Revista Hábitat Sustentable Vol. 14, N°. 1. ISSN 0719 - 0700 / Págs. 102 - 117
https://doi.org/10.22320/07190700.2024.14.01.08



Recibido 09/09/2023
Aceptado 28/05/2024

# RECOGNIZING LIGHT AND THERMAL BEHAVIOR IN THE STRUCTURE AND FUNCTIONALITY OF BABER-ROOMS IN THE VERNACULAR BUILDINGS OF BANDAR LENGEH

# RECONOCIMIENTO DE LUZ Y COMPORTAMIENTO TÉRMICO EN LA ESTRUCTURA Y FUNCIÓN DEL CAZADOR DE VIENTO BABER EN LA ARQUITECTURA VERNÁCULA DE BANDAR LENGUÉ

# RECONHECIMENTO DO COMPORTAMENTO LUMINOSO E TÉRMICO NA ESTRUTURA E NA FUNCIONALIDADE DAS BABER-ROOMS NOS EDIFÍCIOS VERNACULARES DE BANDAR LENGEH

**Hamed Mohammadi-Mazraeh**
Master
PhD Candidate of Architecture, Department of Architecture, Aras international Campus
University of Tehran, Aras, Irán
https://orcid.org/0000-0003-0861-7614
hmm.mohammadi@gmail.com (Correspondence Author)

**Mohammadreza Mahmoudzadeh**
Master of Architecture
Department of Architecture, Bandar Abbas Branch
Islamic Azad University, Bandar Abbas, Irán
https://orcid.org/0009-0001-5872-3688
mhr.mahmoodzadeh@gmail.com

## RESUMEN

La ciudad portuaria de Bandar Lengué se ubica en una región con un clima cálido y húmedo, en el sur de Irán. Como resultado, y dada la inclemencia del clima, se han desarrollado múltiples elementos y espacios para crear un tipo especial de arquitectura sostenible: un cazador de viento Baber. Ya que no hay evidencia de ningún estudio científico relacionado con esta infraestructura, o con su análisis, esta investigación se ha realizado en dos partes, estructural y funcional, para entenderlas mejor como una estructura estable. Para este examen se escogió el área de Bandar-Lengué (36 casas con 70 años de antigüedad o más) para un estudio cualitativo (presentando al cazador de viento Baber, sus componentes, materiales y proceso de construcción, las áreas ocupadas, la orientación y su posición) y cuantitativo (medición de luz usando el software de análisis Ecotec y mediciones de temperatura con un dispositivo "Fluke T3000c"). Esto se realizó en un momento en el que el aire acondicionado mecánico no era el estándar, para ver si estas habitaciones podían satisfacer las necesidades de los habitantes como un aire acondicionado natural.



Palabras clave
ligera, comportamiento térmico, cazador de viento Baber, clima, Bandar Lengué.



## ABSTRACT

Bandar-Lengeh is located in a region with a hot and humid climate in the south of Iran. As a result, given its harsh weather conditions, several elements and spaces have been devised to create a special kind of sustainable architecture, a Baber-Room. Since there is no evidence of any scientific study regarding Baber-Rooms or their analysis, this research has been conducted in two parts, structural and functional, to better understand them as a stable structure. To examine these, an area of Bandar-Lengeh was chosen (36 houses aged 70 or above) for a qualitative (introducing the Baber-Room, its components, materials, and construction process, the occupied areas, orientation, and positioning) and a quantitative study (light-measurement using Ecotect analysis software and temperature measurements with a "Fluke T3000fc" device). This was done at a time when mechanical air-conditioners were not standard, to see whether these rooms could meet the needs of inhabitants as natural air-conditioners.



Keywords
light, thermal behavior, Baber-room, climate, Bandar Lengeh.



## RESUMO

Bandar-Lengeh está localizada em uma região de clima quente e úmido no sul do Irã. Como resultado, dadas as condições climáticas adversas, vários elementos e espaços foram planejados para criar um tipo especial de arquitetura sustentável, uma Baber-Room. Como não há evidências de nenhum estudo científico sobre as Baber-Rooms ou sua análise, esta pesquisa foi conduzida em duas partes, estrutural e funcional, para melhor compreendê-las como uma estrutura estável. Para examiná-las, foi escolhida uma área de Bandar-Lengeh (36 casas com idade igual ou superior a 70 anos) para um estudo qualitativo (apresentando a Baber-Room, seus componentes, materiais e processo de construção, as áreas ocupadas, a orientação e o posicionamento) e um estudo quantitativo (medição de luz usando o software de análise Ecotect e medições de temperatura com um dispositivo "Fluke T3000fc"). Isso foi feito em uma época em que os condicionadores de ar mecânicos não eram padrão, para verificar se essas salas poderiam atender às necessidades dos habitantes como condicionadores de ar naturais.



Palavras-chave:
luz, comportamento térmico, Baber-Room, clima, Bandar Lengeh.

Revista Hábitat Sustentable Vol. 14, N°. 1. ISSN 0719 - 0700 / Págs. 102 - 117
https://doi.org/10.22320/07190700.2024.14.01.08



# INTRODUCTION

Sustainable architecture can be defined as any experience contributing to what humans use for a more suitable environment (Jaradat, Alshboul, et al. 2024). This is increasingly relevant within a context where the construction industry has been responsible for approximately 30-40% of global energy use, and energy-saving issues and applicability have become extremely important regarding the scale of buildings and architecture (Li, Zhai et al., 2024). In the past, the lack of mechanical cooling systems led to natural air-conditioning structures being used to provide comfort for users (Toroxel & Silva 2024) and in Iran, local architecture has attempted to provide greater comfort through elements (like wind towers and latticework) and stable spaces such as the Baber-Room to make their environment satisfactory (Mazraeh & Pazhouhanfar, 2018). These local buildings are taken into consideration as the source of continuous knowledge and the result of centuries of experience and contemplation (Baheretibeb & Whitehead, 2024), and as time has gone by, there has been an increasing familiarity with their role and practicality (Dwijendra & Adhika 2022; Sargazi, 2023). However, this type of architecture has undergone many changes over time.

Since ancient times, climate has played a very significant role in the advent of architecture as it is, but this is also true in architectural elements that are supposed to be a vital part in the recognition of compatible architecture with the climate of a particular region. However, it is the so-called tool, "people's awareness of climate," that has led to a stable development in architecture. In addition, local materials, elements, and spaces have provided users with comfort (Mazraeh & Pazhouhanfar, 2018). One of these elements is the use of latticework when it comes to windows. A variety of changes, simple windows, and latticework windows (Figure 4) in great numbers, especially in a Baber-Room, have been used to face unpleasant weather conditions, namely the high-light-intensity, heat, and moisture, without any mechanical cooling system (Mazraeh & Pazhouhanfar, 2020).

Despite all the evolutionary actions and novelty in the construction world, many Iranians still live in local houses, and surprisingly favor them (Foruzanmehr, 2015; Mazraeh & Pazhouhanfar, 2018). Inhabitants have been looking for methods and elements to provide thermal comfort in spaces (Sargazi, 2023), and to deal with/respond to the nature of climate (Razavian Alemi, et al., 2023).

Bandar Lengeh is one of the Iran's southern regions, characterized by a hot and humid climate. It features a unique space known as the "Baber Room," along with several vernacular architecture elements, which play a functional role in developing the region's native architecture. Since no prior studies or investigations have been conducted, this research adopts an innovative approach to understanding and validating the Baber Room's functional role in sustainability. The research seeks to answer the question of whether the Baber Room and its vernacular architectural elements have positively responded to sustainability issues when no mechanical ventilation systems were available.

# METHODOLOGY

The architecture of a Baber-Room in Bandar-Lengeh follows a unique style seen in the region, especially in harsh weather situations. After the wind towers found on roofs, it is the oldest and most applicable natural air conditioner. Because no study was found to examine/introduce the Baber-Room's natural air-conditioning system, the decision was made to analyze an old context, including 36 houses aged 70 or above. Using a qualitative (introducing the Baber-Room, its components, materials, and construction process, the occupied areas, orientation, and positioning) and a quantitative study (light and temperature measurements using software and a device, respectively), it was determined to scrutinize the functional and structural features of this space. For the structural aspect, the materials, construction process, and components (latticework, shading, the amount of surface usage in three Baber-Room styles) were examined, while the functional part deals with the light analysis and studies the room in two different modes. To do this, the room temperature was measured throughout 24 hours of the day on the 17$^{th}$ of each month.

# CASE STUDY

Bandar-Lengeh, with its 8,210 km$^2$, is located southwest of the Persian Gulf coast (Figure 1). On being next to the sea, it is exposed to a hot and dry coastal air mass plus mild and humid sea air. Consequently, sometimes 60 km/h winds are recorded, blowing from the sea toward the coast. According to the measurements shown in Table 1, the temperature ranges from 33° to 45° C. The hottest period is called "Khoradad" and "Shahrivar," which is unpleasant for users. Moreover, high humidity of up to 100% can often be observed because of the proximity to the sea. Although hotness and humidity produce a challenging and harsh situation, the local architecture of Bandar-Lengeh, thanks to the devised spaces and elements, can subtly handle the situation of its inhabitants (Mohammadi Mazraeh, 2022). It also has facilitated and comforted people's lives in internal spaces (Mohammadi Mazraeh, 2021), in a way that Arabs living around the Persian Gulf come to walk in this region (Mazraeh & Pazhouhanfar, 2018).

## ARCHITECTURAL FEATURES OF BANDAR-LENGEH

The first sample of a Baber-Room appeared among houses that are over 70 years old (Figure 2A), where all the houses had a Baber-Room on the roof. Over time,

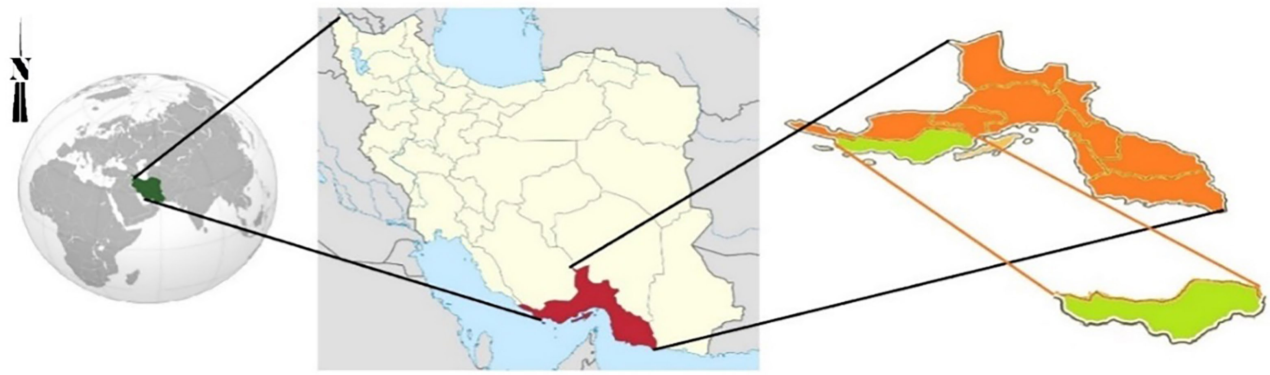


Figure 1. Bandar-Lengeh on a map of Iran and in the world. Source: authors' elaboration

Table 1. Values (PET) for different months in Bandar-Lengeh (Roshan, Yousefi et al., 2018)

| Jan | Feb | Mar | Apr | May | Jun |
|---|---|---|---|---|---|
| Comfortable | Comfortable | Slightly warm | Warm | Hot | Very hot |
| 19.5 | 21.3 | 24.9 | 31.2 | 37.6 | 41.4 |
| **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Very hot | Very hot | Hot | Warm | Slightly warm | Comfortable |
| 43.2 | 43.1 | 40.1 | 34.7 | 27.3 | 21.8 |

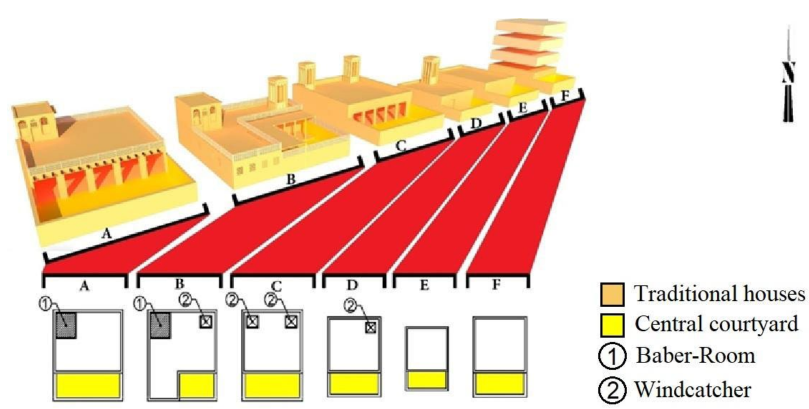



Figure 2. A variety of construction methods from 70 years ago up until the present day. Source: authors' elaboration

among the buildings aged from 50 to 70 years, it can be noticed that Baber-Room is built sometimes with a wind tower or alone on the roofs (Figure 2A & Figure 2B). However, in buildings between 30 and 50 years old, there is only a single or a pair of wind tower(s) (Figure 2C & Figure 2D). In more recent buildings (less than two decades old), the only thing that can be observed is the existence of natural air-conditioning through latticework and or simple windows (Figure 2E). Finally, in the last two decades, with the advent of apartments (Figure 2F) besides the traditional context, a sense of dissatisfaction has spread among the users of A, B, C & D towards the loss of privacy in yards, the lack of safety in earthquakes, and the possibility of badly-made new buildings collapsing on traditional houses.

# RESULTS

## STRUCTURAL ANALYSIS AND COMPONENTS

### An introduction to the Baber-room

In traditional societies, families required places that could facilitate activities such as sitting, eating, sleeping, gathering as a family, entertainment, and for privacy (Mohammadi Mazraeh, 2022). This can be perceived in the role of the Baber Room.

Baber-Rooms can be square or rectangular shaped and are normally 4*4, 6*4, and 6*6 in size. They are located

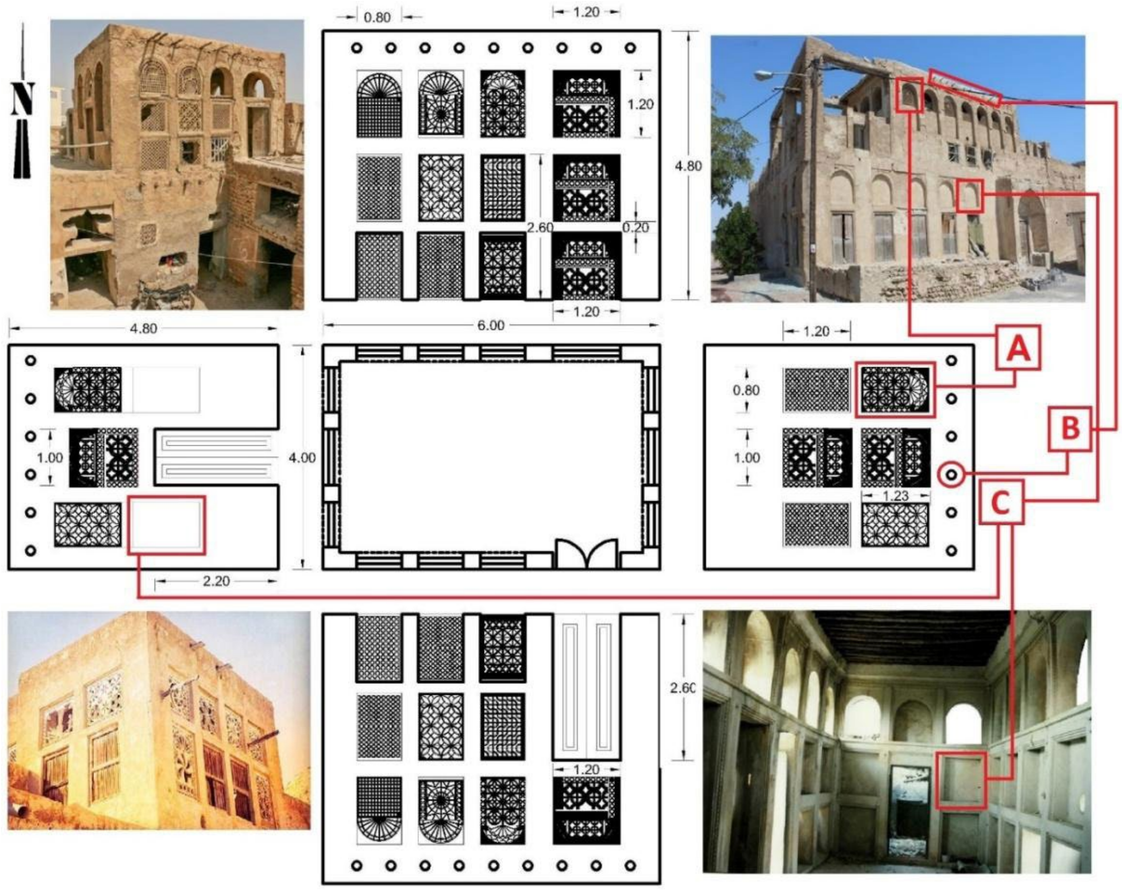



Figure 3. The Baber-Room layout, including its elements. Source: authors' elaboration

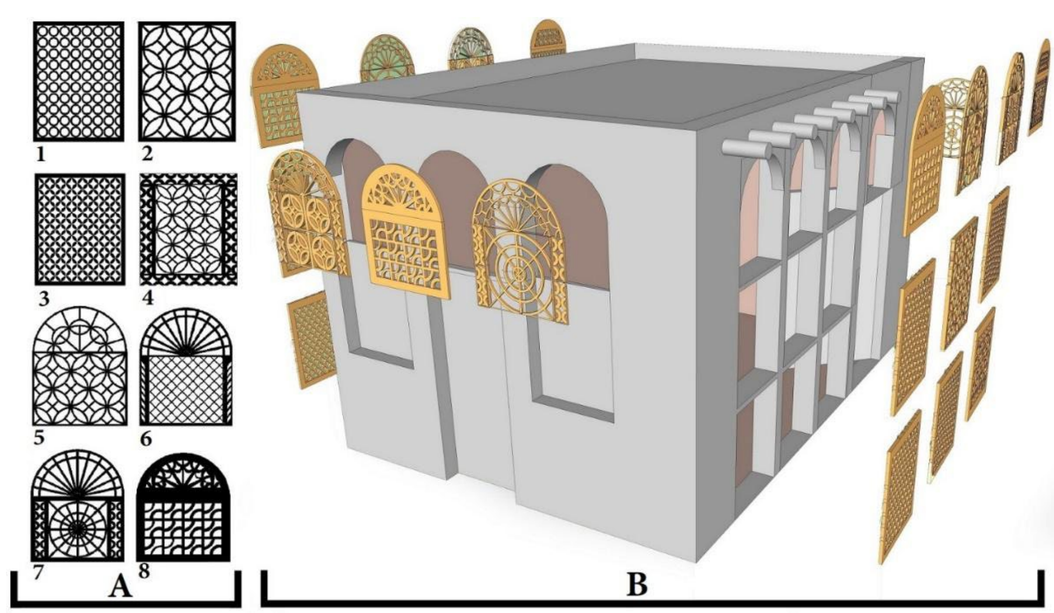



Figure 4. Three-dimensional view of the Baber-Room's internal space. Source: authors' elaboration

Revista Hábitat Sustentable Vol. 14, N°. 1. ISSN 0719 - 0700 / Págs. 102 - 117
https://doi.org/10.22320/07190700.2024.14.01.08


Table 2. The amount of empty and used area for the eight most commonly used latticeworks. Source: authors' elaboration

| Row | Model type | Used surface area | Empty surface area | Total area (cm) |
|---|---|---|---|---|
| 1 | 1 | 39% | 61% | 960(100%) |
| 2 | 2 | 32% | 68% | 960(100%) |
| 3 | 3 | 38% | 62% | 960(100%) |
| 4 | 4 | 34% | 66% | 960(100%) |
| 5 | 5 | 32% | 68% | 960(100%) |
| 6 | 6 | 39% | 61% | 960(100%) |
| 7 | 7 | 32% | 68% | 960(100%) |
| 8 | 8 | 43% | 57% | 960(100%) |

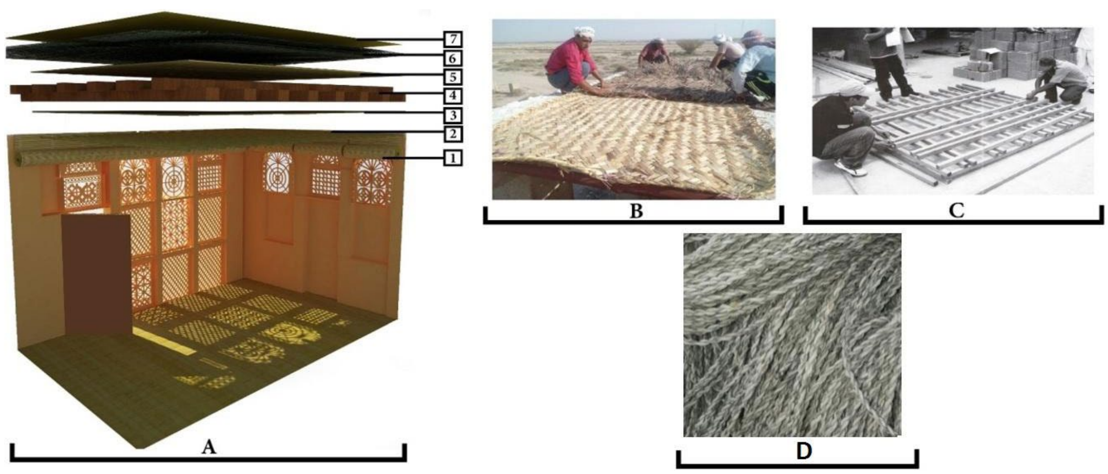



Figure 5. Architectural structure of the Baber-Room's roof. Source: authors' elaboration

on the top floor and are accessible through stairs built at the entrance to the house, or ones in the living room or family room, to the roof/internal space of the Baber-Room (Mazraeh & Pazhouhanfar, 2018; Mazraeh & Pazhouhanfar, 2020). This room is a perfect instance of the sustainable architecture of Bandar-Lengeh (Figure 3), given its variety of components such as latticed windows (Figure 3A), squared timber (Figure 3B), and niches (Figure 3C). Its walls provide suitable conditions for users to sleep, eat, read, etc., by receiving wind from the sea and absorbing light from early afternoon to late morning.

## Latticework

Muslims' houses follow a unique design that has even been emphasized in Islam (Putri & Sunesti, 2021), where privacy in traditional architecture has had a noticeable impact on user satisfaction (Philokyprou & Michael, 2021). Their latticework has commonly been devised as thick curtains ever since the Safavieh Dynasty in Iran. With the latticework, the interior space would not be visible all day long for privacy (Babaei, Soltanzadeh et al., 2013). It also prevents light from entering the house to some extent (Mohammadi Mazraeh, 2023), and the inhabitants can comfortably do their everyday chores. In the past, local architects and users tried to place latticework facing most regional winds (often towards the sea) to experience better air conditions inside the building by directing the wind. Such buildings are often seen in Bandar-Lengeh. The bottom line is that all these functions are there only for user comfort (Nemat Gorgani, 2002; Mazraeh & Pazhouhanfar, 2018). Figure 4 shows the eight most common latticework models in Bandar-Lengeh. Meanwhile, Table 2 shows the proportion of empty compared with non-empty areas, which ranges from 57% to 68%. This is to bring beauty and light into the interior space for user satisfaction.

## Materials and construction process

Local architecture has demonstrated its positive attitude towards nature and cultural significance in black and white (Chen, Xie et al., 2020), while using local components and materials has been an effective action for the design (Mazraeh & Pazhouhanfar, 2018). It has considered that intense heat, moisture, and light to an extreme degree in Bander-Lengeh requires taking advantage of a specific architecture that provides users with comfort, where possible. One of the solutions is to be familiar with climate change to be able to deal with bad weather conditions. Indicators such as taking advantage of local materials

Revista Hábitat Sustentable Vol. 14, N°. 1. ISSN 0719 - 0700 / Págs. 102 - 117
https://doi.org/10.22320/07190700.2024.14.01.08



(thatch, mortar, stone, plaster), recognizing spaces and utilizing them in the opposite direction of sunlight, wall thickness (to protect the building against heat/moisture), using plenty of latticework in the room's wall, positioning a Baber-Room at high altitude and using high-ceilings, play a notable role in this. The main materials used for the ceilings according to Figure 5 are (from indoor to outdoor): 1-mat (light-absorbent type) (Figure 5B) 2-rope fabricated out of date tree leaves (Figure 5D) 3-covering mat 4-squared timber vertically and horizontally on each other (Figure 5C) 5-covering mat 6-date tree leaves 7- thatch. Every single component truly expresses the connection and interrelation between architecture and nature for the special role of Baber-Rooms such as light-absorbent mats to prevent intense light from penetrating the place, rope to hang the mat on the roof, covering mat made from leaves of a date tree, and also this same material for scattering and thickening against heat to avoid dust descending from the ceiling inside the house, squared timber to hold and bear the weight of the ceiling, and thatch to cover the walls and ceiling to provide cooling and heating in summer and winter, respectively.

## SHADING, WINDOWS AND ORIENTATION

### Shading and windows (A place to be away from sunlight)

Shading was one of the very few options used to prevent intense light and hot wind (on the east/west side of the Baber Room) from entering. This was created as a porch to expand latticework on the rooms' walls, besides adding space with shading so users could take advantage of it throughout the day. Among the 36 Baber-Room cases in Bandar-Lengeh, only two included a room with shading.

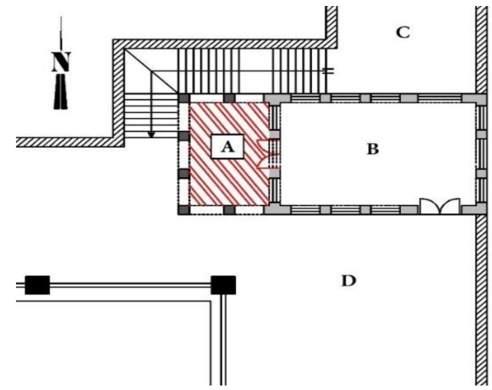



Figure 6. Space occupied by shade on the floor (part A) and in view (part B). Source: authors' elaboration

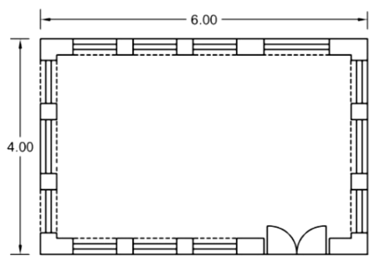
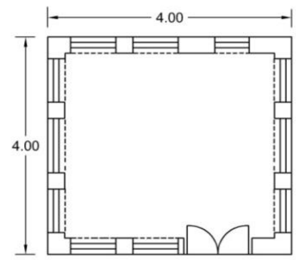
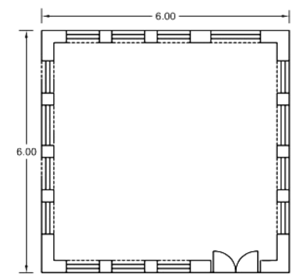
### The proportion of areas used in the Baber-Room in three styles

The Baber-Room included areas such as a wall, a niche in the wall (Figure 3C), the door area, and the lattice window (Figure 3A) that occupied a specific area of wall which is determined through the measurements and data in Table 3. At a glance, it can be concluded that the maximum average of the areas is (in order): wall with 13.25 m$^2$, lattice window with 6.62 m$^2$, niche with 4.5 m$^2$, and door with 1.23 m$^2$. As it can be perceived, they tried to use lattice windows as much as possible in north and south, with 8.93m$^2$ and 10.42m$^2$ (in order), to provide daylight and natural air-conditioning inside the room.

Table 3. Rate of use of each area on different sides. Source: authors' elaboration

| Room expanse (m) | Entire wall area | | | | Wall area (m$^2$) | | | | Niche area on the wall (m$^2$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | S | W | E | N | S | W | E | N | S | W | E |
| 4*4 | 19.2 | 19.2 | 19.2 | 19.2 | 9.9 | 8.38 | 11.5 | 11.5 | 0 | 0 | 7.7 | 7.7 |
| 4*6 | 28.8 | 28.8 | 19.2 | 19.2 | 15.84 | 15.6 | 11.6 | 12.96 | 0 | 0 | 2.24 | 0 |
| 6*8 | 38.4 | 38.4 | 28.8 | 28.8 | 17.4 | 16.28 | 13.28 | 14.8 | 12 | 10 | 6.4 | 8 |
| Component average | 28.8 | 28.8 | 22.4 | 22.4 | 14.38 | 13.42 | 12.13 | 13.09 | 4 | 3.33 | 5.45 | 5.23 |
| Average | | | | | | 13.25 | | | | 4.5 | | |
| **Room expanse (m)** | **Latticed window (m$^2$)** | | | | **Door's surface** | | | | **Ratio of the total wall area to the niche** | | | |
| | **N** | **S** | **N** | **N** | **N** | **S** | **W** | **E** | **N** | **S** | **W** | **E** |
| 4*4 | 9.3 | 7.7 | 0 | 0 | 0 | 3.12 | 0 | 0 | 2.06 | 2.49 | 2.49 | 2.49 |
| 4*6 | 12.96 | 10.08 | 3.12 | 6.24 | 0 | 3.12 | 3.12 | 0 | 2.22 | 2.86 | 3.58 | 3.08 |
| 6*8 | 9 | 9 | 6 | 6 | 0 | 3.12 | 2.24 | 0 | 1.83 | 2.02 | 2.32 | 2.06 |
| Component average | 10.42 | 8.93 | 3.04 | 4.08 | 0 | 3.12 | 1.79 | 0 | 2.04 | 2.46 | 2.80 | 2.45 |
| Average | | 6.62 | | | | 1.23 | | | | | | |

Table 4. Orientation of Baber-Rooms. Source: authors' elaboration

| Type of room | | | | | | |
|---|---|---|---|---|---|---|
| Model | A | | B | | C | |
| |  | |  | |  | |
| | Quantity | Percentage | Quantity | Percentage | Quantity | Percentage |
| | 28 | 77.8% | 5 | 13.9% | 3 | 8.3% |

## ORIENTATION

When designing and building the Baber Room to address climate awareness, spaces were structured considering local weather conditions. These elements include locating the largest rooms from east/west considering their use and length (Mazraeh & Pazhouhanfar, 2018). According to Table 4, among the 36 buildings with Baber-Rooms, it was seen that there were 28 south/north rooms of 6*4, five rooms of 4*4, three rooms of 6*6 ($m^2$) and only two east/west rooms were found. In model C, two are shown on the east/west side.

## TEMPERATURE MEASUREMENTS

The Fluke T3000fc thermometer, used inside the Baber Room to measure temperature, can be used to determine thermal conditions under challenging circumstances like those of Bandar-Lengeh. Fluke Connect allows users to record measurements online by connecting applications and sharing the temperature via the "share live" option. Another advantage of this device is that it can measure temperatures ranging from -200° C to +1,372° C, at a 0.1° C resolution, with an operating temperature from -10° to +50° C, entry protection (IP42), and ITS-90 (thermal-scale). This device is used inside the Baber Room to measure temperature.

Physiological equivalent temperature, or PET, is a well-known indicator used to measure and compare different degrees of heat and physiological stress on humans. It is used here to measure the temperature of Bandar-Lengeh and the interior space of the dwellings (Table 5).

In the past, the temperature was presumed to be one of the substantial indicators of comfort in a building. The Baber-Room could be compatible with different regional climate situations because of its local architectural elements and it provides satisfaction for users. To determine the temperature accurately on the 17th day of each month (for 24 hours), the "Fluke T3000fc" thermometer was placed inside the Baber-Rooms at the height of 1.2 meters (Sleeping space pattern in Table 7) from the floor to examine whether a Baber–Room with 63.4% of use per day (compared to other spaces) can provide better comfort for users of traditional constructions.

Figure 7. "Fluke T3000fc" device for measuring temperatures. Source: Authors' image

Table 5. Physiological equivalent temperature – PET (Matzarakis, Mayer et al., 1999).

| PET (°C) | Thermal sensation | Physiological stress level |
|---|---|---|
| <4 | Very cold | Extreme cold stress |
| 4–8 | Cold | Strong cold stress |
| 8–13 | Cool | Moderate cold stress |
| 13–18 | Slightly cool | Slight cold stress |
| 18–23 | Comfortable | No thermal stress |
| 23–29 | Slightly warm | Slight heat stress |
| 29–35 | Warm | Moderate heat stress |
| 35–41 | Hot | Strong heat stress |
| >41 | Very hot | Extreme heat stress |

Revista Hábitat Sustentable Vol. 14, N°. 1. ISSN 0719 - 0700 / Págs. 102 - 117
https://doi.org/10.22320/07190700.2024.14.01.08



Table 6. Internal temperature of the room at different times of the day during a year. Source: authors' elaboration

| DATA | January | | February | | March | | April | | May | | June | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside |
| 0 | 19.5 | 21.7 | 20.3 | 22.2 | 20.8 | 23.2 | 22.3 | 24.7 | 35.7 | 29.8 | 33.7 | 31.2 |
| 1 | 19.3 | 21.3 | 20.2 | 22 | 20.5 | 23.2 | 21.6 | 24.6 | 34.5 | 28.5 | 33.2 | 30.6 |
| 2 | 19.1 | 21.1 | 20 | 21.8 | 20.1 | 23 | 20.8 | 24.3 | 33.1 | 28.8 | 32.6 | 30 |
| 3 | 18.8 | 21 | 19.8 | 21.5 | 19.7 | 22.8 | 20 | 24 | 31.8 | 28.4 | 32.1 | 29.7 |
| 4 | 18.7 | 21.4 | 19.7 | 21.5 | 19.2 | 22.7 | 19.3 | 23.9 | 30.5 | 28.1 | 31.6 | 29.1 |
| 5 | 18.5 | 21.1 | 19.6 | 21.4 | 18.8 | 22.6 | 19.3 | 23.9 | 30.8 | 28.4 | 32.2 | 30 |
| 6 | 18.3 | 21.3 | 19.8 | 21.5 | 19.8 | 23.2 | 20.6 | 24.9 | 32.1 | 29.8 | 33.2 | 31 |
| 7 | 19.3 | 21.7 | 19.8 | 21.5 | 21 | 24.1 | 22.2 | 25.7 | 33.7 | 31.2 | 34.6 | 31.4 |
| 8 | 19.3 | 21.9 | 20.3 | 22.8 | 22.2 | 25.2 | 23.5 | 27.2 | 35.2 | 32.9 | 35.9 | 31.9 |
| 9 | 19.5 | 22.1 | 21.7 | 24.3 | 23.5 | 26.2 | 25.1 | 27.1 | 36 | 33.7 | 37.2 | 35.2 |
| 10 | 21.3 | 24.5 | 22.6 | 24.9 | 24.8 | 26.8 | 26.6 | 27.8 | 36.7 | 37.3 | 38.2 | 35.4 |
| 11 | 22.6 | 25.3 | 23.6 | 25.7 | 25.5 | 28 | 27.8 | 28 | 37.1 | 39 | 39.1 | 36.3 |
| 12 | 23.2 | 25.3 | 24.3 | 26.1 | 26.1 | 28.6 | 28.6 | 28.6 | 37.3 | 39.1 | 39.7 | 36.7 |
| 13 | 23.6 | 25.4 | 24.8 | 26.5 | 26.3 | 28.8 | 29 | 28.2 | 39.5 | 39.2 | 40.1 | 37.1 |
| 14 | 23.8 | 25.9 | 25.2 | 26.8 | 26.3 | 29 | 29.2 | 27.7 | 38 | 38.4 | 40.1 | 37.3 |
| 15 | 23.2 | 25.4 | 25.1 | 26.7 | 26.2 | 28.8 | 28.8 | 27 | 37.6 | 37.1 | 39.7 | 37 |
| 16 | 22.5 | 22.4 | 24.6 | 25.8 | 25.5 | 28.3 | 28.1 | 26.6 | 37 | 36.3 | 39.2 | 36.7 |
| 17 | 22.3 | 21.8 | 24 | 25.4 | 24.5 | 26.2 | 27 | 25.7 | 36.1 | 34.7 | 38.4 | 35.4 |
| 18 | 22.2 | 21.8 | 23.6 | 21.8 | 24.2 | 23.5 | 26.3 | 25 | 35.4 | 33.4 | 37.4 | 35.1 |
| 19 | 22 | 21.7 | 23.3 | 21.8 | 23.8 | 23.5 | 25.8 | 25 | 34.7 | 31.6 | 36.7 | 34.4 |
| 20 | 21.8 | 21.1 | 22.8 | 22.4 | 23.3 | 23.6 | 25.3 | 25.1 | 34 | 30.7 | 36 | 33.7 |
| 21 | 21.6 | 21 | 22.6 | 22 | 23.1 | 23.7 | 24.8 | 25 | 33.2 | 30.1 | 35.2 | 33.1 |
| 22 | 21.5 | 21.1 | 22.2 | 22.1 | 22.7 | 23.6 | 24.2 | 24.9 | 32.5 | 29.7 | 34.6 | 32.4 |
| 23 | 21.3 | 21 | 21.8 | 21.4 | 22.3 | 23.5 | 23.7 | 24.9 | 31.8 | 29.1 | 33.9 | 32 |
| Average | 20.97 | 22.43 | 22.15 | 23.33 | 22.93 | 25.09 | 24.58 | 25.83 | 34.76 | 32.72 | 36.03 | 33.45 |

| DATA | July | | August | | September | | October | | November | | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside |
| 0 | 35.7 | 33.4 | 33.9 | 32.5 | 30.8 | 28.4 | 27.8 | 25.3 | 24.5 | 23.7 | 20.1 | 20.4 |
| 1 | 36.2 | 34.3 | 33.2 | 31.8 | 30.6 | 28.1 | 27.5 | 25.1 | 23.8 | 22.8 | 19.2 | 19.6 |
| 2 | 36.6 | 34.8 | 32.7 | 31.1 | 30.3 | 27.6 | 27.1 | 24.5 | 23.2 | 22.6 | 18.3 | 18.8 |
| 3 | 36.9 | 34.9 | 32.2 | 35.4 | 30 | 28.9 | 26.6 | 24 | 22.5 | 21.8 | 17.5 | 17.7 |
| 4 | 37.2 | 35.5 | 31.8 | 30.8 | 29.8 | 27.2 | 26.2 | 23.8 | 21.8 | 20.6 | 16.6 | 16.9 |
| 5 | 37.6 | 35.9 | 31.8 | 30.3 | 29.5 | 27.4 | 25.8 | 23.1 | 21.2 | 20.4 | 15.6 | 16 |
| 6 | 38.2 | 36.7 | 32.4 | 30.7 | 30.3 | 27.9 | 26.8 | 24.9 | 21.6 | 20.6 | 14.9 | 15.3 |
| 7 | 39.1 | 38.1 | 33.1 | 30.9 | 31.1 | 29.3 | 28.1 | 26.6 | 22.7 | 21.9 | 17.1 | 17 |
| 8 | 40 | 38.7 | 34.2 | 31.9 | 32.2 | 30.8 | 29.3 | 27 | 24.1 | 23.2 | 19 | 18.8 |
| 9 | 40.9 | 40.1 | 35.4 | 32.4 | 33.2 | 31.6 | 30.6 | 27.2 | 25.3 | 24.1 | 20.3 | 20.5 |
| 10 | 41.7 | 40.3 | 36.2 | 32.8 | 34.2 | 32.4 | 31.6 | 27.9 | 26.3 | 25.8 | 21.5 | 21.8 |
| 11 | 42.7 | 40.4 | 36.9 | 33.4 | 34.7 | 32.7 | 32.4 | 28.7 | 27.1 | 25.3 | 22.2 | 22.6 |
| 12 | 43.2 | 40.8 | 37.5 | 33.8 | 35.2 | 33.6 | 32.7 | 28.9 | 27.5 | 25.2 | 22.7 | 23 |
| 13 | 43.7 | 40.3 | 37.9 | 34.2 | 35.4 | 33.7 | 33.1 | 29.5 | 27.7 | 25.3 | 23 | 23.9 |
| 14 | 43.9 | 41.1 | 38.1 | 34.4 | 35.2 | 33.7 | 32.9 | 28.6 | 27.3 | 25.8 | 22.5 | 23.4 |
| 15 | 43.7 | 40 | 38 | 34.1 | 35 | 33.4 | 32.5 | 28.8 | 26.7 | 25.3 | 21.8 | 22.4 |
| 16 | 43.5 | 39.6 | 37.5 | 33.9 | 34.4 | 32.9 | 31.6 | 28.2 | 25.8 | 24.2 | 20.5 | 22.7 |

Revista Hábitat Sustentable Vol. 14, N°. 1. ISSN 0719 - 0700 / Págs. 102 - 117
https://doi.org/10.22320/07190700.2024.14.01.08


| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 42.9 | 38.2 | 36.7 | 33.3 | 33.7 | 32 | 31.1 | 27.8 | 25.5 | 24.7 | 20.2 | 20.4 |
| 18 | 42.2 | 37.5 | 36.2 | 32.6 | 33.2 | 30.7 | 30.6 | 27.2 | 25.2 | 24.3 | 19.8 | 19.6 |
| 19 | 41.7 | 37.4 | 35.7 | 32.2 | 32.9 | 30.3 | 30 | 26.9 | 24.8 | 24 | 19.6 | 19.3 |
| 20 | 41.1 | 37.4 | 35.1 | 31.6 | 32.6 | 30 | 29.5 | 26.4 | 24.6 | 23.4 | 19.3 | 19 |
| 21 | 40.6 | 37.4 | 34.6 | 32 | 32.2 | 29.6 | 29 | 25.8 | 24.2 | 23.1 | 19 | 19.4 |
| 22 | 40 | 37.1 | 34 | 31.6 | 31.8 | 29 | 28.5 | 25.3 | 23.8 | 22.7 | 18.7 | 19.1 |
| 23 | 39.4 | 37.2 | 33.5 | 30.8 | 31.1 | 28.6 | 28 | 25.1 | 23.6 | 22.6 | 18.3 | 18.9 |
| Average | 40.36 | 37.8 | 34.94 | 32.44 | 32.49 | 30.4 | 29.55 | 26.53 | 24.62 | 23.48 | 19.49 | 19.85 |

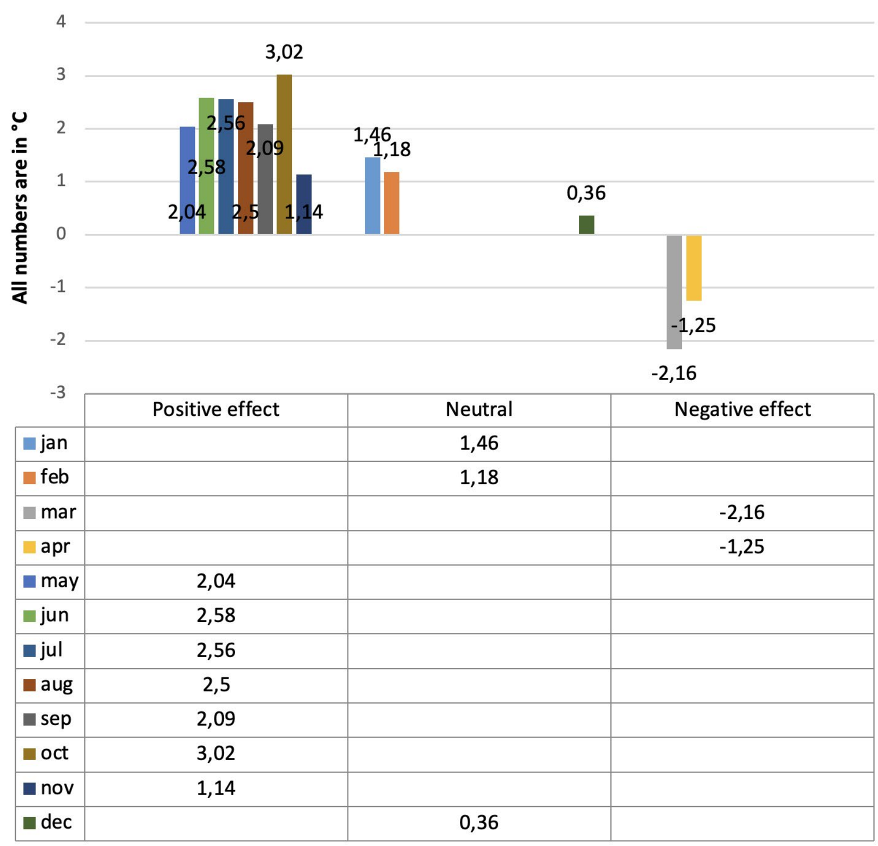



Figure 9. Positive, negative, and neutral role of the Baber-Room compared to the outside-temperature. Source: authors' elaboration

According to the data in Table 5, Figure 8, and Figure 9, it can be seen that the behavior of the Baber-Room in different months of the year is divergent. In January and February, when thermal-conditions are comfortable, a 1.46 and 1.18 (average temperature at different hours from Figure 8) degree temperature increase, respectively, can be seen inside (noted as neutral). In March, the thermal condition is supposed to be slightly warm, and a 2.04-degree increase in temperature can be perceived inside (noted as an adverse effect). However, in April, similarly to March, a 1.25-degree increase in temperature leads to unpleasant conditions inside the Baber Room. People use these spaces less and less during the day/night in March and April.

However, the weather is hot in May and September, and temperatures that are 2.04 and 2.09 degrees lower, respectively, can be noticed. Meanwhile, in June, July, and August, when the weather is considered very hot, temperatures that are 2.5, 2.56, and 2.58 (respectively) degrees lower lead to a relaxing and suitable atmosphere in the inner space. In October, considered as warm, the temperature is 3.02 degrees lower, providing a safer and more pleasant environment for the users compared to outside. On the other hand, in November, which is slightly warm, the room has a temperature that is 1.14 degrees lower. On the other hand, December is comfortable in itself (noted as neutral), providing comfortable conditions for the Baber-Room users.

Mats are placed on the external walls of buildings to dissipate heat in areas with intense sunlight, as depicted in the left image of Figure 9. This practice helps to moderate the temperature entering the room, making it more pleasant. Additionally, these mats are sometimes dampened to create a cooler breeze within the room, enhancing the overall comfort level.

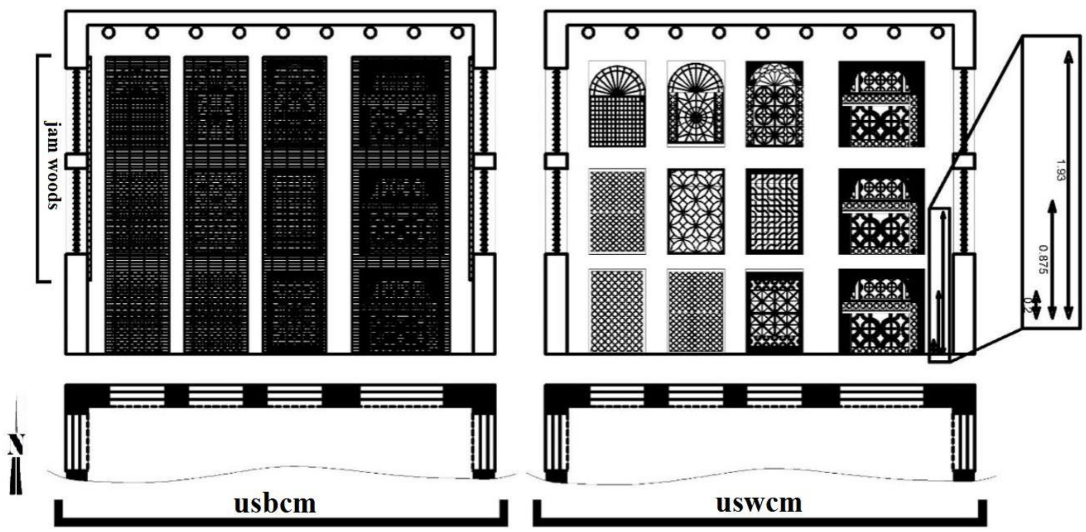
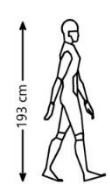



Figure 10. Light measurements in usbcm (left) and uswcm (right). Source: Authors' image.

Table 7. Different types of Baber-Room's usage (Neufert & Neufert, 2012).

| | 1 | 2 | 3 |
|---|---|---|---|
| Position | Lying down (human body at 20 cm from the floor) | sitting (human body at 87.5 cm from the floor) | standing (human body at 193 cm from the floor) |
| |   |   |   |

## LIGHTING MEASUREMENTS

To analyze light in the environment and also the improvement of the building's energy efficiency, several software programs, including "Ecotect," are used. This software provides an advanced modeling method to analyze the role of light in the Baber-Room (Al-Saggaf, Nasir et al., 2020; Lisa, Zuraihan et al., 2021). According to several studies, it is concluded that modeling using Ecotect is very accurate and highly reliable (Salami, Abba et al., 2023; Xu and Liu, 2023). It is also suitable for designing and making initial calculations regarding photometric methods in the construction industry. Figure 10 is used to analyze the role of light in the Baber-Room under two different circumstances. One, with the use of mats, namely USBCM, and without USWCM, to see whether the Baber-Room could provide comfort at hot-peak-hours (i.e., 2 pm) for users in three different conditions or not.

Since people can take advantage of the environment by assuming different positions such as lying down, sitting, and standing, they need to have an interior space with the least light possible at the three heights. Table 7, considers conditions for the human body at 20 cm (lying down), 87.5 cm (sitting), and 193 cm (standing) from the floor, to assess the role of a Baber-Room with local architectural elements.

Considering that light is the second most important factor under observation after temperature in local construction, and according to results achieved in Table 8 and Table 9, it can be noticed that the worst period when extreme hotness is experienced is at 2 pm. In the three different positions examined in the Baber-Room (lying down, sitting, and standing) and in the two different setups (uswcm and usbcm), at 20 cm from the floor with the least light, 210 lux, in both uswcm and usbcm was the best place for users to relax. After that, the second best was at 87.5 cm from the floor with the least light, 240 lux, under the uswcm condition and at 210 lux, in usbcm. Finally, at 193 cm from the floor, the best option was with the least light, 280 lux, in uswcm, and 240 lux, in usbcm. The average in all three, without the mat, is 243.3 lux. On the other hand,

Revista Hábitat Sustentable Vol. 14, N°. 1. ISSN 0719 - 0700 / Págs. 102 - 117
https://doi.org/10.22320/07190700.2024.14.01.08


Table 8. Light-intensity of the Baber-Room in both uswcm and usbcm. Source: authors' elaboration

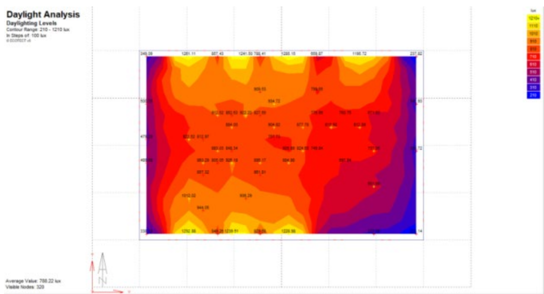
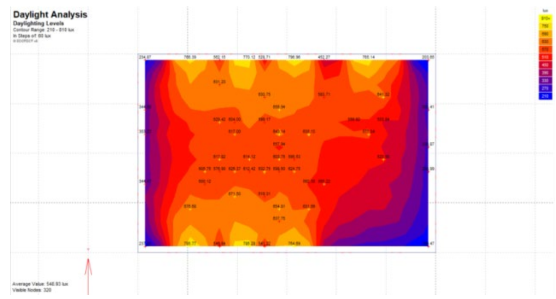
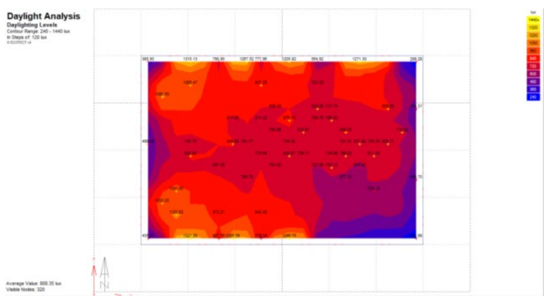
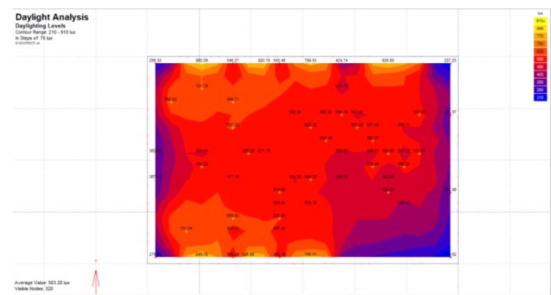
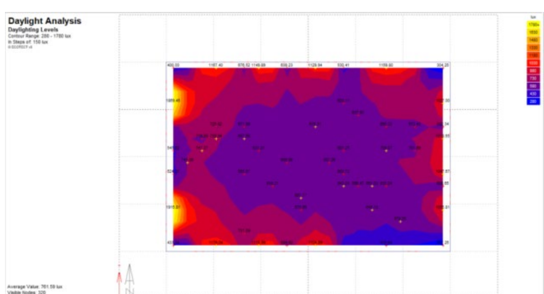
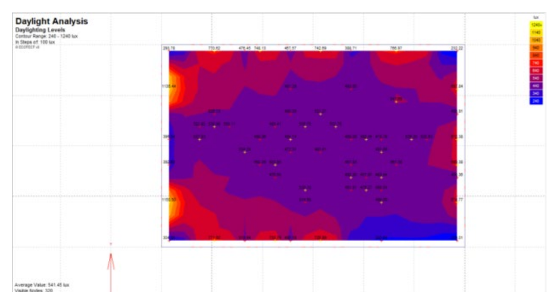
| Position | Uswcm | usbcm |
|---|---|---|
| human body at 20 cm from the floor |  |  |
| human body at 87.5 cm from the floor |  |  |
| human body at 193 cm from the floor |  |  |

Table 9. Minimum and maximum light-intensity in uswcm and usbcm. Source: authors' elaboration

| At a height of | Position | | | |
|---|---|---|---|---|
| | Without mat in LUX(uswcm) | | With mat in LUX(usbcm) | |
| | Minimum | Maximum | Minimum | Maximum |
| 20 cm from the floor | 210 | 1210 | 210 | 820 |
| 87.5 cm from the floor | 240 | 1440 | 210 | 910 |
| 193 cm from the floor | 280 | 1780 | 240 | 1240 |
| Average | 243.33 | 1476.67 | 220 | 990 |

with the mat, at an average of 220 lux, there is a 23.33 lux reduction. Consequently, a more relaxed and pleasant light condition allows users to rest or sleep during the night compared to other situations without a mat.

The information on maximum light-intensity entering the space is collected as follows: at 20 cm from the floor with a maximum of 1210 lux in uswcm and 820 lux in usbcm (a 390 lux difference). At 87.5 cm it has a maximum of 1440 lux in uswcm and 910 lux in usbcm (a 530 lux difference), and finally, at 193 cm from the floor, there is a maximum of 1780 lux (the worst light entrance into the room) in uswcm, and 1240 lux in usbcm (a 540 lux difference).

Comparing the average in all three, without mat 1476.67 lux, and with mat 990 lux, a 486.67 lux reduction can be perceived, which led to increased user satisfaction for sleeping, resting, and relaxing.

According to similar existing research, the thermal performance used the Ecotect software as seen in the work of Sonawane and Vakhari (2023), who studied traditional Indian homes with a stone wall covering, clay, and slopped roofs made of straw. They discovered that the materials were environmentally friendly and provided comfortable temperature conditions for building occupants. In the study of Ratree et al. (2020), by examining the style of native houses in Bangladesh and Sri Lanka based on the region's climate, they looked at building techniques, passive design strategies, thermal comfort, etc. among mud houses in both countries using the Ecotect software, and recommended improvements to recover passive energy and increase user comfort in buildings. Ratree et al. (2020) also examined three styles of current European construction based on the collected information, showing that 74% of the participants are dissatisfied with this construction style. Unlike those building systems that were built with eco-friendly materials, they were very efficient, and the purpose of this was to analyze thermal comfort during a critical period of time. Meanwhile, Gupta et al. (2020) investigated the style of rural native buildings near Ranchi in the state of Jharkhand in eastern India, where Ecotect and Climate Consultant software were used, using houses made with materials from native resources, that have been able to create more suitable conditions for human life than new materials. In comparison to the current research, according to a review of the literature, it was found that no such research has been done on the Baber-Room style. This construction style demonstrates the attention of architects and users of local structures in the region (Hormozgan, Iran) to thermal comfort conditions and their knowledge of climate and materials. The building blocks of this research depict that this style has been able to create satisfaction among its users in the sense of thermal behaviors, light detection, and blocking excess light to make use of the wind currents.

## CONCLUSION

Among the six different styles of building construction in Hormozgan-Iran throughout the last 70 years, the local architecture is important among building users and architects. One instance of such a building is located in the south of Iran and is known as the Baber-Room. Its unique construction style, which encompasses the methodical application of techniques, has caught the interest of everyone from tourists to building users and architects. Although the local architecture of Bandar-Lengeh has undergone many changes over time, it has kept its identity and introduced itself as valid evidence and documentation in the construction procedure. This local architecture uses specific elements (wind towers and latticework) along with spaces (Baber-Rooms) to provide comfort for users, particularly when no mechanical cooling system is used. The intention behind this article was to introduce the Baber-Room with structural analysis to scrutinize materials, the construction process, and its elements, such as latticework and local materials, shading, and the areas used in three different styles of Baber-Rooms, while assessing the Baber-Room under usbcm and uswcm conditions through functional analysis of light and temperature. In the photometric part, the person was evaluated in three positions (lying down, standing, and sitting) at 2 pm. Consequently, it is determined that the best conditions are uswcm and usbcm in lying down and sitting positions (20 cm and 87.5 cm from the floor) with 210 lux, while the worst condition is under uswcm when standing.

In comparison, measurements were taken standing (193cm from the floor) with a maximum of 1780 lux. On the other hand, using the temperature indicated, the most advantages are provided in May, June, July, August, September, and October, while January, February and December had a neutral temperature and minimal advantages. Finally, adverse conditions were seen in March and April resulting in the least use and benefit for the users.

Upon review, it has been determined that the Baber-Room exhibits specific strengths and weaknesses, as outlined in Table 9. Moreover, in the realm of research focusing on light analysis, the study by Ahmad, Prakash et al. (2022) investigated the influence of building materials on the entry of light and indoor temperature. This study revealed that the thermal properties of nano-building materials

Table 9. Strengths and Weaknesses of the Baber Room

| | Strengths |
|---|---|
| 1 | The Baber-Room has been a favored space for a night's sleep, consistently attracting the attention of vernacular building users from the past to the present. |
| 2 | This area was primarily used for family gatherings during the late-night hours. |
| 3 | Using latticed window openings and positioning this space at the highest part of the building, occupants can maximize natural ventilation from the sea. |
| 4 | With its extensive geometrical design between latticed windows, the Baber-Room has successfully been used for natural ventilation and maintaining privacy. |
| 5 | According to the analyses in Table 7, the arrangement of elements within the Baber-Room spaces is such that the most suitable location for receiving wind is at a height of 20 centimeters, encompassing the sleeping area of the Baber room. |
| 6 | Unlike modern constructions in Bandar Lengeh, the Baber-Room's windows were strategically placed from the floor level, enhancing the comfort of a night's sleep. |
| 7 | Vernacular and handmade materials were used to build the Baber-Room. One such material is the mat, which has been effectively used as a cover in different building orientations to reduce the harsh midday sunlight entry. |
| | **Weaknesses** |
| 1 | With the advent of mechanical air conditioning systems, such spaces have lost their functionality, and most buildings with Baber-Rooms have been abandoned, either demolished or with all their latticed walls filled in with mortar. |

have a notably positive impact compared to traditional building materials. Barzegar and Sajjadi (2023) explored light and temperature dynamics in traditional Shiraz houses in a related study. Their findings highlighted that using local houses under current conditions often leads to dissatisfaction, as they do not adequately respond to modern needs. This aspect is particularly relevant when comparing traditional houses with the Baber-Room, suggesting that the latter's applicability is restricted to certain favorable weather conditions throughout the year rather than being universally adaptable to contemporary climatic demands, And, as is well known, the Baber-Room is regarded as a unique sort of native architectural space in Hormozgan-Iran, capable of providing comfort to people's lives by using local materials, understanding the environmental conditions, and meeting the cultural needs of society (by creating meeting spaces). All this leads to comfort in human life. There are seven positive points and one weak point (where the use of the Baber-Room was lost due to the usage of mechanical air conditioning equipment), indicating that this area can be used as a new solution to preserve the region's local culture while using modern methods.

The current use of local housing has also led to dissatisfaction and does not adequately address current conditions. This is significant, especially when compared with the Baber-Room, indicating that it is only feasible to use these local spaces under current conditions during certain times of the year when the weather is pleasant and favorable.

The results achieved came from Baber-Rooms in the local architecture of Bandar-Lengeh, which indicated that architects and users have been looking for function and beauty in local architecture under the hot-humid conditions of the region. Therefore, it shows users'/architectures' contemplation and reasoning in the past. Hopefully, this research will provide architectures with a stable structure to achieve and implement these in new constructions. Besides, users should do their best to keep this architecture as a legacy. Another topic for future research is exploring how the Baber-Room can be used in contemporary settings to preserve vernacular culture and architecture.

## REFERENCES

Ahmad, A., Om, P., Anil K., Hasnain, S. M. M., Verma, P., Zare, A., Dwivedi, G. and Pandey A. (2022). Dynamic analysis of daylight factor, thermal comfort and energy performance under clear sky conditions for building: An experimental validation. *Materials Science for Energy Technologies,* 5, 52-65. https://doi.org/10.1016/j.mset.2021.11.003

Al-Saggaf, A., Nasir, H., & Taha, M. (2020). Quantitative approach for evaluating the building design features impact on cooling energy consumption in hot climates. *Energy and Buildings*, 211, 109802. https://doi.org/10.1016/j.enbuild.2020.109802

Babaei, M., Soltanzadeh, H., & Islami, S. Y. (2013). A study of the lighting behaviour of Moshabak in Kashan's houses with emphasis on the notion of transparency. *Architectural Science Review*, 56(2), 152-167. https://doi.org/10.1080/00038628.2012.729309

Baheretibeb, Y. & C. Whitehead (2024). It takes a village to raise a child," university teachers' views on traditional education, modern education, and future I integration in Ethiopia. *Frontiers in Education*, Frontiers Media SA. https://doi.org/10.3389/feduc.2024.1348377

Barzegar, Z. & K. Sajjadi (2023). Analogy of thermal comfort with the influence of openings by PMV method in traditional houses and apartments in Shiraz. *Journal of Iranian Architecture & Urbanism (JIAU)*, 14(1), 117-131. https://doi.org/10.30475/isau.2023.231996.1424

Dwijendra, N. K. A. & I. M. Adhika (2022). The Resilience of Undagi's Role in Traditional Balinese Architecture Based on Asta Kosala Kosali in Bali, Indonesia. *Res Militaris, 12*(6): 1099-1113.

Foruzanmehr, A. (2015). People's perception of the loggia: A vernacular passive cooling system in Iranian architecture. *Sustainable cities and society*, 19, 61-67. https://doi.org/10.1016/j.scs.2015.07.002

Gupta, J., Chakraborty, M., Rallapalli, H. S. & Nevidhitha, R. (2020). Climate-Responsive Architecture in Rural Vernacular Dwellings: A Study in Composite Climate in Ranchi, Jharkhand, India. AEGAEUM Journal, 8(7).

Jaradat, H., Alshboul, O. A. M., Obeidat, I. M., & Zoubi, M. K. (2024). Green building, carbon emission, and environmental sustainability of construction industry in Jordan: Awareness, actions and barriers. *Ain Shams Engineering Journal*, 15(2), 102441. https://doi.org/10.1016/j.asej.2023.102441

Li, J., Zhai, Z., Li, H., Ding, Y., & Chen, S. (2024). Climate change's effects on the amount of energy used for cooling in hot, humid office buildings and the solutions. *Journal of Cleaner Production*, 442, 140967. https://doi.org/10.1016/j.jclepro.2024.1409

Lisa, N. P., Zuraihan, Z., Fernand, R., & Siska, D. (2021, April). Estimation of energy consumption efficiency in office rooms cooling systems to create thermal comfort for the user. In IOP Conference Series: Earth and Environmental Science (Vol. 738, No. 1, p. 012016). IOP Publishing.

Matzarakis, A., Mayer, H., & Iziomon, M. G. (1999). Applications of a universal thermal index: physiological equivalent temperature. International journal of biometeorology, 43, 76-84. https://doi.org/10.1007/s004840050119

Mazraeh, H. M. & M. Pazhouhanfar (2018). Effects of vernacular architecture structure on urban sustainability case study: Qeshm Island, Iran. *Frontiers of architectural research*, 7(1): 11-24. https://doi.org/10.1016/j.foar.2017.06.006

Mazraeh, H. M. & M. Pazhouhanfar (2020). Functionalism of wind renewable energy in vernacular elements of wind catcher and Moshabak (Case Study: Quesh Island). *Journal of Urban & Environmental Engineering*, 14(1). https://periodicos.ufpb.br/ojs/index.php/juee/article/view/51925/30532

Mohammadi Mazraeh, H. (2021). Position of Entrance in the Architecture of Vernacular Buildings of Bandar-Lengeh. *Journal of Urban Development and Architecture-Environment Identity (JUDA-EI)*, 2(6): 21-39. https://www.armanshahrjournal.com/article_80507_c10c85bd9676bec9be9e5b07ea2bc694.pdf

Mohammadi Mazraeh, H. (2022). The Role of the Function of Semi-Open Space in the Structure and Architecture of the Native Buildings of Bandar-Lengeh. *Journal of Urban Ecology Researches* 13(Series 27), 1-18. https://doi.org/10.30473/grup.2022.58150.2607

Mohammadi Mazraeh, H. (2023). Recognition of Designs and Motifs of Architectural Windcatchers and Openings Native to City of Bastak. *Journal of Iranian Handicrafts Studies*, 5(2), 115-128. https://doi.org/10.22052/HSI.2022.246448.1026

Nemat Gorgani, O. (2002). Light Background in Architecture and Lighting Fixtures in Iran Islamic Art, Asar.

Neufert, E. & P. Neufert (2012). *Architects' Data*, John Wiley & Sons.

Philokyprou, M. & A. Michael (2021). Environmental sustainability in the conservation of vernacular architecture. The case of rural and urban traditional settlements in Cyprus. *International Journal of Architectural Heritage, 15*(11), 1741-1763. https://doi.org/10.1080/15583058.2020.1719235

Putri, A. K. & Y. Sunesti (2021). Sharia branding in housing context: A study of halal lifestyle representation. *Journal Sosiologi Walisongo*, 5(1): 77-92. https://doi.org/10.21580/jsw.2021.5.1.7268

Ratree, S. M., Farah, N., & Shadat, S. (2020, June). Vernacular Architecture of South Asia: Exploring Passive Design Strategies of Traditional Houses in Warm Humid Climate of Bangladesh and Sri Lanka. In Proceedings of the International Conference of Contemporary Affairs in Architecture and Urbanism-ICCAUA (Vol. 3, No. 1, pp. 216-226).

Razavian, F., Alemi, B., Kamali Zarchi, S., & Tafreshi, F. (2023). Studying and Proposing an Energy-efficient Residential Design for Kashan with a Hot and Dry Climate. *Journal of Solar Energy Research*, 8(2), 1559-1573. https://jser.ut.ac.ir/article_92582.html#:~:text=10.22059/JSER.2023.354267.1273

Roshan, G., Yousefi, R., Kovács, A., & Matzarakis, A. (2018). A comprehensive analysis of physiologically equivalent temperature changes of Iranian selected stations for the last half century. *Theoretical and applied climatology*, 131, 19-41. https://doi.org/10.1007/s00704-016-1950-3

Salami, B. A., Abba, S. I., Adewumi, A. A., Dodo, U. A., Otukogbe, G. K., & Oyedele, L. O. (2023). Building energy loads prediction using bayesian-based metaheuristic optimized-explainable tree-based model. Case Studies in Construction Materials, 19, e02676. https://doi.org/10.1016/j.cscm.2023.e02676

Sargazi, M. A. (2023). The Effect of Natural Materials-Based Climate Adaptation Techniques on Thermal Comfort in the Vernacular Architecture of Sistan, Iran. *Iranian Journal of Archaeological Studies*, 13(2). https://ijas.usb.ac.ir/article_8042.html

Sonawane, M. & A. B. Vakharia (2023). Comparative Analysis of Thermal-performance of vernacular dwelling in Arid climate of India. *International Journal of Technology Engineering Arts Mathematics Science*, (1), 403-408. https://aissmsioitresearch.com/wp-content/uploads/2023/12/SB_IJTEAMS_61.pdf

Toroxel, J. L., & Monteiro Silva, S. (2024) A Review of Passive Solar Heating and Cooling Technologies Based on Bioclimatic and Vernacular Architecture. *Energies* 17(5), 1006. https://doi.org/10.3390/es17051006

Xu, F. & Liu, Q. (2023). Building energy consumption optimization method based on convolutional neural network and BIM. *Alexandria Engineering Journal,* 77, 407-417. https://doi.org/10.1016/j.aej.2023.06.084