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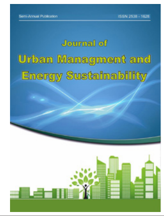


CASE STUDY RESEARCH PAPER

# Studying the effect of wall materials on thermal comfort of traditional residential buildings in hot and dry climates (Case studied: Dehdashti and Sartipi Houses)

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ABSTRACT

This research examines the internal thermal comfort of historical houses in Isfahan from the Qajar period, focusing on the impact of wall materials. In Iran's hot and dry climate, houses must be designed to protect against direct sunlight and intense heat. The Dehdashti and Sartipi houses serve as successful examples of sustainable architecture that provide thermal comfort through the use of earthen walls and designs compatible with the hot and dry climate. Earthen materials play a crucial role due to their high thermal capacity, insulation properties, and breathability. Both houses have harmonized with local climatic conditions through the application of indigenous architectural principles and local materials. The research employs a quantitative and descriptive-analytical methodology, utilizing software such as AutoCAD, Rhino, and Design Builder for data analysis. Ultimately, the findings indicate that most historical buildings in these areas are constructed from high thermal capacity earthen materials, with an assessment of occupant dissatisfaction hours also conducted for these two houses.

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## INTRODUCTION

A warm and dry climate is one of the influential conditions on architecture. The climatic features in this area include low water availability and extreme heat in summer, accompanied by sandstorms at certain times of the year, as well as winds from different directions and severe cold in winter. The main architectural criterion in this climate is introversion. In a warm and dry climate, which experiences very severe storms and high temperatures in summer and extreme cold in winter, it is essential to harmonize with the environment and nature. In these regions, due to the intense sunlight in summer and the harsh cold in winter, the orientation of buildings should face south and southeast to make better use of energy during winter. Additionally, the use of windcatchers in warm and dry climates plays a significant role in energy management. Windcatchers perform the function of suction (Sharifian Qazijehani, 2016). Kasmai, in his book titled "Climate and Architecture," explains the optimal architectural conditions for buildings and determines the appropriate shape of buildings compatible with the climate of each location (Kasmai, 2003). Isfahan is the capital of Isfahan Province, located at a geographical position of 51 degrees longitude and 32 degrees latitude, situated in a semi-desert region with a warm and dry climate. This city, at an elevation of 1580 meters above sea level, has the most sunlight hours from early summer, while in the last month of autumn, the sunlight hours reach their lowest (Shafaqi, 2003). The prevailing winds, with an average speed of 10 m/s, blow from a direction between southwest and northwest. Isfahan is one of the cities with a semi-arid cold climate (Bahadori, 2015). In this climate, selected materials must be heat-resistant and have high thermal capacity. Due to the compatibility of clay and its derivatives with dry weather, mixtures with stone or wood have been used in construction. The soil for this mixture was sourced from the same excavation site, eliminating the need for energy consumption for transporting materials. Furthermore, energy consumption was reduced by using local materials. In construction sites, they preserved the surrounding environment with minimal material waste. The thickness of walls in the past was intended to increase thermal capacity during the day and utilize this heat at night. The outer surface of the walls was painted in light colors to reflect light during the day (Sadati et al., 2023). The urban layout was determined based on climatic factors such as the intensity and direction of winds and the direction of sunlight, which resulted in the orientation of main and secondary buildings and pathways. This orientation played a crucial role in enhancing spatial quality in buildings for the comfort of users (Tsutsumi et al., 2007). In most warm, dry, or temperate countries, soil has always been the most common construction material (Mavromatidis et al., 2012).

Ashrae considers an individual's satisfaction with their thermal environment as thermal comfort, describing it as a mental issue (2010). To express this, two main approaches are proposed: 1. The heat balance approach, based on research results by Fanger in 1970 under laboratory conditions. 2. The adaptive approach, which has a close theoretical basis related to heat balance and the thermal sensations of the body's temperature regulation system (Van Hoof, 2008). Four environmental factors that affect thermal comfort include air temperature, mean radiant temperature, relative humidity, and air movement. Metabolism and clothing are two individual parameters; based on this, the predicted percentage of dissatisfaction (PPD) is shown in Figure 1. The gray area in the figure indicates the thermal comfort zone, which was determined by a questionnaire that assessed the thermal sensation of users in many global samples of buildings utilizing natural ventilation. The investigation of these linear relationships provided the comfortable thermal temperature. The relationship of the indoor space is expressed based on the average outdoor temperature using ASHRAE standards for evaluating thermal comfort in naturally ventilated buildings. Both approaches have their strengths and weaknesses in determining comfortable thermal temperatures (Van Hoof, 2008; Simões et al., 2012; Rodrigues et al., 2019), which are presented in Table 1. In the adaptive approach, with changes in comfort, individuals behave in ways that correspond to their thermal comfort and expectations, preferences, and thermal histories also define their thermal environment. The theory of adaptive comfort encompasses physiological adaptation, psychological adaptation, and behavioral adaptation. Researchers identify the reason for the discrepancy between the average projected PMV votes and the average actual AMV votes obtained from questionnaires in field studies. In contrast to the adaptive approach, the heat balance approach defines thermal comfort based on external air conditions. This method can be applied in buildings where the users have control over the indoor environment controlling their type of clothing, movement, and the opening and closing of windows—under specific conditions. (Fig. 1-2) (Tab. 1)

A: No mechanical heating and cooling systems should be used.

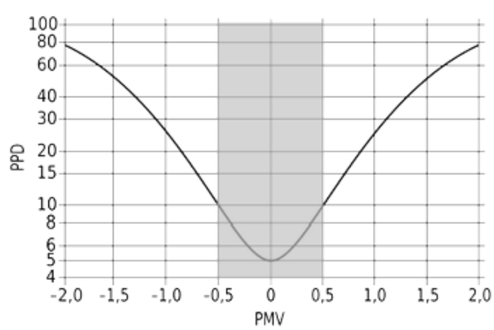
B: The metabolic rate of users should be between 1.0 - 1.3 Met.

C: Users should be able to adjust their clothing insulation level between 0.5 - 1 Clo (ASHRAE, 2010).

Table 1: Strengths and weaknesses of the thermal comfort balance approach and the adaptive approach

| Weakness Points | Strength Points |
|---|---|
| Diversity without the presence of environmental restraints in realistic conditions | Compatibility of buildings with mechanical systems |
| Inconsistency in applying standards for individuals | More attention to secondary aspects |
| Failure to consider the culture and climate in building design | Importance of human physiology |
| Lack of consideration in building endeavors regarding natural airflow and temperature conditions | Considering environmental parameters in the flow of air and psychological aspects |
| Failure to consider buildings regarding practical conditions | Alignment with natural conditions |
| Lack of consideration in building designs that control environmental parameters | More compatibility in buildings with natural conditions |

Nicol and Humphreys, who were the founders of this theory, set aside the factors involved in analyzing environmental comfort, which relate the clothing and activity levels to the outdoor air temperature (Naeibi, 2002, Nour Mohammadi, 2009). Hoof and Halawa stated that the mean radiant temperature and air movement were not considered in their analyses (Kakhneel Sen, 2010).



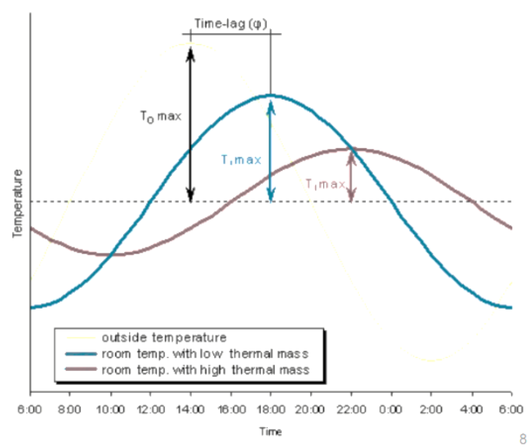




Figure 1 (Left): Correlation between the Mean Vote (PMV) and the Percentage of Dissatisfaction (PPD).
(Source: Parson, 2002, p. 269)

Figure 2 (Right): The effect of external walls on indoor temperature compared to outdoor temperature.
(Source: Heydari, 2014)

The adaptive thermal comfort approach uses the factors that interact with the environment to assess thermal comfort more qualitatively, influenced by the heat balance approach, which understands individual comfort conditions but faces limitations. The most comprehensive thermal comfort approach, according to De Dear, a prominent researcher in this field, is one that integrates both the adaptive and heat balance approaches. Thus, attention must be paid to environmental factors such as air temperature, humidity, air movement, and mean radiant temperature, as well as adaptive parameters that include culture, context, and user behaviors (Reilly & Kinnane, 2017; Rodrigues, 2023; Szokolay, 2015). Several studies have been conducted concerning the behavior and thermal performance of external walls in buildings. For instance, Yihang Lu and colleagues, in a paper titled "An Approximate Parametric Model for Quantifying Thermal Mass with Harmonic Changes in Outdoor Air Temperature," highlight the importance of thermal capacity in heat transfer through external walls and ultimately result in downplaying the impact of thermal mass and its effect on reducing heat transfer and time delay (Sokhdan Sorkhabi & Khanmohammadi, 2016). Numerous studies have examined the relationship between building orientation towards the sun across various climates. For example, in the book "Climate and Architecture," the appropriate orientation of buildings in relation to the sun in the traditional architecture of Iran's warm and dry climate considers the building positioning between southeast and southwest depending on geographical location (Tosili, 1982). To reduce surfaces exposed to obstructive winds (westerly winds) in the city of Isfahan, buildings have been oriented east-west, with plans extended accordingly (Rohani, 2015). The average annual temperature, based on long-term statistical studies from 1951 to 2015, is 16.4 degrees Celsius. Additionally, the average temperature of the coldest month, the first month of winter, is 3 degrees Celsius, while the hottest month of the year, the first month of summer, is 29.5 degrees Celsius. Based on this data, the average monthly relative humidity is 38.7%, with a lower average humidity of 23% and a higher average relative humidity of 57.6%. The annual average wind speed in Isfahan is approximately 2.5 meters per second. In this station, the prevailing wind direction throughout the year, except in the hot season, is from the west, while the predominant wind direction is from the east. The average annual precipitation in Isfahan Province is about 252 millimeters, and the average annual temperature is 26.6 degrees Celsius (Pekdogan & Basaran, 2017).

Analysis of the impact of adobe materials in the walls of Dehdashti and Sartipi houses and the reasons for their similarity in thermal comfort: In warm and dry climate architecture (such as in Isfahan), walls made of adobe play a significant role in achieving thermal comfort. The Dehdashti and Sartipi houses, utilizing adobe materials and intelligent designs, are notable examples of employing indigenous materials to create a sustainable and comfortable environment. The impact of adobe materials and the reasons for the similarity of these two houses in providing thermal comfort will be examined. Both houses belong to the Qajar period, during which special attention was given to climate-responsive architecture and the use of indigenous materials. This era witnessed the evolution of Iranian house designs to meet biological needs and thermal comfort across different regions of the country, including warm and dry climates. The similarity in the construction period of these two houses leads to the application of shared principles of Qajar architecture, which include climate-conscious design, incorporation of a central courtyard, and the use of indigenous materials such as adobe and clay to achieve thermal comfort.

Characteristics of the warm and dry climate:

- Very hot and dry summers with high daytime temperatures and relatively cool nights.
- Cold and dry winters.
- Low humidity and direct sunlight for most of the year.
- Need to reduce heat infiltration in summer.
- Retention of heat in winter.

- Reduction of daily temperature fluctuations.

Impact of adobe materi als in the walls of historic houses: Physical and thermal properties of adobe:

1. High thermal capacity: Adobe walls absorb and store daytime heat and gently release it during the night. This process prevents severe temperature fluctuations.
2. Insulation against heat: The thickness of adobe walls reduces heat transfer from the outside to the inside and vice versa.
3. Breathability: Adobe has the ability to absorb and release moisture, helping to maintain temperature and humidity balance within the building.
4. Summer effect: On hot days, thick adobe walls prevent solar heat from penetrating inside. At night, they release the stored heat, creating a pleasant environment.
5. Winter effect: In winter, adobe traps indoor heat and prevents it from escaping quickly.

Reasons for the similarity between Dehdashti and Sartipi houses: (Tab. 2)

1. Use of indigenous materials: Both houses are constructed from adobe and clay, which are locally available. These materials are compatible with the characteristics of a warm and dry climate.
2. Intelligent design: Thick, high walls, a central courtyard, and arched vaults are designed to regulate airflow and natural light. The use of shade devices and small openings prevents direct sunlight from entering.
3. Reduced energy consumption: The design and use of local materials have led to a decrease in the need for heating and cooling systems.

This issue arose from the fact that we decided to evaluate the state of local architecture in these regions with the materials used in the exterior walls in order to create optimal thermal comfort for the building's users using Fenger's criteria. What effect do the materials used in the walls have on creating thermal comfort? What is the relationship between the current thermal conditions and the Fenger Thermal Comfort Index based on the materials used in the walls? What is the rate of thermal dissatisfaction hours of residents according to the materials used in the walls?

Table 2: Comparative Analysis of Dehdashti House and Sartipi House

| Similarities | Shartipi House | Dehdashti House | Feature |
|---|---|---|---|
| Both belong to the Qajar period, reflecting the architecture of that era. | Qajar | Qajar | Historical period |
| Both were built in the warm and dry climate of Isfahan. | Isfahan | Isfahan | Building location |
| Use of indigenous materials with high thermal capacity. | Adobe and clay | Adobe and clay | Wall materials |
| Reduction of heat transfer and natural insulation. | Thick walls (50-80 cm) | Thick walls (50-80 cm) | Wall thickness |
| Creation of shade and temperature moderation in the interior space. | Central courtyard with a water feature | Central courtyard with a garden | Interior design |
| Optimization of thermal conditions considering the features of the climate. | Preserving coolness at night and preventing daytime heat | Preserving coolness at night and preventing daytime heat | Interaction with climate |
| Thermal comfort achieved through adobe walls and proper design. | Suitable in summer and winter | Suitable in summer and winter | Thermal comfort |

## MATERIALS AND METHODS

*Litrature Review*

*Thermal comfort*

Thermal comfort is influenced by four factors: air temperature, mean radiant temperature, relative air velocity, and vapor pressure, which can be controlled (Fanger, 1972). These factors, along with the level of activity, clothing amount, and personal expectations, shape the thermal environment that affects individual comfort (Van Hoof, 2008). The most important international thermal comfort standards are ISO 7730 in Europe and ASHRAE 55 in North America. The basis of these standards is the theoretical analysis of human heat exchange, gathering data from climatic rooms at 30-60 degrees latitude, as well as the climates of Northern Europe and Northern America (Jamali Poor & Arbabaan, 2015). These standards are suitable for controlled laboratory conditions; thus, they are not very applicable for uncontrolled outdoor environments. Evidence of this theory lies in the discrepancy between the predicted thermal comfort temperature provided by these standards and the human comfort experience in various locations (Haj Qasemi, 2004). These standards define thermal comfort zones where most users feel their comfort temperature according to their personal conditions. Accordingly, 80% of users define an acceptable temperature range according to these standards (Hasan Qolinasad Yasoori & Mofidi Sharani, 2019). Implementing the characteristics of these standards in reality does not guarantee 100% satisfaction of users with the environment, and individual differences among people make it challenging to keep everyone satisfied with the environment (Hashmi Rafsanjani & Heydari, 2017). Users require thermal comfort in indoor environments to enhance their capabilities, and because it is one of the priorities of indoor environmental quality, it was examined in adobe houses (Heidari, 1995).

*Thermal comfort limits and neutral temperature*

The concept of comfort is the core of creating healthy human environments (Heydari, 2014). Humans are creatures with different physiological and psychological needs, because they are social creatures that need to interact with their fellow human beings. To create appropriate architecture for humans, the designer must pay attention to all these needs and address each one appropriately (Holz et al., 1997). Cold spaces in which people experience cold stress and vice versa are spaces that create discomfort for the inhabitants. A space with a comfortable temperature is a level in which a person does not experience cold or heat stress, but rather, the comfort of that space is provided by a balance between the variables of weather, temperature, humidity, wind, and sunlight entering the space. In such a space, a person does not feel cold or hot, and in terms of all variables, it is at a comfortable level, which can be called a neutral temperature or comfort temperature. (Javed et al., 2016).

*Principles of architecture and use of materials in hot and dry climates*

In the hot and dry climate of Iran, where local cities have a compact and dense structure and texture, and houses have continuous walls that are indistinguishable from each other. The orientation of the building is largely dependent on the general orientation of the city. Of course, the main goal in choosing the orientation of buildings in this climate (hot and dry) is to minimize the intensity of the sun in summer and also to reduce the daily temperature in the interior of the building. Another goal is to maximize the intensity of the sun in winter, and the north-south direction is preferred. Architects describe the characteristics of introverted houses as follows (Kheirabadi, 1997). Other advantages include thick walls and the amount of heat that can be absorbed without increasing the temperature. Massive walls also lose heat through conduction at night, and their temperature remains low and moderate during the day (Khoda Bakhshei & Mofidi Sharani, 2001). In buildings where heavy materials are used, heat conduction and transfer are slow and delayed, and the daily heating situation is maintained (ibid., 18). Native buildings were always built with available materials. In hot and dry climates, mud is generally used to build walls. Other materials for building massive walls were stone, brick, and adobe (Martin et al., 2008). In most hot and dry or temperate countries, soil has always been the most common building materia. The limitation of natural resources has made it impossible to meet the needs related to the housing sector in different countries with industrial building materials such as brick, concrete, or steel. In Mexico, as in most Latin American countries, adobe is the most widely used building material in rural areas. In central Iran, the interior walls and ceilings are usually plastered, and the exterior walls are covered and leveled with a mixture of clay, water, and straw chips. Adding straw to this mixture also makes them flexible and strong. Lime is sometimes added to this mixture in parts of buildings that are vulnerable to moisture. The plaster, which is ultimately applied to a rough-textured surface, turns it into a smooth and even surface, and when golden chips are added to this surface, The straw color will be very attractive. The thermophysical properties of these materials are important factors in this climate (hot and dry). These materials have thermal resistance, as well as high heat capacity and absorption of sunlight through external surfaces, which are the result of three important properties (Mohammad, 2013).

*Methodology*

In the research under study, a quantitative-comparative approach was used based on field and library studies and with the help of simulation in DesignBuilder software, which examined two types of walls of a historical house in Isfahan. DesignBuilder software, which is used for building modeling using consumable materials, architecture, cooling and heating technologies, etc., has high accuracy in calculations, therefore it is one of the most accurate software available in this field, which was developed by the US Department of Energy. (Moslehi et al., 2016). The information obtained from the survey and field method was simulated in the software in order to achieve the thermal comfort point of people. Also, all data has been professionally and analytically analyzed in AutoCAD (which includes detailed drawings of these two buildings), Rhino, and Design Builder software. All software data has also been compared with Fenger's thermal comfort indices, and then the correlation between the measured variables has been analyzed.

*Dehdashti House Cognition*

Dehdashti House is one of the old houses in the beautiful city of Isfahan, built during the Qajar era, and therefore its building can be considered an example of the buildings built during that historical period. The architecture of Dehdashti House is a product of Iranian-style architecture, slightly influenced by Western architecture. It

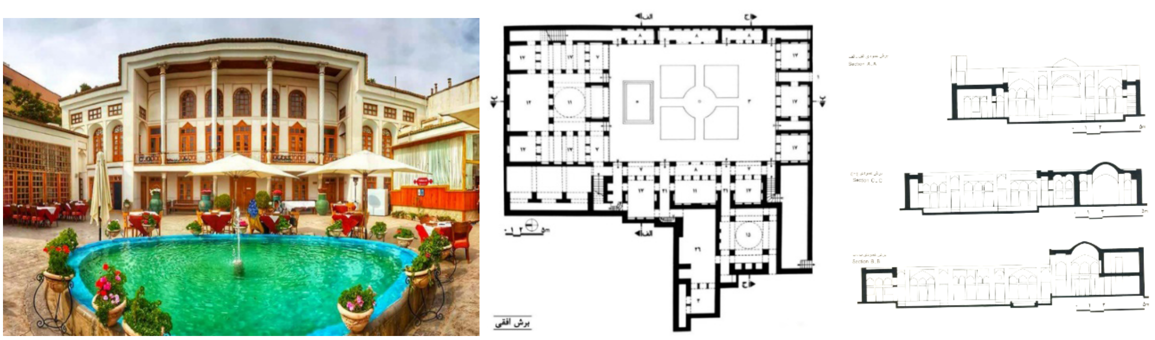


Figure 1: Dehdashti House, (Source: Online-architect)

can be said that the house plan is rectangular and it was built using adobe, brick, and wood. It is worth mentioning that the area of the house is approximately 10,000 square meters. Among its prominent architectural features are the decorations on the wooden doors, the sash windows, and the stucco moldings on the columns on the porch. (Fig. 3-6)

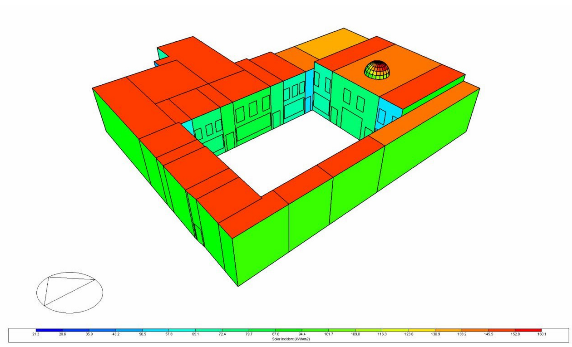


Figure2: Modeling of the Dehdashti house in software (Source: Authors)

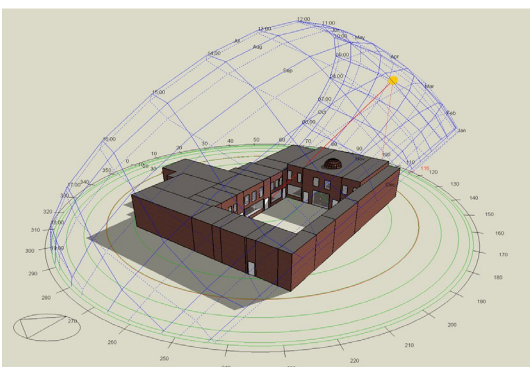


Figure 3: Solar rays of the Dehdashti house, (Source: Authors)

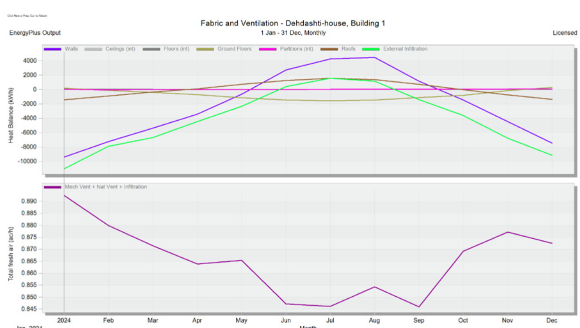



Figure 4: Air conditioning in Dehdashti House, (Source: Authors)

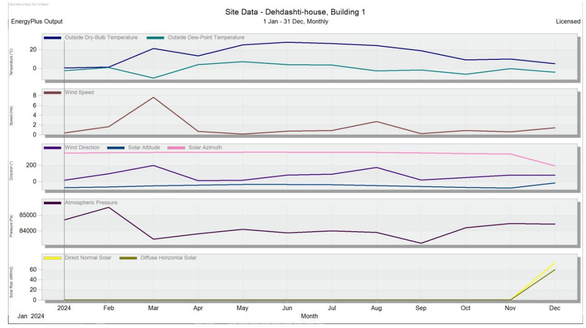



Figure 5: Air temperature of Dehdashti House, (Source: Authors)

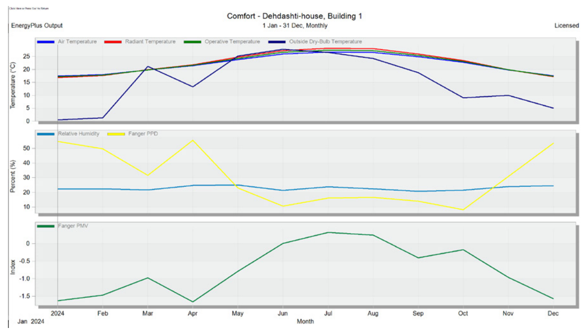



Figure 6: Suitable temperature comfort and its comparison with the Dehdashti House Fangarkhane chart, (Source: Authors)

*Sartipi House Cognition*

The house of Sartipi is from the Qajar period. The house of Sartipi is one of the most important historical monuments of Khomeini City, which is considered a unique example of contemporary structures with a combination of Iranian and Western architecture. The architectural form and colors used in the decoration of the building belong to the Qajar architectural style. And the materials used for its construction were adobe, brick and wood. In this type of architecture, the provision of lighting, winter heat and summer coolness was mostly done through natural factors such as sunlight and air flow. The entire complex was built on a land area of about 3,800 square meters. (Fig. 7-11) (Tab. 3)

Figure 7: Sartipi House, (Source: Online-architect)

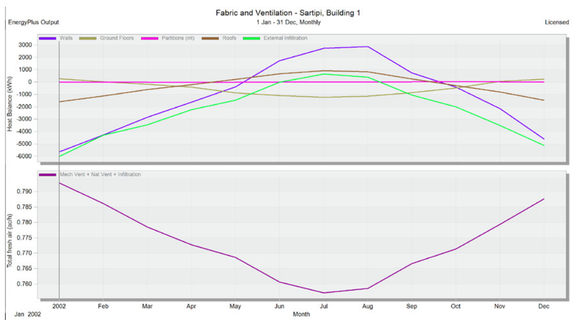



Figure 8: Modeling of the Brigadier General's House in Software, (Source: Authors)

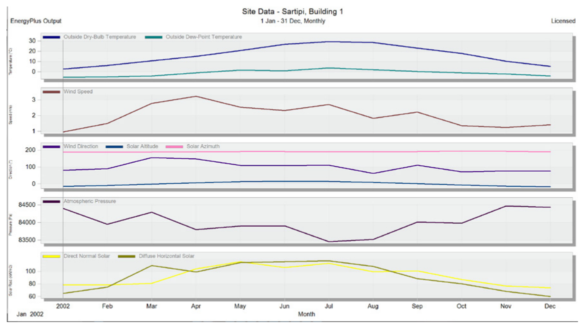



Figure 11: Appropriate thermal comfort and its comparison with the brigade headquarters' technical diagram, (Source: Authors)

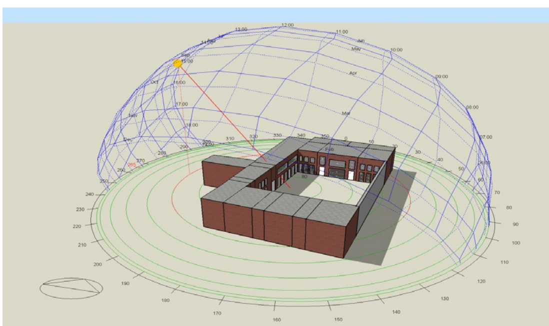


Figure 9: Air Conditioning of the Sartipi House, (Source: Authors)

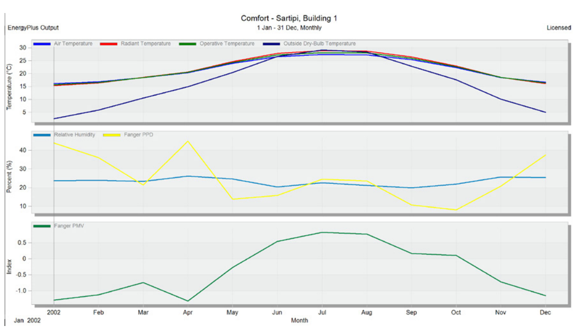



Figure 10: Air temperature of the brigade headquarters, (Source: Authors)

Table 3: Wall materials modeled in the software, (Source: Authors)

| Row | Material | Thermal Conductivity (Lambda) | Dry Specific Weight | Layer Thickness |
|---|---|---|---|---|
| 1 | Brick | 0.72 (w/mk) | 1700 kg/m³ | 0.0035 m |
| 2 | Adobe | 1.1 (w/mk) | 2100 kg/m³ | 0.002 m |
| 3 | Gypsum | 0.72 (w/mk) | 1300 kg/m³ | 0.0005 m |

## DISCUSSION AND FINDINGS

According to the graphs obtained from the difference in outside and inside temperatures, considering the materials used in the walls and their effect, the inside temperature has been kept between 16 and 27 degrees. The thermal delay obtained according to the comparison of the graphs and considering the external thermal graph, which is from -5 to 30, but the inside temperature is from 16 to 17 degrees to 27, meaning that the building has a relatively balanced and desirable temperature inside, and the wall materials have played a significant role in creating thermal comfort inside. (Fig. 12-38)

## Dehdashti House Analysis

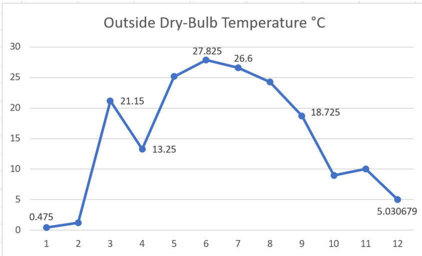



Figure 12: Operating temperature (workable) of the Dehdashti house (Source: Authors)

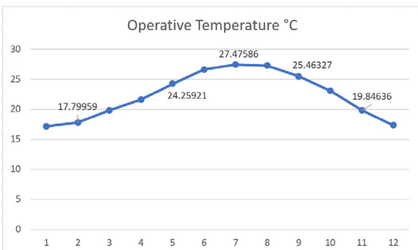



Figure 13: Air temperature (outside air) of the Dehdashti house (Source: Authors)

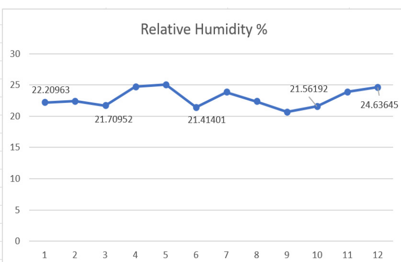



Figure 14: Radiant temperature of Dehdashti house (Source: Authors)

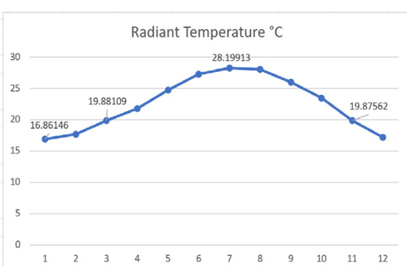



Figure 15: Relative humidity of the room of Dehdashti house (Source: Authors)

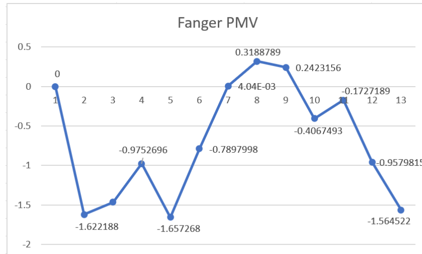



Figure 16: Hours of dissatisfaction at Dehdashti House (Source: Authors)


Figure 17: PMV chart of Dehdashti House (Source: Authors)

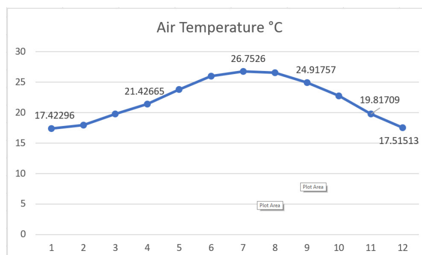



Figure 18: PPD diagram of the Dehdashti house fan (Source: Authors)

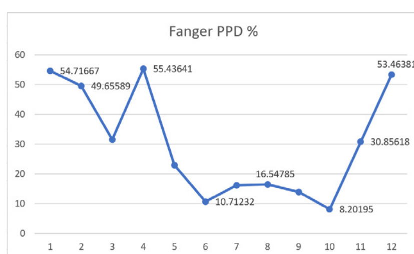



Figure 19: Room temperature (indoor space) of the Dehdashti house (Source: Authors)

*Sartipi House Analysis*

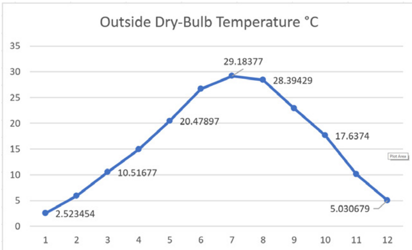



Figure 20: Operating temperature (workable) of the Sartipi house (Source: Authors)

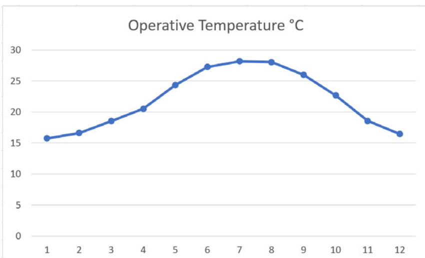



Figure 21: Air temperature (outside air) of the Sartipi house (Source: Authors)

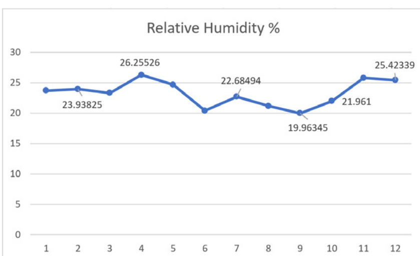



Figure 22: Radiant temperature of a typical house (Source: Authors)

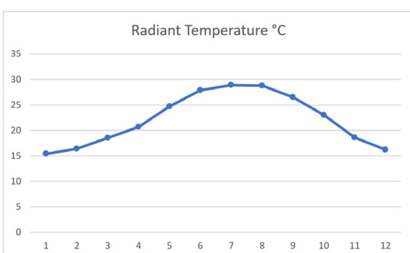



Figure 23: Relative humidity of a typical house room (Source: Authors)

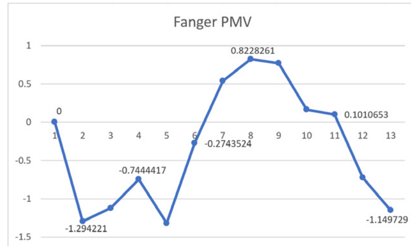



Figure 24: Hours of dissatisfaction at the Sartipi House (Source: Authors)


Figure 25: PMV chart at the Sartipi House (Source: Authors)

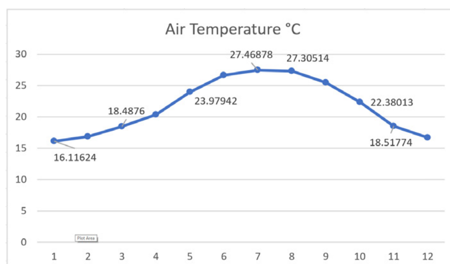



Figure 26: PPD diagram of the Sartipi house (Source: Authors)

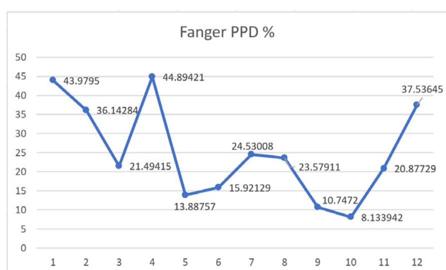



Figure 27: Room temperature (indoor space) of the Sartipi house (Source: Authors)

### *Sartipi House Evaluation*

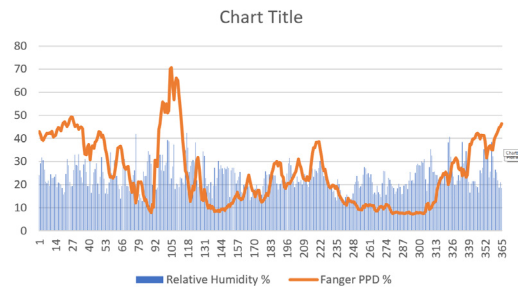



Figure 28: Hours of dissatisfaction in the Sartipi house (Source: Authors)


Figure 29: Relative humidity in the Sartipi house (Source: Authors)

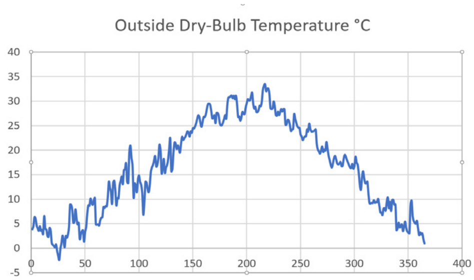



Figure 30: Air temperature (dry bulb temperature of outside air) of the Sartipi house house (Source: Authors)

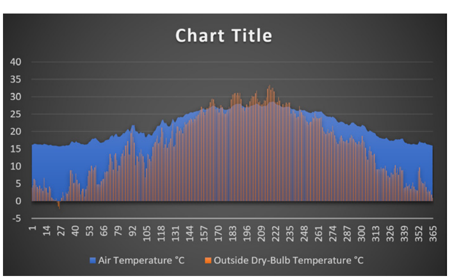



Figure 31: Outside air temperature of the Sartipi house (Source: Authors)

### *Dehdashti House Evaluation*

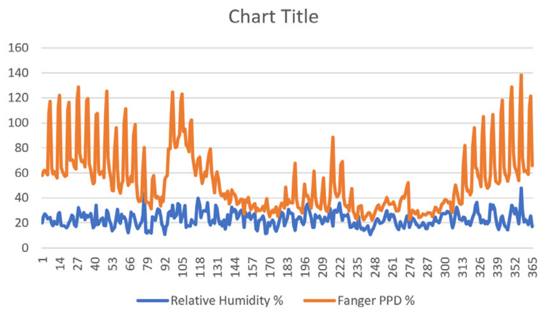



Figure 32: Comparison of room temperature and Dehdashti House comfort model (Source: Authors)

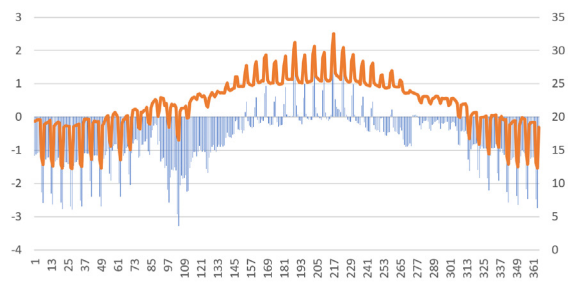


Figure 33: Dehdashti House relative humidity (Source: Authors)

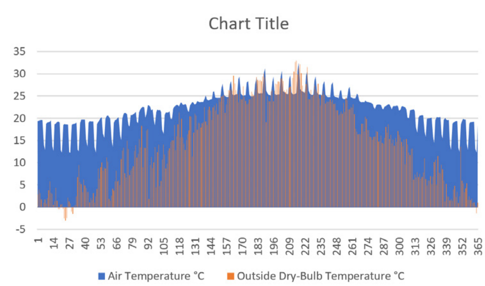



Figure 34: Hours of dissatisfaction in Dehdashti House (Source: Authors)

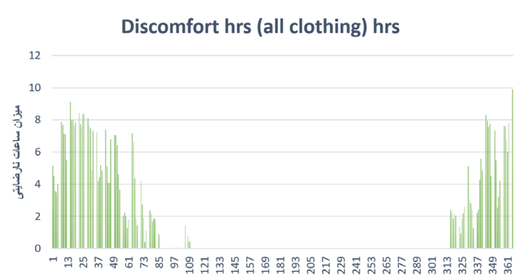



Figure 35: Outside air temperature in Dehdashti House (Source: Authors)

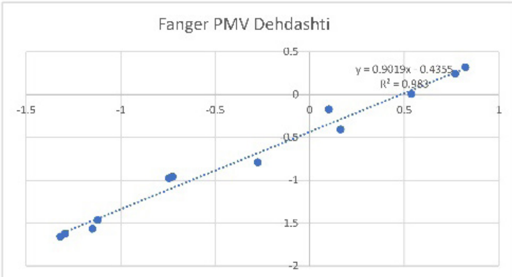



Figure 36: Regression of the current situation and the Fangar index of the Sartepi house (Source: Authors)

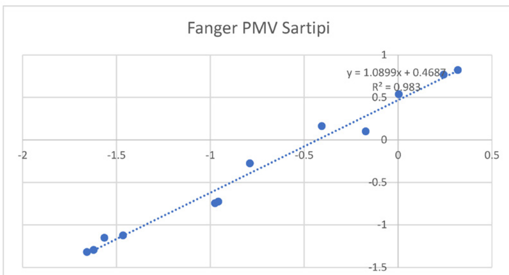



Figure 37: Regression of the current situation and the Fangar index of the Dehdashti house (Source: Authors).

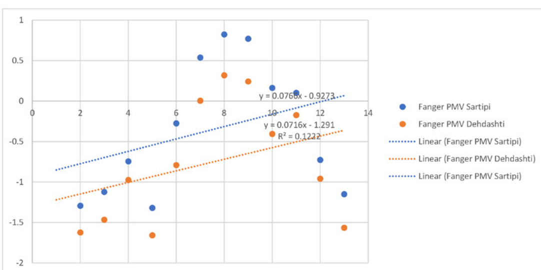



Figure 38: Combined regression chart of Dehdashti House and Sartibi House (Source: Authors)

## RESULTS AND CONCLUSION

The research results indicate that in the traditional method used during the Qajar period, the selection of materials such as adobe, brick, and wood in walls was highly effective in achieving thermal comfort, significantly reducing the need for mechanical heating and cooling systems. The entire environment and the spaces that make up a house functioned as an aerodynamic design, operating through natural ventilation by creating different pressure zones depending on the size and layout of the spaces. In the summer, the maximum thermal load was on the roof, while the eastern and western walls received half of the roof's heat, and the southern walls received less heat. With the onset of winter and the sun's angle approaching vertical, the southern walls captured the most heat. The internal walls of the houses and the results obtained in the research regarding the appropriate thermal behavior of materials aim to provide thermal comfort for individuals inside the homes in every possible way. Additionally, the charts obtained in the findings section explain this topic. Generally, buildings in this climate are constructed with materials that have high thermal capacities, such as adobe and clay. Based on the charts obtained from the Design Builder software for both historical houses in Isfahan, including comparisons of relative humidity for assessing thermal comfort as indicated by the diagrams for indoor air temperature and the levels of satisfaction and dissatisfaction, and comparing this with Fanger's method, it can be concluded that if we consider thermal comfort from zero, the coldest is -3 degrees and the warmest is +3 degrees. The optimal air temperature, if it is between -1 and +1, is desirable for 75% of the individuals, meaning that thermal comfort is adequate and they feel satisfied. Therefore, based on the charts obtained in the findings, it shows that for the Shartipi House, the PMV index according to Fanger ranges between +0.82 and -1.29, while for the Dehdashti House, it ranges between +0.31 and -1.65 during various times of the year.

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