



# Traditional solutions in low energy buildings of hot-arid regions of Iran



Mitra Khalili, Sanaz Amindeldar<sup>\*,1</sup>

Department of Energy, Faculty of Fine Arts, University of Tehran, Tehran, Iran

## ARTICLE INFO

### Keywords:

Hot arid climate  
Traditional architecture  
Climatic elements  
Behavioral adaptations  
Energy efficiency

## ABSTRACT

While the quality of contemporary architecture and energy consumption is being criticized by many scholars and professionals in the world, traditional climate-responsive buildings seem to be good patterns. Using the technology and material of their own time, these buildings provided the users with environmental comfort conditions along with minimum energy consumption and ecological foot print.

This article is an attempt to understand the solutions used in traditional architecture of Iran with an emphasis on dry and hot regions. Twenty traditional houses were studied and finally, two factors were found to be significant; first, constructional patterns based on climate considerations (such as basements, courtyards, wind-catchers, domical ceilings and porches) and second, the behavioral patterns as wide-ranging intelligent responses to climate (i.e. behavioral adaptations) seen in past lifestyles. Both factors are analyzed, since they are good evidences of the way lifestyle and knowledge have been used in order to overcome hot summers in considerable parts of the country.

The main objective is to investigate how these solutions worked and how they can be used in low energy designs at present. It is not just to follow the formal elements, but to look at their thermal rules and take advantage of the logic behind them, which can be applied in current building methods. These results can help a better design to overcome today's global energy crisis.

© 2014 Elsevier Ltd. All rights reserved.

## 1. Introduction

Energy crisis and climatic change are the biggest challenges facing the world today. In developing countries, energy consumption has increased due to population growth and industrialization; all believe that more than a third of all energy is spent on heating and cooling of buildings in any country (Pérez-Lombarda, Ortizb, & Poutb, 2008).

Achieving optimal efficiency in building solutions requires deep study; among which traditional climate-responsive buildings seem to be good patterns. It must be acknowledged that the past man were more familiar with the concept of sustainability prior to the Industrial Revolution.

Since the climatic boundaries are not related to political ones, climatic characteristics for people who live in similar regional areas,

will pose similar problems. Although the solutions found by people in arid-hot regions around the world to meet the climatic problems are different in shape, they can be considered alike in terms of notion. In areas with arid-hot climate like Iran, where the most inappropriate climatic conditions have affected the living of residents, patterns could be observed that have played an important role in creating thermal comfort and are worth analysis. Despite the outdoor harsh conditions during summer, heat storms and wind flow with dune sands, the method of construction is such that it is possible to create a suitable environment to live in and it has been carried out without any dependence on other equipment and that is the reason these buildings are presented as low energy consumption ones.

This paper primarily focuses on identifying the environmentally friendly components of buildings which are according to traditional climatic patterns resulted over the centuries of experience. For centuries, Iranian architects and engineers have been able to create masterpieces by using wind flow and the difference in temperature of day and night in order to achieve thermal comfort conditions in buildings of hot deserts without energy consumption. These elements include windcatcher, domed roof, courtyard, underground cellar, *Ivan*, *Soffeh*, *Khishkhan*, shutter, groundwater reservoir and natural ice pit design.

\* Corresponding author at: Master of Energy-Architecture, School of Architecture, Faculty of Fine Arts, University of Tehran, Iran. Tel.: +98 21 88248499; fax: +98 21 88248499; mobile: +98 912 3773486.

E-mail addresses: [Sanaz.deldar@alumni.ut.ac.ir](mailto:Sanaz.deldar@alumni.ut.ac.ir), [deldar.snz@gmail.com](mailto:deldar.snz@gmail.com) (S. Amindeldar).

<sup>1</sup> Permanent address: Flat No. 6, No.4, Shahid Mansouri (KIA) St., Shahrara St., Tehran, Iran.



Fig. 1. The four cities located in center of Iran.

These constructural patterns are abundant, but considering the fact that there is a tendency in contemporary architecture to eliminate the use of some of these elements, this paper seeks to revitalize these important elements which can be used based on thermal rules and applied climatic concepts and offer solutions for today energy crisis. Besides these constructural patterns, also some kinds of behavioral patterns – as wide-ranging intelligent responses to climate – have been observed. In other words, the building was not the only one responsible for reducing energy consumption but certain behaviors (type of food, clothes, type of activity and chosen site, etc.) also used to an important role in achieving comfort and reducing energy consumption.

## 2. Materials and methods

In this study, twenty houses were selected from four cities of Yazd, Kashan, Zavareh and Isfahan. These cities are located in the central part of Iran with arid-hot climate (Fig. 1). Some investigators have studied climate considerations of these houses before (Haeri, 2010a; Memariyan, 1994); however, there is still lack of information regarding some climate – sensitive elements and behavioral adaptations for achieving thermal comfort. The main focus of this research was studying various books which included detailed drawings. Six samples were chosen from the drawing of Memarian (1994), eight samples from Haji-Qassemi (1998) and six samples from Mosavi (2004) (Haji-Qassemi & Karbassi, 1998; Mosavi, 1996). In order to investigate the behavioral patterns and local life style, further detailed examinations and face-to-face interviews with occupants were also conducted.

## 3. Climatic condition

Iran is located in a warm climatic district that lies between 25° and 40° latitude. The dry deserts of northern Africa and Saudi Arabia extend from the Atlantic Ocean in western Africa across Iran and finally end in Afghanistan and Turkmenistan (Keshtkaran, 2011).

Iran has 8 different kinds of climatic regions as follows:

- 1) Regions with approximately hot summers and nearly cold winters accompanied by great amount of humidity.
- 2) High mountainous regions, with mild summers and very cold winters.
- 3) Nearly high mountainous regions, with approximately hot summers and almost cold winters.
- 4) Low mountainous regions, with warmer summers and winters compared to the third group.

- 5) Regions mostly located in the central part of Iran, with arid-hot summers and cold winters.
- 6) The borders of the Central Desert (Dasht-e Kavir) with extreme hot-arid summers and nearly cold winters. In these areas achieving human comfort especially in hot season could be very difficult.
- 7) Regions with very hot and semi-dry summers and moderate winters.
- 8) Coastlines and islands of Persian Gulf and Omman Sea, which are very hot and humid in summer and moderate in winter. In this climatic area hot and humid weather condition makes it difficult to achieve thermal human comfort (Haghparsat & Niroumand, 2007).

For this study, we selected two regions from groups 5 and 6. The air temperature in these regions ranges between maximum of 40–45 °C and minimum of 0–5 °C. Precipitation is very low and relative humidity is under 30% with clear sky during the summer days. In addition, dusty wind is an important factor in these regions which is very unstable.

## 4. Constructural patterns compatible with climate

Climatic issues have always been serious problems for residents of these regions. Over the thousands of years, these problems have driven people to find solutions to reduce the disturbing aspects of the climate and use the convenience aspects of it astonishingly. These passive approaches in dry and hot regions have resulted in constructural patterns which interact with the nature rather than conflict with it, and so minimize the amount of artificial lighting and cooling loads. Constructural patterns, climatic elements, and anything that makes traditional architecture in accordance with climate and environment, play a significant role in eliminate the need of energy consumption. In a study of Mahmoudi house, Foruzanmehr & Vellinga reported that basement is one of the most important spaces of residence and also passive cooling strategy has been considered in the design of this house in Yazd. Mahmoudi has defined the windcatcher room temperature of 28 °C in midday in Yazd (Foruzanmehr & Vellinga, 2011; Mahmoudi & Mofidi, 2008). Ghobadian states the cellar temperature of 24 °C, in hot hours of Kashan (Ghobadian, 2003). The central courtyard and main space of Isfahan houses which have been determined by Khalili, are defines as in thermal comfort range (Khalili, 2011). Roaf expressed that the temperature and humidity of the windcatcher in the basement and hall of Yazd houses satisfied the residents (Roaf, Crichton, & Nicol, 2005).

It is evident that in such a difficult climatic conditions, brilliant solutions were devised which would provide thermal comfort in accordance with environmental conditions. For example, the reduction of interaction with the summer heat and solar radiation, especially providing shade has had a major role in the composition of compact and closed building sets. Building orientation, method of communication with ground, introversion and closure, wall thickness, height of rooms and applied materials have also been of such patterns. The most important architectural provisions found in the buildings of the area and play an important role in providing of resident's comfort conditions are:

### 4.1. Courtyard (Godalbaghche)

Courtyard has been used for long in Iranian traditional and other hot-arid regions' architecture. In addition to protection, helping the building residents' security and cultural-social events, a courtyard creates a small, cool and humid microclimate inside the building which reduces the energy required for cooling. This

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات