of Gaziantep houses with the prevailing wind on the northwest facade is increased.

2.2.3 *Environmental design*

Within the Gaziantep region, the dominant wind pattern during the winter months originates from the northwest. As a result, the architectural arrangement of houses primarily involves a south-facing orientation. An especially salient observation is that the windows situated on the north-facing facade are comparatively smaller in size than those on the south-facing counterpart. This consistent design approach across the locality culminates in a cohesive architectural unity, readily evident throughout the streets (Figure 7).

Located within a hot and arid climatic zone, Gaziantep exhibits a housing layout where dwellings are closely aligned, and streets are intentionally narrower than contemporary norms. This design philosophy significantly contributes to shielding inhabitants from the intense summer sun and the harsh cold of winter. The elevated building density serves to obstruct the penetration of scorching sunlight into the confined streets, giving rise to shaded areas. During the winter months, this configuration acts as a barrier against chilling winds, fostering a more comfortable street environment in comparison to open expanses.

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Figure 5. *Gaziantep traditional wall detail; Keymık and Havara stone example.*

Figure 6. *Windows and window covers of Gaziantep residences.*

Although the prevalent architectural style emphasizes neighbouring building structures, cultural elements seamlessly intertwine with design considerations, resulting in introverted living spaces. Nevertheless, residents maintain a connection with the street, evident through projecting windows that expand perspectives onto the thoroughfare. The height of the buildings is also strategically orchestrated to prevent obstruction of natural light to adjacent residences.

As explained in Section 2.2.1, the material used in the exterior facades of Gaziantep houses is Keymık stone. The gaps in the structure of the Keymık stone are quite tight, and it is a stone with high strength; in addition, it is a stone that is very difficult to process. For this reason, there are no special stone embroideries on the exterior facades of the buildings. However, the gaps created on the facades come from the original dimensions of the stone. Windows and doors are arranged according to the possibilities of stone dimensions, creating a rhythm on the facades. This existing rhythm follows each other throughout the neighbourhoods. One of the elements that complete this rhythm is wrought iron. These aesthetic elements created with the shapes given to cast iron can be created with simple or various geometric shapes. One of the elements that complement this rhythm is iron street doors. As a result, the special rhythmic and original perception of iron and stone materials creates aesthetic perception for Gaziantep neighbourhoods.

2.2.4 *The effect of courtyard on thermal comfort in Gaziantep houses*

The pools in the courtyard, called gane, affect the visual aesthetics of the buildings and are used as a passive cooling strategy. The enclosed courtyard, enveloped by walls and architectural structures, engenders a microclimatic environmental enhanced by a variety of plants and water features. There is a fascinating cooling concept called evaporative cooling, which is the cooling process of the space with the water element. In this system, the moisture cools the dry air by direct evaporative cooling [28]. During the summer months, when daytime temperatures peak, inhabitants find respite within the comparatively cooler confines of the courtyard. Following the waning of the sun, irrigation is employed to temper the heated surfaces, leveraging the cooling effects of evaporation. The enclosure incorporates materials such as white stone, black stone and pink marble. Notably, white stone possesses

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Figure 7. *Traditional street view of Gaziantep.*

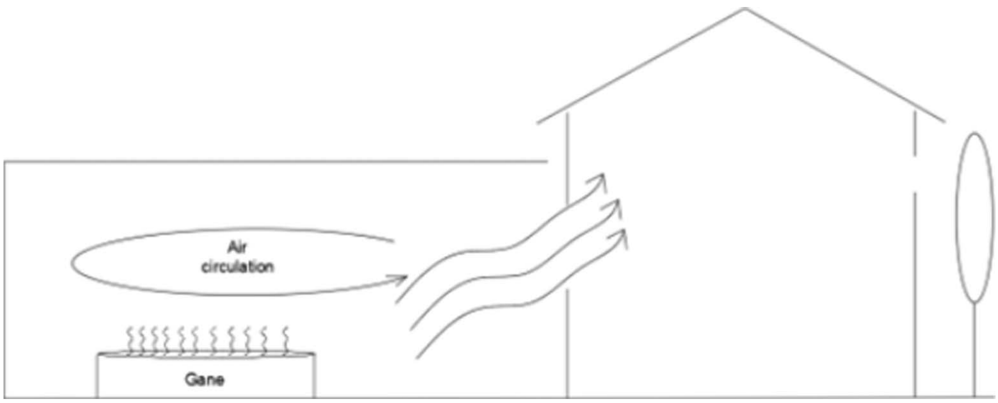

Figure 8. *Reflection of the air conditioning in the courtyard on the building.*

the capacity to retain water, facilitating temperature moderation through the continuous evaporation of its contained moisture during irrigation events. The water used for the irrigation of the courtyard is well water drawn from the wells and filled into the gane, as mentioned earlier. Moreover, the courtyard serves a crucial role by regulating both light entry and temperature modulation within the residing spaces. One of the biggest reasons for the widespread use of water elements is the low relative humidity of the air. Water elements have the ability to humidify and cool the air with the effect of evaporation (Figure 8).

Through the incorporation of courtyards, dwellings have evolved into intricate systems capable of generating their own microclimates. The diurnal and nocturnal heat exchanges occurring within these courtyards operate organically, obviating the necessity for unsustainable mechanical energy inputs. Consequently, the passive cooling techniques embedded within the design of traditional courtyard houses ought to serve as foundational principles for contemporary methodologies. So as to assess the impact of the courtyards on the temperature of the spaces, the temperature and humidity values are measured with a thermometer in the courtyard of the traditional Gaziantep residence, which is currently used as the ÇEKÜL office, located on 1064 block 102 parcels, on 18 August 2023 between 12:00 and 17:00. The measurement results are given in Table 1. Measurements were made with TTT-ECHNI-C DS120 brand digital thermometer and hygrometer. The measured building has been modelled in Autodesk Revit programme, and the thermometers have been placed as shown in Figure 9. Accordingly, in the area numbered 1, data related to the shadow inside the courtyard, in the area numbered 2, sunshine measurements inside the courtyard, in the area numbered 3, shadow data outside the courtyard and in the area numbered 4, sunshine data outside the courtyard have been obtained. Meteorological data indicate an average temperature of 35°C; measurements are usually higher than this. In a region, meteorological stations or official measuring instruments are usually located and calibrated in accordance with certain standards. However, due to various factors such as materials in the region, architectural design effects and temperature change in the region as a result of the reflection of sunlight on the surfaces, the measurements made in the field are different from meteorological measurements. These temperature differences in spaces and areas affect the thermal comfort of people. In order to determine these temperature changes, measurements were made from the sunlit part of the

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Table 1. *Evaluation of courtyard temperature and outdoor temperature according to time in traditional Gaziantep houses.*

Hour	Courtyard in the shade (first measure point)	Courtyard in the sun (second measure point)	Exterior in the shade (third measure point)	Exterior in the sun (fourth measure point)
12:00	32.3°C 20% Humidity	40.3°C 11% Humidity	40.5°C 11% Humidity	42.2°C 11% Humidity
13:00	32.8°C 19% Humidity	42.6°C 11% Humidity	44.3°C 11% Humidity	47.5°C 11% Humidity
14:00	34.5°C 19% Humidity	47.5°C 11% Humidity	44.7°C 11% Humidity	49.6°C 11% Humidity
15:00	35.9°C 19% Humidity	48.6°C 11% Humidity	45.1°C 11% Humidity	49.8°C 11% Humidity
16:00	35.7°C 19% Humidity	48.4°C 11% Humidity	45.2°C 11% Humidity	49.4°C 11% Humidity
17:00	33.4°C 19% Humidity	45.3°C 11% Humidity	40.1°C 11% Humidity	46.4°C 11% Humidity

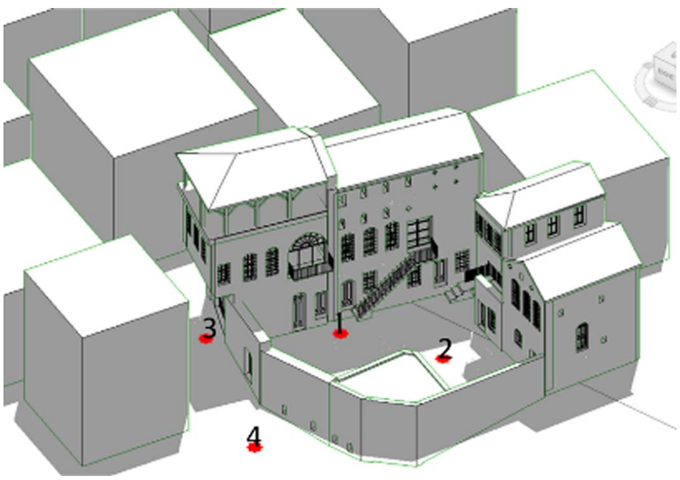

Figure 9. *Data receiving locations.*

courtyard, the shaded part of the courtyard, the outdoor sunlit part and the outdoor shaded part.

The measurement difference between a sunny courtyard and a sunny outdoor environment varies between about 2°C and 5°C. The measurement difference between a shaded courtyard and a shaded outdoor environment range from about 8°C to 10°C. The materials used in the courtyard, the heat reflected from the materials, the architectural design, the core heat qualities of the materials and the relative humidity within the materials have been effective in such different measurements inside and outside the courtyard with similar characteristics. The temperature difference between the shaded area and the sunny area in the courtyard is approximately 8°C to 13°C. As indicated in Table 1, the temperature difference between the shade inside the courtyard and the sun inside the courtyard is quite high. Due to the architectural design, the same places are in the shade between the same hours every day, which maintains the heat conservation and moisture content in the material. This situation has made the shaded courtyard more comfortable thermally. It can be concluded that the increase in the comfort of the courtyard depends on the ratio of the floor height of the building, the height of the wall surrounding the courtyard and the width of the courtyard.

3 RESULT OF CASE STUDY (TRADITIONAL GAZIANTEP RESIDENCE)

Buildings typically consist of two storeys, with rare instances of three-storey structures. The height and number of storeys are determined in accordance with the requirements of the occupants. Gaziantep houses exhibit an introverted architectural design characterized by enclosed courtyards and building walls of greater height than the average line of sight. This design feature is closely associated with the region's cultural perception of privacy and takes into account the prevailing climatic conditions. The elevated walls and positioning of the buildings contribute to the formation of the courtyards, which assume a functional significance, particularly during the summer months when the temperatures soar. Consequently, the courtyards receive meticulous attention and are accorded considerable relevance. The courtyard flooring is adorned with stone embellishments, while floral arrangements adorn the periphery, and the central area features a collection of various geometric structures referred to as 'gane'. The 'gane' serves as a distinctive architectural element, employed both for the purpose of cleansing the courtyard and providing a cooling effect.

The main entry to these structures is provided through access points from the street, leading to the inner courtyard, and further access into the building is attained by traversing the square. The first floors of the edifices offer direct accessibility from the courtyard, whereas the upper floors are reached through staircases that are connected to the courtyard. Upon examining the typologies of residential plans, they encompass rooms organized around a semi-open space known as an 'iwan'. As depicted in Figure 10, the iwans are enclosed spaces, whereas the facades facing the courtyard remain open spaces. These areas are utilized during the hot hours of the day when the courtyard becomes impractical for use. The rooms surrounding the iwan serve multiple functions,

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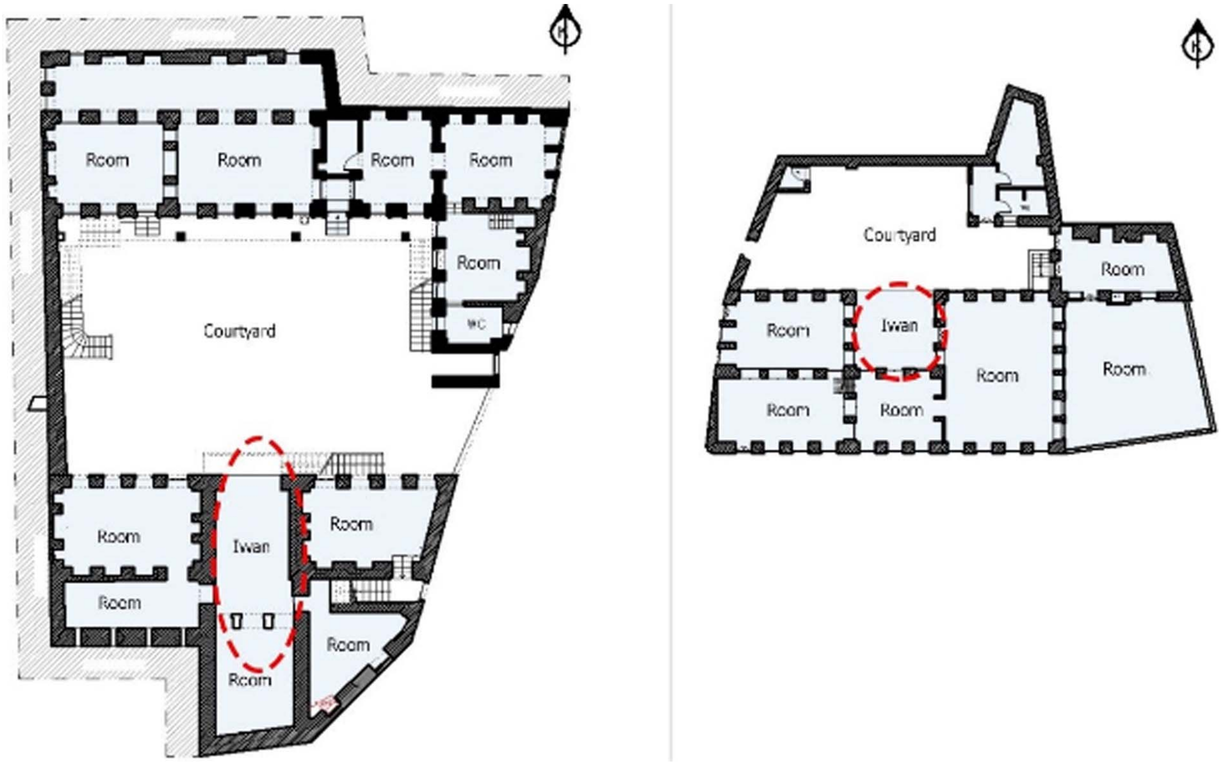

Figure 10. *Plan typology of traditional Gaziantep residences.*

being adaptable to various needs. Over time, the buildings have been augmented with additional spaces in response to evolving spatial requirements. These flexible rooms have been purposefully designed to accommodate activities such as dining, sleeping and everyday functions [29]. In Gaziantep houses, the form is intricately linked to operation. In other words, the spaces are added and expanded according to the specific demands, ultimately shaping the final form.

When the facades of Gaziantep residences are analysed, the windows on the facades facing the courtyard are larger and more frequent. In comparison, the facades facing the street have smaller and sparser windows. This situation is the result of both cultural requirements and the necessity of a natural image. In addition, the shapes of the windows and the wrought iron in front of them reflect the religious beliefs of their owners and add to the aesthetic diversity.

The ÇEKÜL building, which reflects the traditional Gaziantep houses, has various passive strategic measures according to the climatic conditions. These can be listed as follows:

- Buildings are produced by adding space later. In this case, as the number of family members increases, there is no need for a new parcelization. In this case, the spaces in the building can be developed by constantly adding new rooms.
- The layout and rhythm of the windows and ventilation windows are arranged to ensure the air comfort of the space.
- The orientation of the building is organized in a way to benefit from wind circulation and to provide faster ventilation of the interior space.
- It consists of two layers as a walling system. Keymık stone, which is less affected by environmental conditions, is used in the outer part, and Havara stone, which takes air due to its voided structure, is used in the inner environment. The wall is built in two layers and filled with rubble between the layers. This rubble also provides thermal insulation.
- The walls covered with nacar workmanship, which are made primarily with aesthetic concerns in the interior, constitute one of the passive strategies that prevent heat loss.
- The pools in the courtyard of the buildings, called gane, constitute a passive cooling strategy called evaporative cooling.
- The shaping of the streets forms narrow wind corridors.

The research shows that the traditional Gaziantep houses have many passive strategic measures that increase energy efficiency and thermal comfort in many respects. In the research conducted, there are no data on the numerical effect of these measures for the Gaziantep region, but in the literature research, it has been determined that passive strategic measures provide approximately 10% energy savings [30].

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Table 2. *Reflection of sustainability parameters on traditional and modern buildings*

Parameters	Traditional Gaziantep residences	Modern Gaziantep residences
Natural image	• The presence of caves due to the extraction of material from the site • Access to underground water sources through livas and kastels	• Natural images are not reflected in the architectural design
Cultural image	• Flexible space through family structure and cultural inputs	• No flexible design
Technological image	• Masonry construction system • Special ventilation arrangement	• Frame construction system • Need for artificial ventilation
Material	• Natural and local ecological materials	• Concrete material
Facade design, building form and orientation	• Facade window orientation in the courtyard • Elements providing heat and light control	• Facade orientation random • No heat and light control element
Environmental design	• Privatized street layout	• Random street layout
The effect of courtyard on thermal comfort in Gaziantep houses	• Special air conditioning in the courtyard	• No courtyard

4 DISCUSSION

Within the scope of the study, passive strategies for energy conservation in traditional houses in Gaziantep were identified. Material properties, environmental features and courtyard systems were examined, taking into account the influence of natural images, technological images and cultural images in the formation of these passive strategies. All these inputs have been effective in increasing the thermal comfort of the buildings. The comparison of these parameters revealed in the study with modern buildings is given in Table 2. Accordingly, the use of natural imagery results in the formation of caves and the use of energy to store and protect supplies. In addition, the presence of 'livas and kastel' resulted in passive measures such as the use of underground water sources for watering the garden and using the water needs of the 'gane' in the courtyard. However, it is known that in modern buildings these natural images are ignored and refrigerators or various electrical devices are used for food storage. Besides, underground water resources have been ignored in architectural design. The cultural life of Gaziantep creates the possibility of adding spaces. This situation reveals flexible architectural designs. But modern buildings do not allow the addition of spaces. In the traditional construction system of Gaziantep, the technology of the period required the buildings to be masonry stone structures. It has revealed the window system that will count natural ventilation on the facades. In modern buildings, the carcass system is used as a construction system. Although more technological systems are used in the use phase of the buildings, these technological devices have made the buildings more energy-dependent.

The traditional construction material of Gaziantep consists of natural stones extracted from under the building or from its immediate surroundings. These stones have high strength and a hollow structure. The placement of the stones in the building according to their mechanical properties has provided the building with a breathing feature. As a result, more comfortable structures were produced. On the other hand, in modern buildings, the use of concrete as a construction material, the transportation of this concrete from power plants and the pollution caused during transportation have led to a design approach that is far from sustainable design. In the traditional building system, the facades have an orientation towards the courtyard. In this way, the positive climatic properties of the courtyard were utilized. In addition, the presence of a double-layered system consisting of windows and covers on the facades

When traditional buildings are analysed, streets have also become a part of energy-saving systems, as the buildings use the natural images, cultural characteristics and technological images of the region. However, in modern buildings, the relationship between streets and buildings is weak and there is no regular pattern within their integrity. The courtyards formed as a result of natural, cultural and technological images are one of the most prominent spaces of the traditional construction system. The courtyards have special climatic characteristics for traditional spaces. However, modern buildings do not have courtyards.ensured the thermal control of the buildings. However, there is no clear orientation in modern buildings. When heat control is desired, shading elements that bring an additional cost or air conditioning systems that require energy are used.

5 CONCLUSION

Within the scope of the study, passive measures for the energy efficiency of traditional Gaziantep houses built between the 1800s and 1900s have been analysed. As a result of the examination, it has been concluded that the decisions taken during the construction and design stages are sustainable decisions that maximize thermal comfort. Since the study is based on historical buildings, cultural inputs, natural conditions and technological features are evaluated, and the measures taken to ensure thermal comfort in traditional houses are explained. However, these measures could not be transferred to modern buildings, and cultural parameters could not be reflected in the design of modern buildings. In modern housing design, individual preferences are prioritized, and design decisions are generally based on similar typologies.

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When modern buildings are compared with traditional buildings, it becomes clear that modern architecture tends to ignore cultural inputs and natural imagery. However, by acknowledging cultural changes and addressing the problems observed in traditional residential buildings, it is possible to improve the quality of life and comfort through the incorporation of today's technology. By harmonizing these two images, spaces can be created that respect their context, meet technological demands and cater to contemporary lifestyles. In conclusion, this study reveals passive energy strategies in traditional buildings. It represents important data in terms of transferring these measures to future generations.

AUTHOR CONTRIBUTIONS

Merve Anaç(Conceptualization [equal], Formal Analysis [equal], Investigation [equal], Writing—original draft [equal]), Erdem Cuce (CRediT contribution not specified), Erdem Cuce (Conceptualization [equal], Formal Analysis [equal], Investigation [equal], Methodology [equal], Supervision [equal], Writing—original draft [equal], Writing—review & editing [equal]) and Pinar Mert Cuce (Data curation [equal], Investigation [equal], Methodology [equal], Supervision [equal], Writing—review & editing [equal]).

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