

# Wind prefiltering and Indoor Air Quality in the vernacular architecture of hot arid regions of Iran.

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## ABSTRACT

The results of a recent research and its statistical analysis, show that in some of the Iranian cities like YAZD, there are two periods (from end of August to end of September and from end of February to end of March) in which outdoor pollution is higher than other periods.

School starting and industrial activities in the summer could be the prime reasons of this phenomenon. Also dry land due to high temperature and less humidity make summer be the most contaminated period (Naddafi, 2006).

The above problems are increased after industrialization of the city by construction of

the new and modern buildings instead of the ancient way of architecture in some quarters of the city.

It's clear that more attention should be paid to increase the quality of indoor air and the three strategies for reducing pollutants-which are source control, ventilation, and air cleaning-(in order of effectiveness) should be respected.

While obvious solution to such problems is to install a mechanical air filtration system, that is not always practical. In particular, the character of some historical houses and some archaeological sites would be degraded by presence of mechanical air distribution system.

This paper presents some rules of design in the vernacular urban design and traditional houses to better understand how to avoid entrance of sands, dusts and large particles into the indoor environment.

Of course the ancient strategies of air-supplying are not completely and enough

efficient to filter particles; but help us to examine possibility of using some simple design criteria to have passive pre filtration of the wind (which is the first source of natural ventilation in the hot arid vernacular architecture).

## 1. INTRODUCTION

The ancient desert buildings are equipped with air traps, arched roofs, water reservoirs with arched domes and ice stores for the preservation of ice. Each of these elements, directly or indirectly helps the quality of Indoor air, with minimum costs, becomes better.

Wind in the central regions of Iran has an important role to provide the natural ventilation required by buildings and Badgirs (wind catchers) are famous for their presence in Iranian hot and arid cities. Studying the ancient architecture demonstrate the wind impact on designing of the city and consequently buildings to achieve more indoor comfort by natural ventilation and natural air cleaning.

Here below some of these strategies which were have been considered in the planning and design stage of buildings and urban context are remembered .

## 2. PRINCIPAL ADOPTIONS ON URBAN DESIGN

### 2.1 Compact Settlements

The compact or semi-compact settlements of courtyard houses, with many shared walls, at first saves construction costs and reduces the total exposed surface area of the walls to the sun and hence cause less cooling needed in the hot summers. The compact cluster of contiguous houses creates a high population

density, organized around travel on foot. It also is conducive to social interaction and family relations. (Fig 1&2).

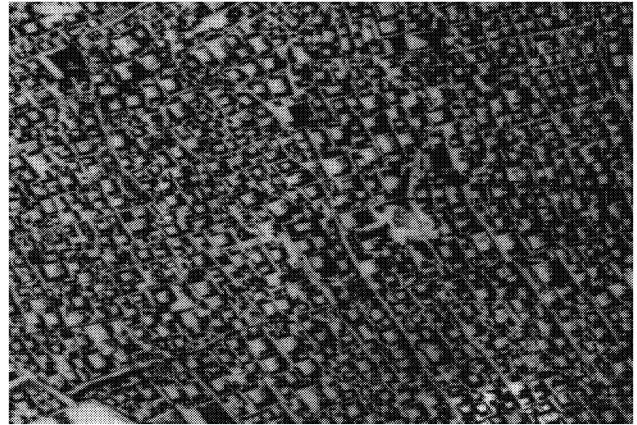


Figure 1 – city of YAZD: the compact urban design (Source Kowsar.).



Figure 2 – city of YAZD: A view of the city (Source author)

### 2.2 Narrow streets

Traditional settlements and housing often are located on narrow streets and alleyways. With the tall walls of the houses, considerable shade is provided in the hot summers. This not only reduces the sun's heating of the house walls, but also makes the wind change the direction as requested (Fig 3).

### 2.3 Windowless walls

In the Middle East narrow alleyways weave among tall, windowless walls of houses (or have very few, small windows). Not having windows facilitates keeping out wind and dust from the living space, as well as promoting better thermal characteristics by not having to deal with windows (Fig 3).

This pattern is also conducive to the cultural values of Islamic society by promoting privacy. In some regions houses have a few windows, covered by a lattice work. The occupants can see out, but people in the street cannot see into the house. This decorative kind of windows also helps the wind to enter into the room without the birds! ( Fig 6).



Figure 3 – city of YAZD: The windowless walls (Source author).

## 3. PRINCIPAL ADOPTIONS ON ARCHITECTURAL DESIGN

### 3.1 Construction materials

The most important materials in these regions are mud brick, clay and brick. These kind of materials get warm late during the day and lose

the warmth very late at night and contribute to the temperature adjustment in the arid periods.

To emphasize of the importance of the rural material on the filtration of the indoor air, some of properties of clay is mentioned here.

Clay can absorb and release airborne humidity relatively fast. As a result, air humidity is regulated and a healthy room climate is created. When the relative humidity raises from 50% to 80%, non-burned bricks can absorb 30 times more humidity than regular bricks within a two day period. A five year period of measuring in a residential home with walls made of clay brick, clay strand or light clay showed a constant relative humidity through out the entire year. On the average it stayed at 50% +/-5% (Reitz, 2007).

Clay swells when water is added and shrinks when it dries. This must be taken in to consideration when building with clay.

Clay is Healthy Building Material. Due to its moisture regulating properties clay may prevent drying out if mucous membranes and reduces the build-up of the fine dusts. These qualities suggest that clay structures can help prevent many colds, respiratory problems and allergies.

When used as a healthy building material clay should only be mixed with sand or plant-based materials such as hemp, flax or straw. It may also be tinted with natural pigments or mica (Reitz, 2007).

### 3.2 Architectural elements

#### 3.2.1 Badgir (wind catcher)

The Badgirs or Wind Catchers (Fig 4) are Ancient air conditioning plants which are usually made in the summer-sitting part of the houses. They cause the air circulation to

circulate in the building.

The temperature difference between the inside and outside of the building and different parts of it which causes the pressure difference and at last move the air. Since the moisture is very low in Yazd (The average moisture: 30.33%), wind catchers not only makes the air circulate, but they provide comfort for the residents by evaporating the air as following:

The dry and warm wind passes over a small stone pond with a fountain (sometimes located exactly under the wind catcher as showed on fig.5 and sometimes in the living room near the entrance of supplied air) gets cool and wet through tower evaporation. Then the cool and wet air flows in the rooms (Fig 5).

To increase more moisture and quantity of cooling air, the occupants put also mat, pan tile, or thorns over the badgirs opening and sprinkle water on them.

By passing the wind through these wet pads, some of the sand and dust particles from the air could be removed. Thus delivering cleaner air to the space could be easier. Entrance of dust into the living space in desert regions is a major problem, and definitely one of the disadvantages of employing wind catcher for ventilation and passive cooling systems.

To remove some of the larger dust particles from the air before entering the living space, the air velocity can be reduced by increasing the flow area.

For example, the air entrance to the upper floors can be made to flow through the basement (the air will pass before through the basement and then to the upper floors). With low air velocity, most of the larger dust particles will be collected on the floor.

Badgirs are often related to the moisturizing

elements such as halls, basements, pools, gardens and compensate the shortage of ground moisture and therefore provide a fresh and suitable place for living during the hot and intolerable summer for the residents and people.

Wind catchers materials are always mud brick, brick, mud, and wood. By using clay for their construction, design, is contribute considerably to saving energy. When the architect factor in the low energy requires for the preparation of clay in its processing and usage, building with clay is very environmentally friendly.

It uses only about 1% of the energy used for making bricks or concrete.

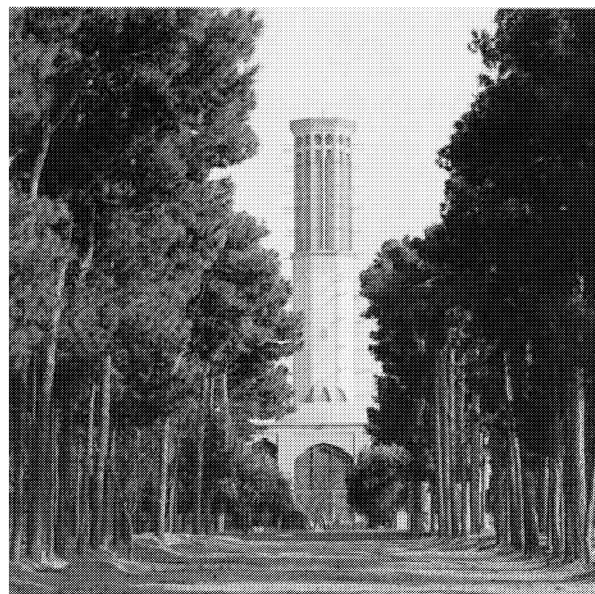


Fig 4 – Octagonal Badgir of Dowlat Abad (Source Dehghani).



Fig 5 – Internal view of the room under Dowlat Abad's Badgir and it's related fountain (Source Author).

### 3.2.2 Taremi (Lattice Wall)& Latice Window (perforated screen)

An artistic kind of wall and window or perforated screen, divided into small panels arranged diagonally which is faced on the court side of building and provide not only privacy but also least obstacles against the night breezes (Fig 6 &7).



Figure 6 – Taremi or lattice wall (Ref: Kowsari ).

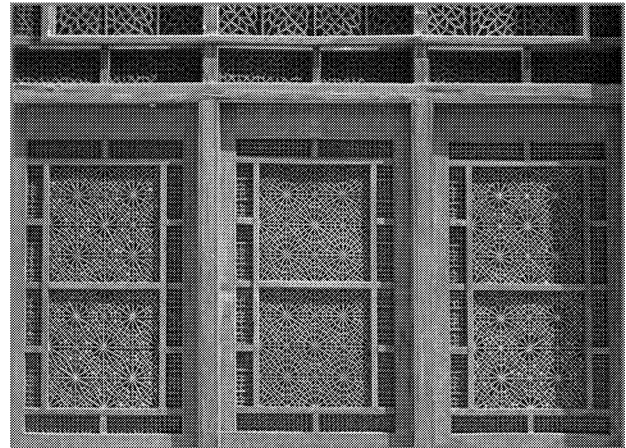


Figure 7– Lattice Window.

## 4. CULTURAL IMPACT ON ARCHITECURAL DESIGN

### 4.1 Customs, Privacy and using Window Blind

Window blinds is a very practical home fixture innovation. They are called “blinds” basically because of what they do: they blind a viewer of the window, not allowing him to see the insides of the room. The blinds are used to reduce entering sunlight as well.

Window blinds have been in use in decades, even centuries. It may not be in the form that we are familiar today but the “ancient” blinds have the same functionality. Desert dwellers, for example, have been recorded to use wet cloths to cover the windows of their shelters.

This form of blinding the window, was used not only for having more privacy , but also to make more comfortable indoor air quality. These cloths were used as an additional cooling device for their homes, much like a modern air conditioning unit.

Further, they used Bamboo to gain a similar effect. Bamboo, by the way, is still being used today in countries in Asia. When the Middle Ages came, more elegant and finer cloths were

used to drape the windows and around the poster beds. These cloths offer protection from drafts.

Using the blinds act also as the wind pre filtration which is as important as cooling and humidification of inlet air of course.

The popular Venetian blinds were actually invented in Persia. It was the traveling Venetian traders which brought the blinds to Venice and Paris thus were most often being credited as the inventor of this type of window blinds. The Venetian blinds became so popular that they were included in historical paintings, being part of the detailed background. They dotted the windows of well known buildings and offices.

## 5. CONCLUSION

The hot arid regions' housing tradition bears the opportunity to be learned from the tried and evolved architectural solutions. As mentioned on this paper, the vernacular architecture of hot regions, was able to supply air to the building and to the urban areas, at higher flow rates, with less dust and finally with higher quality. Generally for having a better indoor quality, air cleaning may serve as an adjunct to source control and ventilation. However, the use of air cleaning devices alone, cannot assure adequate air quality, particularly where significant sources are present and ventilation is inadequate.

The theoretical performance of conventional and local building science, may use as a guideline for designing natural ventilation and passive cooling and passive prefiltration systems in these regions. Evaluating these values parallel to today's discourse, sustainable identity can be achieved by emphasizing

especially the locality. In brief, this study tried to define the appropriate design principles for the contemporary housing developments and find the ways of sustaining existing unique traditional patterns.

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