

Thermal Comfort in Traditional Erbil Houses

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Abstract Located in the north of Iraq, the historic city of Erbil is one of the oldest cities in the Middle East. The historical Erbil Citadel in the city is the first settlement area of the city and it is built on the mound, and it resembles a small city with its traditional houses, mosques, baths, tekkes and narrow streets. This study explores the spatial characteristics and thermal comfort performances of an exemplary traditional Erbil House. The study focuses on the architectural features of the spaces in the historical houses (the iwan, terrace and rooms on the upper floor; the porch, the cellar on the lower floor) and the top roof. It provides design data that can be used in thermal comfort, reuse, restoration and energy infrastructure planning in historical environments in historical buildings. Energy consumption of historical buildings can be determined with thermal comfort, and more efficient and healthy environments will be obtained by applying this heat level in new buildings. Improvements in thermal comfort level as a result of data obtained from historical buildings contribute to the sustainability of new buildings by increasing their spatial performance values. With the help of these studies, we can evaluate the effects of parameters such as temperature and humidity on building materials, location and shape. Only in this way can we create an important data source for sustainable contemporary building designs.

Keywords: *thermal comfort, housing, climate, traditional material, building materials*

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1. Introduction

Investigation of thermal comfort conditions and thermal behavior properties in historical buildings should constitute an important stage of the implementation of new buildings. Thermal comfort, comfort of people, animals and even machines using volumes is a design function that must be kept within the recommended normal values. As is known, thermal comfort is not only related to heat values, but also includes atmospheric events such as air temperature, radiant heat, humidity, air circulation rate, metabolic temperature as well as the heat emitted by people or machines using the volume [1].

ASHRAE [2] (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) (1992) standards define thermal comfort for one person as follows: "Mental state explaining satisfaction with thermal environment". Regardless of the outdoor conditions, the temperature of the human body must be kept constant depending on the comfort conditions. The factors that determine the heat loss in the human body are the temperature of the air, the relative humidity of the air, the wall, flooring, etc. is the temperature. The sun and the wind are the two main factors that affect room layout and location in a courtyard house. Thermal comfort in historical buildings, the desired temperature, humidity and lighting level depending on the purpose of use in indoor

spaces, the weather conditions determined by the sun, wind, temperature and humidity in the outdoor environment and the physical characteristics of the boundary elements such as walls, roofs, doors and windows that distinguish between the interior and exterior, these are the most decisive variables for analysis [3].

By utilizing the thermal comfort information in the old buildings in the historical areas, energy consumption is utilized by being used in the new contemporary modern buildings. In addition, during the heat and water vapor transfer between the indoor microclimate and outdoor conditions, the temperature and water vapor partial pressure distribution in the building sections are examined in detail and the detection of visible condensation on the surfaces plays an important role in determining the distorting effects on the historical building material [3].

Besides these, orienting historical buildings reflecting the experience of centuries to the sun, the wind, the choice of material type, color and size, thermal mass effect due to thick masonry, learning of passive architectural climate solutions such as natural ventilation or thermal chimneys, sustainable contemporary structure reconciled with location and climate can be an important data source in terms of designs [3].

The aim of this study is to evaluate thermal comfort behaviors in historical buildings of Erbil by analyzing them in terms of material, location and structure. Three historical traditional houses selected in the Erbil historical citadel, walls, roofs, windows which will be evaluated

within the scope of the study, were examined and the physical properties of the building materials were determined by field studies consisting of the collection of building material samples. Thermal behavior analysis in historical buildings and thermal improvements related to these analyzes have increased rapidly starting from 2000s due to the concept of sustainable architecture [4].

Similar to these standards, it is seen that many national and local government organizations have developed local thermal intervention guidelines and regulations by examining the architectural heritage characters in their areas of responsibility. Examples include the Regulation on Energy Efficiency and Historic Buildings (2012) by Historic England and the Material Improvement Guide for Energy Efficiency in Traditional Buildings by Historic Scotland (2013). Similar studies on thermal comfort properties for historical buildings in Erbil will contribute to the protection area. This study investigates the spatial characteristics and thermal comfort performances of an exemplary Traditional Erbil House. The study focuses on the architectural features of the spaces in the historical houses (the iwan, terrace and rooms on the upper floor; the porch, the cellar on the lower floor) and the top roof.

2. Methods and Instruments for Thermal Comfort Analysis in The Historical Structures of Erbil

Thermal comfort analysis in the historical buildings of Erbil requires the cooperation of different disciplines such as conservation architects and materials. In the thermal comfort analysis of the buildings, architectural details, construction sections and dimensions of the building materials (stone, brick, wood, plaster, etc.) forming the architectural elements such as walls, roofs, flooring systems and doors and windows were examined. Thermal comfort analysis process; field studies and on-site inspection and documentation, historical research, modeling of the current situation, and photography. The method to be applied in historical houses;

2.1. Historical Research

It would be useful to carry out historical research on both the structure and settlement scale. With the works to be carried out at the structure scale:

- Year of construction,
- Physical changes of the structure over time,
- The original heating and ventilation elements of the structure,
- Information such as user profile of building, usage density and original functions of buildings and spaces can be determined [3].

2.2. Research on the settlement scale

- Can help structure restitutions with comparative studies,
- Contribute to the solution of original urban tissue and physical neighborhood relations,

- In historical environments, changing thermal trends due to the transformation of user life and the traditional physical solutions referring to these trends (the closure of open living room over time; the decrease in window size and number; the introduction of stoves and air conditioners instead of traditional cookers etc.) can reveal [3].

Thus, the air exchange in the interior of traditional houses; Depending on the movement of the air mass affects the amount of heat transfer. At the same time, the examinations of the historical houses in the historical settlement reveal how thermal comfort is applied considering the characteristics of the historical buildings such as land and mass planning, topography and solar orientation, construction techniques and material usage.

3. General Characteristics of Traditional Settlement of Erbil

3.1. Location

The city of Erbil is located in the north of Iraq. Located 350 km north of the city of Baghdad, the first settlement probably dates back to the 5th millennium BC and is considered one of the oldest permanent settlements in the world. The first establishment of the city, which dates back to the Assyrian period, consists of the ancient citadel on the top of the mound and the first settlement area around the citadel.



Figure 1. The current location of Erbil Citadel (<https://whc.unesco.org/en/list/1437>)

The total area of the citadel is 102,000 m² and lower base of 410 x 340 meters and a upper base of 25 x 32 meters. It is understood from the physical traces and the users that the citadel was used as the main settlement area in the city. There are houses, religious takya, mosque and hammam. The existing structure of the citadel has not changed since the 18th century and has a major role in shaping the city plan. 250 houses, dating back to the 19th century, remain original. 30 of these houses are palaces, the remaining 120 houses are medium and 320 houses are small. Its narrow streets are mostly flat and ramp-shaped. The historic Erbil citadel has been a UNESCO World Heritage Site since June 21, 2014.

3.2. Climate

Erbil's climate is hot, dry in summer and cold and rainy in winter. Seasonal precipitation falls between November and the average annual rainfall in Erbil in April is about 350 mm and with more than 1100 mm with heavy snowfall with average precipitation in the mountainous regions [5]. Due to the high altitude of the citadel, the settlement area is under the influence of both the sun and the hot desert wind.

3.3. Date of Settlement

Although the exact history of the citadel is not known, it is seen that the archeological excavations date back to the 5th century BC. The current name of Arbil is derived from the Assyrian word "Arba-Illu" which means "Four Gods".

The city of Erbil, which includes many ethnic communities; It has been a sovereign area by Assyrians, Sassanids, Persians, Byzantines, then Karakoyunlu, Akkoyunlu and Ottomans.

4. Features of Houses in Historical Erbil Citadel

4.1. Formation of the City Depending on Settlement

The topographic structure of the settlement of the fortress of Erbil was built on the citadel mound and had a great influence on the planning of the houses. It has ensured that the houses in the citadel are organically seated on the upper floor. However, the surrounding walls of the citadel are also located within these houses. The main living units are therefore gathered inside the citadel and it is seen that there is development towards the southeast region after the citadel.



Figure 2. Development of citadel and its surroundings (https://www.researchgate.net/figure/Erbil-Citadel-in-1950-Figure-14-Erbil-Citadel-in-the-present_fig8_283606055)

In terms of the spatial planning of the houses in the citadel, all the spaces appear to be gathered around open spaces (courtyards and terraces). Due to the high density

of the settlement, the houses are close and adjacent to each other. The flat area causes the number of flats to remain constant. The historical houses in the citadel are therefore only developed horizontally and the residences are single or double storey.

4.2. Spatial Features

The houses in Erbil Citadel are known to have a courtyard, room, kitchen, toilet and storage area. In addition, it should be noted that buildings such as terraces and roofs are important elements.

4.2.1. Living units

We can divide the living units into three sections in Erbil Citadel, these;

- a. Open spaces (courtyard, terrace and roof),
- b. Semi-open spaces (iwan and portico)
- c. We can sort of indoor spaces (rooms)

The courtyard, which is one of the open spaces, is the focal point and meeting place of the house. The courtyard is one of the most important elements of historical buildings. The courtyard is a focal point in the design of the house, especially in areas with warm and dry climate. It is also used for private family ceremonies in the courtyard. The spaces around the courtyard are positioned according to the strategy of exploiting the sun or escaping from the sun according to the season and daily use [6].

The courtyard is used for many purposes both as seasonal and daily movement between these spaces. Bekleyen and Dalkılıç [7] described the moving movement of the users according to the seasons between the spaces around the courtyard as move seasonal moving movement in horizontal” and the seasonal moving movement between the various floors of the house was called seasonal vertical moving movement in vertical”. The movement of movement that consists of daily use between the spaces on various floors of the house is called daily movement in vertical”.

The courtyard evolved in ancient times with the idea that the earth, sky and wind are connected. The courtyard, which is considered the most active place in Islamic architecture, is located in the middle of the house and located between the guest rooms and bedrooms. Usually there is a fountain in the courtyard [8].

On the upper floors, the courtyard is replaced with a terrace and most movement circulations occur here. Both the rooms and the iwan are accessible from the terrace. Roof, which is the highest and widest part of the house, is an open space.

The iwan is the one-way open space, usually with rooms next to it. The portico is the only opening with a series of arches and opens to the courtyard. The larger and bigger the indoor spaces, the more the landlord's status, the more crowded family structure, and therefore the power it represents. The guest room (divan) is generally seen in all the houses in the citadel. Guest rooms, which are the most impressive in terms of location, dominate most of the houses in terms of space. It is seen that there are decorations on the ceiling and beams on the walls. Since the rooms are generally longitudinal, the windows are positioned in this direction and daylight is used to provide a more spacious and brighter center.



Figure 3. Guest reception rooms of the residences in the citadel (<https://www.picfair.com/pics/06127054-ottoman-painted-ornamentation-in-a-divan-inside-the-erbil-citadel-kurdistan>, <https://iwpr.net/global-voices/erbil-citadel-set-major-renovation>)



Figure 4. Semi-basement in Erbil traditional residence (<http://www.erbilcitadel.org/>)

The called service areas are kitchen, pantry, cellar, bathroom and toilet. The kitchen section is located at the entrance and next to it there are places such as cellar and pantry, sometimes these areas are located in the sun-free sections or the courtyard floor one or two steps below of the terrace. The toilet, which is mostly located at the door entrances, is sometimes located on one side of the terrace and sometimes near the kitchen.

5. Building Material and Construction Technique of the Houses in the Citadel

In the Middle East, it is seen that architecture focused on natural materials and traditional building techniques until the oldest periods of history [9]. The most common construction technique in the Middle East is the brick wall. Bricks provide energy savings around the houses and generate the amount of energy required to heat or cool the interior. Because it is very durable, the brick eliminates the need for exterior maintenance and reduces most energy-related maintenance and replacement, leaving most exterior cladding products behind. In summer, the brick absorbs the heat of the sun during the day and prevents the temperature from rising rapidly. In winter, the bricks maintain the temperature and prevent the cold and wind outside. Most of the houses have two-sided masonry walls and a space between them. This space is filled with mortar and rubble, which increases the overall rigidity of the wall and helps to insulate the interior of the house.

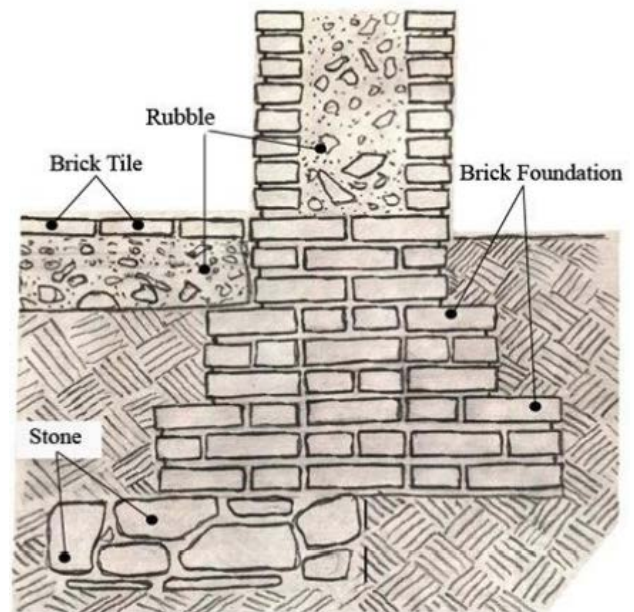


Figure 5. Foundation construction in traditional houses [10]

In the northern part of Iraq, the traditional houses are built with several floors and baked bricks. The wall construction material is usually adobe wall suitable for the region's possibilities. The reason is that other building materials are scarce in the region and they are compatible with the climate and have a long life. Most of the houses are made of mudbrick and some of them are masonry. It is known that these stones help heat insulation. Bricks extracted from the quarry are white in color and darkened

by the effect of sun and air. The vaulted stone wall technique is seen on the foundation and garden walls and in the houses around the citadel. The exterior walls have recently been plastered with cement based scattering plaster. A mortar material consisting of lime-sand mixture was used in the masonry. The floor of the courtyard is completely or partially covered with stone. The materials are generally compatible with the environment and can be found in the region, pressure, impact resistance, has the property of long life. The walls of the buildings are thick due to their climatic characteristics and small openings are used to isolate the temperature.

Ventilation is an important part of maintaining the microclimate in a courtyard house. A number of strategies are implemented to protect the cold air flowing throughout the house. There is natural ventilation in the buildings and the spaces and wooden sections close to the ceiling provide air flow inside the building.

The proportions of doors and windows have been kept small due to the tropical climate. It is seen that wooden building material is used in door and window joinery and cabinet doors of these houses. The ceilings are usually covered with wooden planks and painted with bright colors and floral decorations.

Timber beams were used for the ceilings of the semi-basement floors. The interior walls are plastered with plaster and have many niches and shelves, often decorated with colorful patterns.



Figure 6. Ceiling decorations in houses (<http://www.erbilcitadel.org/>)

Depending on the interior of the room, the internal microclimate differs from region to region within the house. Accordingly, the walls in the south have different climatic responses compared to the north, east and west. In closed spaces, openings (door-window) on the exterior façade are kept extremely small. Windows and transfer holes are designed to allow the wind to enter and exit easily.

On the roofs, because the region is arid climate, it is flat because it is affected by the amount of rainfall. In general, the roofs of the houses are flat and covered with mats. Flat roofs were built in the houses using wooden timber beams placed horizontally to support the roof. Flat roofs were built using wooden roofs, then covered or filled with

thermal mass materials such as broken bricks or rubble. A heavy stone drum of about 60 cm in length was used to flatten and compact the roof surface, making the entire structure more resistant to rain.



Figure 7. Wooden beams used in the ceiling in historical houses in Erbil (<http://www.erbilcitadel.org/>)

Eaves, rain water and for protection from the sun are only protruding enough to prevent water from draining through the wall, and inadequate protection from the sun. However, in some houses, the roofs are flat and rain water downspouts are available. It is also used for sleeping and putting beds on roofs during summer nights.

6. Space Usage

The settlement of the historic Erbil houses is a small city that houses large mansions where native Erbil families live and houses of various sizes used by smaller families. In these houses, the open spaces where most of the daily work of the house is carried out are the courtyard and terrace. The surrounding walls of the courtyard are closed to the street with high walls. The function of the courtyard is a private space towards the street, which is a public place, but it has the property of being a semi-private space shared by many relatives [11]. One of the most important features of the courtyard is cool in summer and warmer in winter. Due to its climatic characteristics, the courtyard was shaped and designed in terms of its architectural structure. Located in the north of Iraq, the historic city of Arbil is one of the oldest cities in the Middle East. The historical Erbil citadel in the city is the first settlement area of the city and it is built on the mound, and it resembles a small city with its traditional houses, mosques, baths, tekyas and narrow streets. Traditional Historical Erbil Houses seem to have climate-appropriate living spaces. In our research, it was found that the indoor spaces of traditional houses in Erbil are less than the thermal activities of the summer season.

It is the place were using for social activities such as weddings, engagements, circumcision and condolence are held and especially the daily life of women. The functions of the terraces and courtyards are similar. The flat roofs of the houses are used for both sleeping and drying food during the summer months [12].

There are three types of houses in the citadel's traditional houses, which include houses with a central courtyard (used by families with good income), houses with a side courtyard (the courtyard is not used as the main element) and houses without a courtyard [13]. Courtyards are usually square or rectangular [14].

The iwan is an open area facing the courtyard and is a closed area rising above the level of the courtyard in a few steps. The iwan unit is a common area where daily works are carried out especially in spring and summer. In the evening, it is used as a seating area by the residents.

Portico is usually found in larger houses. Porticoes create shady and cool areas during the hot summer months. Rooms; It is a multi-purpose usage area with functions such as seating, hospitality, eating, bathing, sleeping [15].

The kitchen, toilet, bathroom, storage and stairs are located in the corners of the houses. The basement has a cool air and is used as storage and cellar. The ground-level windows of the small arched courtyard are used to illuminate and ventilate the basement.

7. Method

In this study, which consists of general investigations about the settlements and houses of the historical city of Erbil, first of all the observations are based on interviews with the public and literature studies. The traditional citadel settlement (location, topography, climate, history, demographic and social structure) and the traditional houses (shaping depending on the settlement, spatial features, building materials and construction techniques, use of spaces) are examined in general. The thermal comfort of the traditional Erbil House, which is the main subject of the general research, was investigated. In order to investigate the existence of planning in these houses, it is necessary to select a suitable house first. With its courtyard, portico, iwana, terrace and rooms on various floors, the sample houses which have the general planning features of Traditional Erbil House have been selected and preserved their original structure.

The houses are connected to the street from the lower floor. Downstairs there are semi-open spaces (courtyards and porticoes) and indoor spaces (rooms, cellars and kitchens) and all of the downstairs spaces overlook the courtyard. On the upper floor there are semi-open (iwan), indoor (room) and outdoor (terrace) spaces. All the rooms on the upper floor are oriented south (open view).

8. Thermal Comfort in Historical Buildings of Erbil

The wind is one of the main factors that affect housing planning. The reason is that although the wind is useful for the natural conditioning of the mass, it is also a polluting element with the dust and straw particles it carries during the dry seasons. In order to protect against the polluting effects of the wind, the courtyard was surrounded by walls and a calm and clean environment was obtained in the open space inside the courtyard.

Horizontal and vertical movement plays a vital role in creating a comfortable microclimate in the courtyard house. It is seen that horizontal movement is used in single storey houses and vertical movement is used in multi storey houses [16].

When examined in terms of climatic characteristics in residential settlements, it is remarkable that this factor is important. It is understood that there is a planning principle in which the solar movements are very important and positioned accordingly, that sunlight is utilized in certain (winter and spring) periods and protected from harmful sunlight in unwanted (summer) periods. By using the shade, openings such as doors and windows were kept small on the exterior of the houses. There are also shelters to protect direct solar radiation in the houses. In addition, porches and iwans appear to have an important function in protecting from the sun and rain. In addition, the doors are made one step lower than the ground level and dust and rain water are prevented from entering the room.



Figure 8. Level difference in rooms in historical houses (<http://www.erbilcitadel.org/>)

The main elements of residential been dominant winds, cold winter wind blowing in a northerly direction closed in summer blowing west and north-westerly winds to benefit from the mass settlement have been made. In addition, windows or remittance holes for indoor spaces are arranged in such a way that the wind blowing from the west or north-west direction can easily enter and exit the space. As the heated air rises, it is preferred that the parts up to a human height (approximately 1.75m) be cool in the summer season and the height of the spaces is 3.50-4.00 m. This is an indication that climatic characteristics are taken into consideration in the building construction system [16].

Due to the thermal insulation caused by the climate feature, the walls were kept in thickness and the openings were reduced. In this way, the direct rays and heat of the sun are restricted to enter the indoor space as much as

possible. As a result, indoor interiors remained cooler and a kind of natural air conditioning was provided. Windows opening to the cool wind direction also support this formation [17].

In traditional residential settlements in the region, climatic characteristics have been the main factors starting from residential settlements to the use of functional relations between volumes, planning and selection of building system and building materials. Settling according to climatic characteristics can be said to have brought thermal comfort to that house [18].

In the historical houses in the citadel, the iwan has no direct sunlight, so the iwan has its position to the north. In summer, the portico creates a space that reduces direct sunlight to the rooms of the house, allowing cool air to be distributed throughout the space.

In general, the use of individual rooms is synchronized with temporary and seasonal or daily time changes; therefore, the purpose of use varies according to the seasons. In the Middle East, the climate is hot, dry in summers and cold in winters. For this reason, residents use the daily northern rooms in winter. Because during the day it allowed a large amount of sunlight to enter and the rooms in the corner were used at night. The openings of the rooms in the corner were kept small which prevented the loss of heat [19]. In the summer, southern rooms were used. The rooms on the west side of the house are avoided in summer due to direct exposure to light and heat.

Another important factor for the micro climate is the presence of plants, trees and fountains in the courtyard. Another technique is to open the windows of the rooms towards the courtyard. Thus, the effect of sunlight on the rooms is reduced and cool air is provided. In the outer wall it has few windows and vent's location is situated high on the wall. The arched portals between the open courtyard and the rooms protect the rooms from direct sunlight and at the same time allow wind and light to enter [20].

The courtyard also serves as a barrier to dust storms and strong winds due to the climate of the region. Ensures the privacy of the family, regulates the temperature of the house with passive cooling and natural ventilation and provides natural light to all parts of the house [21].

In warm and dry areas, the courtyard house witnesses three regular temperature cycles each day in the summer. The first cycle starts at night and cool air flows into the courtyard and the surrounding rooms, the second cycle occurs in the afternoon with a gradual increase in temperature. When the outdoor temperature reaches a high level, thick walls prevent heat from penetrating into the house all day long. During the third cycle, open floors, walls and courtyard heat up and surrounding rooms lose cool air late in the evening [22]. In general, the main façade wall of the houses is shared with the façade and the other three façade walls are shared with the wall of the neighboring houses. Therefore, only the roof and the main exterior wall are exposed to summer heat and winter heat.

Flat roofs are exposed to heat all day, except late hours, as the parapet provides some shades to the roof in the early morning hours. In addition, the dwellings are built close to each other, the narrow streets between the mutual houses create a shade creating a cool atmosphere. Shade is an important element of the natural cooling system of houses with courtyards. Thus, with the shading system, the temperature in the house decreases by five to ten degrees. The windows facing the alley are smaller, while the windows facing the courtyard are larger and there are various decorations around the window.

The windows inside the house are positioned to open towards the courtyard. Windows opening to the courtyard help reduce the temperature inside the house through the attenuated effect of direct sunlight on the rooms [23]. In order to maintain the cool air of the room the windows are kept closed to get rid of the heat of the day in summer; In the evening, the windows were kept open to allow cool air to enter.

Architectural elements, such as eaves, are used to break the glare from the sunlight and create shadows on the inside. Balconies and overhangs have shades on the walls of buildings. fountain is a creative factor integrated into the design of courtyard houses as a passive cooling source to create a suitable microclimate in the hot and dry Middle East. The citadel also seems to have such houses. The temperature in the house can be reduced by evaporating water; Hot air causes water to evaporate, which makes the air cooler and makes the house more comfortable. Evaporation increases when contact between water and air increases [24]. Another task of the fountains is to aesthetically look at the courtyards by absorbing the heat from the sunlight and reflecting the light.

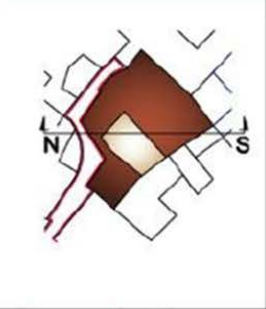
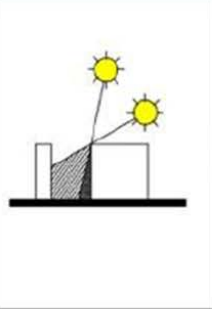

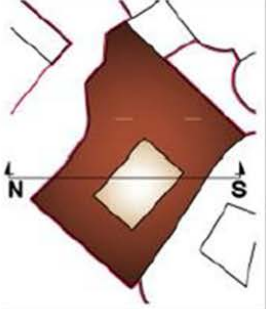
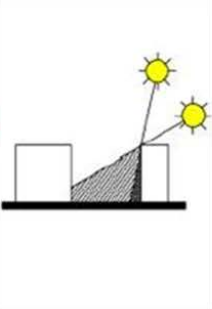
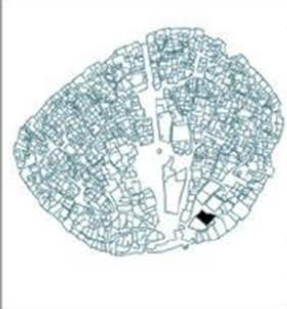
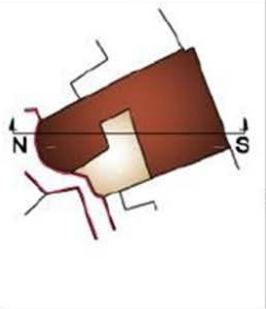
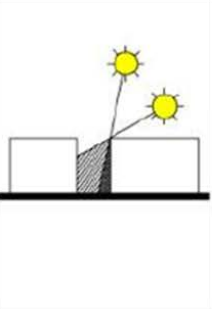

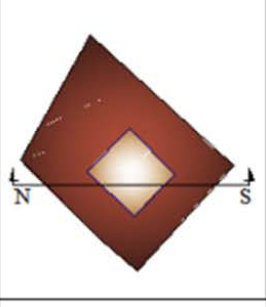
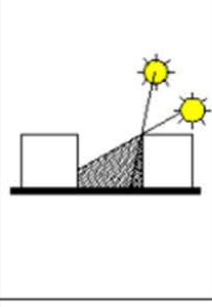

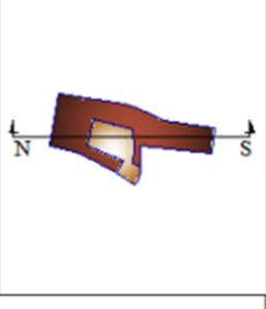
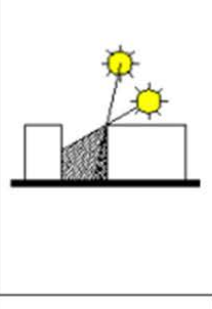
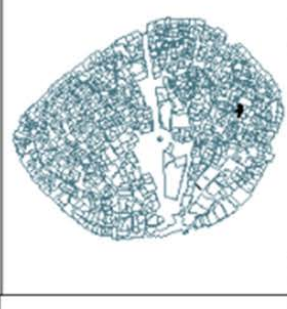
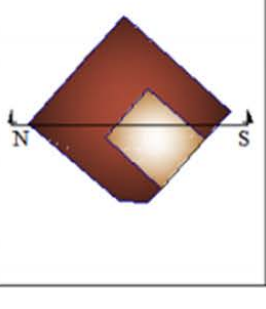
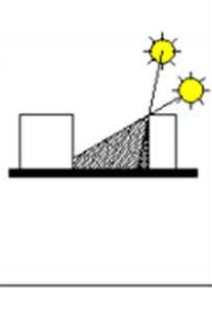

The location of the rooms in the houses is from north to south. Because in the summer, the east and west sides receive light and heat, so the sun shines in the morning and afternoon at a low angle [25]. Therefore, the rooms on these sides have the less and smallest openings.

The living rooms are positioned to optimize the cooling breezes in summer and to prevent cold weather in winter. In winter, the northern rooms in the courtyard, which have been exposed to sunlight for a long time, are used as dining and living rooms, because the use of space is more constant and has more heat and daylight. The rooms in the west and east are used for functions that require short-term use, such as bathrooms, laundry, corridors, stairs and bedrooms.

As it can be seen from the table, all houses have a position from north to south. The average area of the courtyards is 6 meters x 4.5 meters. The average height to width ratio is 1: 0.7, which is equal to 5 m at 7 m. Thus, it is seen that the contemporary architectural structures to be built in the city are an active solution both in terms of ventilation and thermal comfort.

Figure 9 [27], shows section A-A of a historical residence on the adjacent slope around the citadel. Rooms in the south have exterior openings overlooking the city below. In winter, the angle of the sun is low. Sunlight reaches both the northern and southern rooms as shown. This helps keep warm air on both sides of the rooms.

Table 1. Location of the Residences in The Historical Erbil Citadel [26]

			Plot area 170 Built area 138 Courtyard area $7.46 * 4.4 = 31.9$ Courtyard percentage 18.7 * Metric system * Small c-house
			Plot area 430.9 Built area 366.7 Courtyard area $9.7 * 6.6 = 64.2$ Courtyard proportion 14.8 * Metric system * Large c-house
			Plot area 271 Built area 216 Courtyard area 55 Courtyard proportion 20.2 * Metric system * Medium c-house
			Plot area 418.75 Built area 355.14 Courtyard area 63.61 Courtyard proportion 15 * Metric system * Large c-house
			Plot area 124.14 Built area 95 Courtyard area 29.14 Courtyard proportion 23 * Metric system * small c-house
			Plot area 324.81 Built area 245.13 Courtyard area 79.71 Courtyard proportion 24 * Metric system * Large c-house

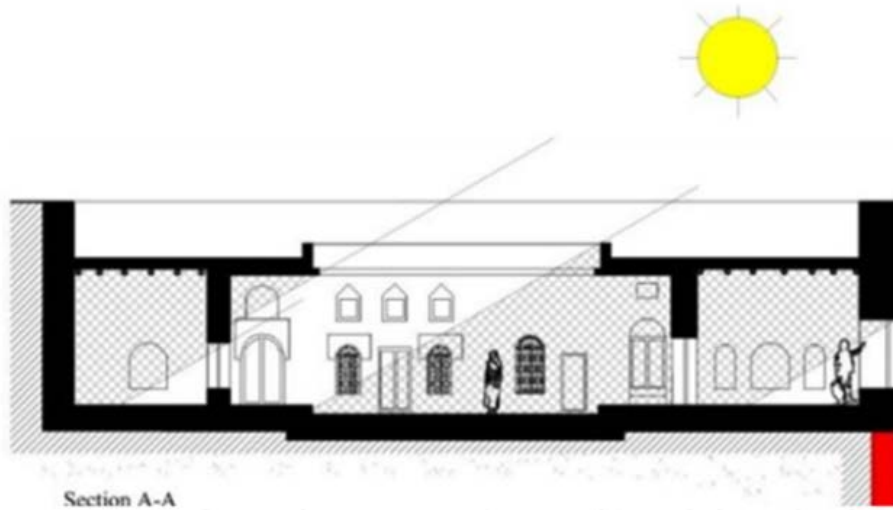


Figure 9. North-south sample section of the residences in the historical Erbil Citadel, Sunlight reaches the northern and southern rooms in winter. In [Figure 10 \[27\]](#), the same cross-section shows that the angle of the summer sun comes directly from above.

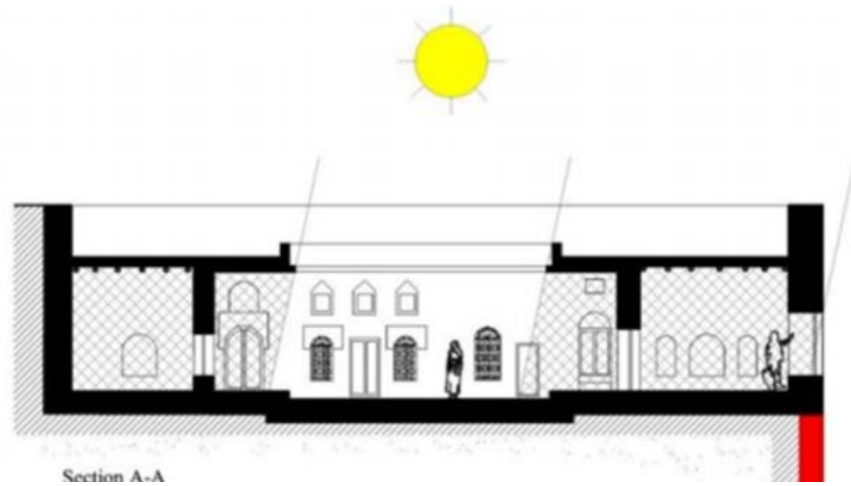


Figure 10. Porches help keep rooms cool by shading in summer

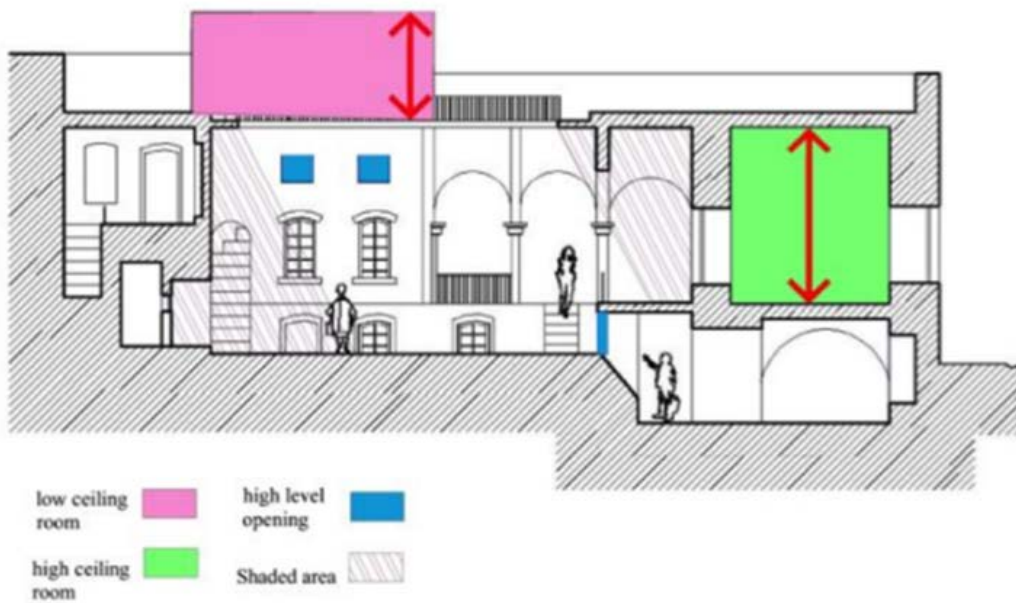


Figure 11. Cross section of houses in the castle with different ceiling height in winter and summer rooms

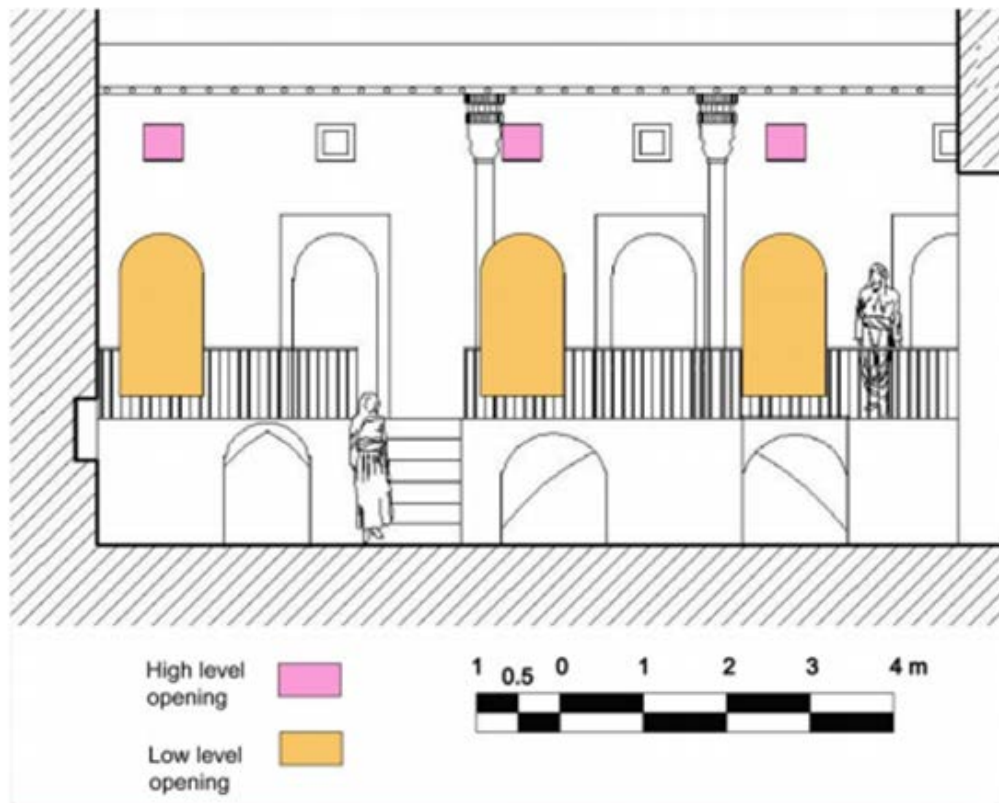


Figure 12. Cross-sectional view of high and low openings

Figure 11 [28], shows a cross-section of another vernacular house in the Erbil citadel. The upstairs room (shaded pink) and the rooms on the north side of the courtyard are often used during the winter months because they receive more sunlight, which helps keep them warm. Winter rooms are built with low ceilings to help keep warm. The green-shaded room is located on the ground floor on the south side of the courtyard. This room is primarily used in summer due to the southern settlement and high ceilings. The high ceiling keeps the room cool by convection with hot air. This warm air is removed from the room through the outer opening (blue) and is replaced by colder air than the shaded area in the courtyard. Porticoes provide air-absorbing shade for rooms. The ground floor is slightly elevated above the courtyard level. The ground floor rooms have a semi-basement room. This room is generally used as storage, cellar. The elevated ground level allows natural light and ventilation to the semi-basement, allowing the opening between the different floor levels. Semi-basement floors generally have low ceilings and constant temperature properties [29].

The portico is placed on the north and south sides of the courtyard and is a useful element, especially since it provides shade to the courtyards and rooms. Ground floor rooms with ceiling heights are usually found in the south and have high ceilings to keep the summers cool. Located on the northern top floor, rooms have low ceilings to keep you warm in the winter. Guest rooms and living rooms have a ceiling height of approximately 4m, while rooms located north are generally between 2.6m and 3.2m.

Figure 12 [30], shows a cross-section of traditional houses in Erbil. Areas with pink zones are the ventilation openings located high on the walls of both floors. Areas with yellow zones are low-level ventilation openings. This

strategy helped cross-ventilation, so that in summer the warm air in the rooms would come out of the high-level openings and the cold air from the low-level openings would be solved.

9. Conclusion

This research is an answer to the questions which design strategies can be derived from architectural strategies and how these design strategies can be adapted to contemporary architecture in Erbil. Thus, it is considered that local design strategies can be adapted for the development of contemporary buildings in Erbil and aesthetic, social, structural and environmental aspects can be improved while meeting today's needs. Firstly, the information obtained from various sources in the local architecture in hot, arid regions was compiled in the literature review. Then, the study area was analyzed with the historical houses in the historical citadel in Erbil. With the results obtained, it is revealed that thermal comfort can be applied with old techniques in today's architecture.

- The brick in the kiln is stronger, easier to use, requires less maintenance and is more weather resistant.

- High denim rooms were used to prevent rain and dirt from entering the room. This strategy can be developed by reaching the courtyard. From each room you can go through an entrance foyer instead of going directly into the courtyard. This will improve the insulation of the house while minimizing the amount of dirt, mud or water introduced into the house.

- Considering the climate and the environment, the houses were built by natural means, that is, with thick

walls, natural lighting and ventilated from the courtyard. Thus, energy efficiency has been increased.

- Another important factor is the presence of large and small openings in the buildings. Thus, air circulation is provided and the temperature of the room is maintained. The inner openings are wide and directed towards the courtyard for sunlight.

- The courtyard is the most important element of the housing and has undertaken the most active duty in all seasons of the year. It provides canopy and cool air transfer in summer and warms the house with enough light in winter. The location of the courtyard will also affect the ventilation depending on the dominant wind direction. Therefore, the location of the houses to the city is from north to south.

- The semi-basement floors have an almost constant temperature throughout the year and have a versatile comfort area.

- It is important to use water fountain in various parts of the house. It helps to cool the hot air, especially when placed in the wind direction in summer.

As a result of the data obtained, it will be beneficial to use thermal comfort in new buildings in local houses. It seems that the thermal comfort to be used in new buildings will increase sustainability, use of natural resources and energy efficiency.

It provides design data that can be used in thermal comfort, reuse, restoration and energy infrastructure planning in historical environments in historical buildings. Energy consumption of historical buildings can be determined with thermal comfort, and more efficient and healthy environments will be obtained by applying this heat level in new buildings.

Improvements in thermal comfort level as a result of the data obtained from historical buildings contribute to the sustainability of new buildings by increasing their spatial performance values. With the help of these studies, we can evaluate the effects of parameters such as temperature and humidity on building materials, location and shape. Only in this way can we create an important data source for sustainable contemporary building designs.

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