

## Badgir in traditional Iranian architecture

A. A'zami

*Islamic Azad University of Tabriz, Department of Architecture, Member of ISES, ASES, IRSES*

### ABSTRACT

Environmental and natural phenomena play a very significant role in laying the region's inter-related cultural, economic and social infrastructures. The buildings in the Iranian desert regions are constructed according to the specific climatic conditions and differ with those built in other climates. Due to lack of access to modern heating and cooling equipment in ancient times the architects were obliged to rely on natural energies to render the inside condition of the buildings pleasant.

In the past, without modern facilities, it was only the intelligent architecture of the buildings that enabled people to tolerate the hot summer. The ventilation structures called Badgirs were the most important means by which the interior was cooled. The wind-catcher operates according to the condition of the wind and sun radiation in the region. In ancient times and in traditional buildings in arid and dry regions the air trap functioned like the present modern air conditioning system.

Wind-catcher is like a chimney whose end is in the underground and the top is set over a specific height on the roof and were built at the entrance of the house over underground water reservoirs or ponds built inside the house.

The dry and warm wind will pass over a pond with a fountain gets cool and wet through evaporation. The Badgir's material again plays another role. Due to high fluctuation of temperature differences between day and night in this climate and night time coldness, Badgir which is made with mud-brick, gets cool by radiation and convection.

The system works, when there is no wind, but when wind is blowing this system does not

have problems. Because during the day, if there is wind, then cool air flows faster and at night, with wind, it may absorb the heat of the walls, because the night wind is cool enough.

### 1. INTRODUCTION

The wind-catcher has been used in Iran since early times, it is one to the special masterpieces of Iran's architecture and it is also the signs of predecessors' intelligence in agreement with the climate, you can consider it the most specific examples of clean energy. The most number of wind-catchers are in Iran; these wind-catchers are made in two areas: the hot and humid area in south (such as Lenghe Port) and the hot and dry area of central plateau (such as Yazd)

### 2. HOW TO PERFORM AND SOME POINTS IN WIND-CATCHERS DESIGNING

A wind-catcher is a device with real/noble form and constant structure in Iran architecture, it leads the suitable wind through the inner part of the building and it is the most effective function in making comfort. There are actually two kinds of main functions about wind-catchers:

*2.1 The function according to the principle of traction of opening facing the wind and the suction of openings back against the wind.*

"The way a wind-catcher works is mainly based on taking the fresh air into the building and sending the hot and polluted air out or" the suction functions" perhaps it is not so necessary to explain that when the wind hits against the walls of internal blades of the wind-catcher it necessarily falls down, but it is necessary to refer to

this point that the other holes of the wind-catcher turning back to the wind direction, gives the hot and polluted air into the wind and so works like a ventilation and a sucked machine (Pyrnia, 1981).

The function of this kind of a wind-catcher is actually performed according to this fact that when the wind hits an obstacle, and since the density of the air is thick on the side of the wind direction, so in this direction there is a positive pressure, but a negative pressure on the other side. Therefore, when the ventilation is open on the side of the wind there will be a positive pressure to a negative pressure. In the wind-catchers, according to this principal, the opening facing the wind takes the air into the porch and the air in the porch with its negative pressure on the opening back of the wind is drawn out (Fig. 1). Sometimes according to the superficial evaporation the wind-catcher supplies the necessary moisture by conveying the wind over the weather and the cold-storage.

### 2.2 The function according to temperature difference.

But it seems that there is a little attention of technicians about the function of a wind-catcher regarding the temperature difference. In fact when there is not a windy blast sensibly, the wind-catcher acts according to this action.

During the day, since the sun hits on the southern face of the wind catcher, the air heats in the southern face of the wind catcher, and goes up. This air taken above through the inner

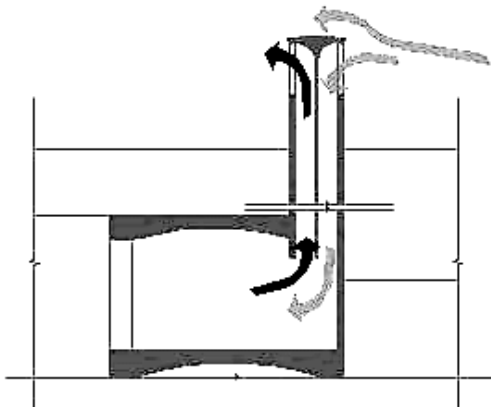


Figure 1: traction and suction in wind-catcher.

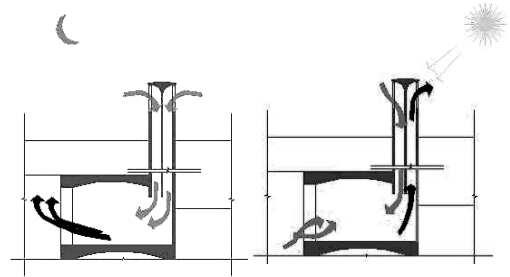


Figure 2: Wind-catcher function during the day and night.

air of the porch is compensated and in fact it makes a kind of proportional vacuum inside the porch, and takes the cool air of the inner court into itself, so the existing air in the northern opening is pulled down too (Fig. 2).

During the night it becomes cold outside, and the cold air moves down. This air is saved by the heat and becomes warm on parapets and then goes up. This circle continues till the temperature of the walls and outside temperature become equal. But before it usually arrives at this situation the night ends and once again the wind-catcher acts its function as mentioned above. In general, in most time, wind-catcher does as we explained it, in order to the traction, suction, and the effect of temperature difference.

## 3. LOCATION OF WIND-CATCHER

Wind-catchers are generally used in two kinds of building: water-reservoirs and houses.

### 3.1 Water-reservoirs

By considering the appropriate direction of wind blast, in city water-reservoirs, about seven wind-catchers are used, each wind-catcher acts its function with the other one through traction and function.

In field water-reservoirs, there is usually a unidirectional or bilateral wind catcher. These wind-catchers are located around the water-reservoir and their directions facing the appropriate wind. By putting the wind-catcher hatches towards the wind or the appropriate winds, they are led into the reservoir to prevent the growth of microorganisms, of course, by passing it over the water in a hot and quiet environment which there is not air circulation. After the wind hits the water, it goes out from the opposite side of the wind catcher (Fig. 3).

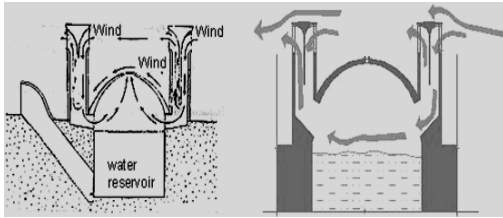


Figure 3: Water-reservoirs.

### 3.2 Houses

In houses the wind-catcher is usually made in the summer-sitting part of the house.

Wind-catchers are often related to halls, pools and basements.

They cause the air circulation to circulate in the building. They also relate with the moisturizing elements such as: 1) pool, 2) garden, 3) trees, 4) basement walls, 5) Payab 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 of mud brick, brick, mud, and "shoruneh" wood. It is one of the woods which resists against natural factors and termite attacks.

The temperature difference between the inside and outside 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 gets cool and wet through evaporation. Then the cool and wet air flows in the rooms.

Sometimes they put mat, pantile, or thorns over the wind-catcher opening, and they sprinkled water on them, and as a result they increased the moisture and the arrivery cool air.

### 4. SIZE AND DIMENSION

In the south of the country, wind-catchers are quite huge and less high, because the intensity of wind blast in these regions are rather low, in addition there is not black wind in this area. So it is not necessary to make wind-catchers high. In some ports like Lenghe port and Ghangh port and etc. generally located in Hormozgun prov-

ince. There are so many wind-catchers of these kinds in these areas there is at least a wind-catcher for each room. Like these wind-catchers, there are some in the south of Persian Gulf, and in Emirates and, in Bahrain. Wind-catchers in hot and dry areas have more height than those which are in hot and moist areas. Because in these areas, the more height causes the fresh air to enter the building and also there is little dust there.

The volume of these wind-catchers is less than the south ones. Because the density of winds in these areas are high compared to the south coasts. In cities such as Yazd, Naein, Kerman, Kashan, you can see these kinds of wind-catchers. The world height wind-catcher with 33 meters high is located in Yazd in Dowlat-Abad Garden.

### 5. KINDS OF WIND-CATCHERS

Wind-catchers are usually small towers in the form of quadrilateral and regular polygons, triangular forms are not seen at all among them. Wind-catchers can be divided into one-sided, two-sided, three-sided, four sided, hexahedral, and octahedral both of the shaping and regional point of view.

#### 5.1 One Sided Wind-Catcher

One sided wind-catcher is related to the areas in which there is "black wind" and it is near the Kavar. Cities like Meybod, Ardakan, Mahan and Bam.

#### 5.2 Two-sided wind-catcher

The water-reservoir in Yazd has a two sided wind-catcher.

#### 5.3 Three-sided wind-catcher

This kind of wind-catcher is not so usual, but types of wind-catchers like the wind-catcher in Tabas are being made with this form.

#### 5.4 Four-sided wind-catcher

Four-sided wind-catchers are the most current wind-catchers in Yazd. This kind of wind-catchers is made of both squaral and rectangular plans. The rectangular forms are usually made specially the big face is towards the appropriate wind.

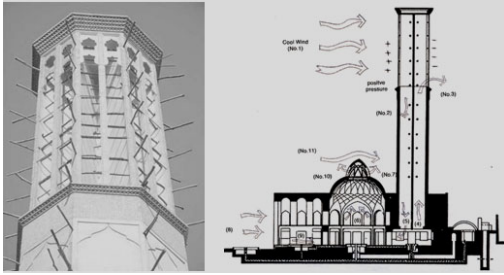


Figure 4: Wind-catcher of Dowlat-Abad Garden in Yazd.

### 5.5 The hexahedral and octahedral wind-catchers

The hexahedral and octahedral wind-catcher can be found in the water-reservoirs of Yazd Shrine, and the octahedral one can be found in the water-reservoirs of Khanom-Jan in Ezz-Abad Village. These kinds of wind-catchers are very limited and the best known of them is the wind-catcher of Dowlat-Abad Garden in Yazd with 33 meters high (Fig. 4) and the wind-catchers of the water-reservoirs of six wind-catchers. These wind-catchers are higher than any other wind-catchers, and they have been designed in the form of octagon, because in this case the form of the wind-catcher has more flexibility against the wind, and also the wind. Lateral forces decrease against the wind-catcher frame. The six wind-catchers of water-reservoir in this region from the viewpoint of climatic conditions and wind blast direction are in the octahedral forms. Of course, it is necessary to say that wind-catchers are different structures from each other according to their functional similarities. Regional differences of hot and dry climates and some social and economical factors, and various functions of buildings are effective in this regard.

In regions like Yazd, the wind-catchers according to their functions are divided into two general groups: merely functioning and symbol functioning.

The first one is most seen in ordinary houses in the form of one-sided wind-catcher. The second one not only has a special function but also shows the distinction of the land lord. Here, the wind-catcher dimensions have been more from a three-door room.

## 6. WIND-CATCHER ELEMENTS

Each element of a wind-catcher form is effective in its final formation. A wind-catcher in order from down to upward is formed of following parts: 1) chimney, 2) stalk, 3) catgut and chain, 4) shelf.

### 6.1 Chimney

The chimney part of the wind-catcher is usually an incomplete pyramid form. The different proportions of upper part of the wind-catcher are arranged with this part. In some samples, its height is as high as a person's height and in some other it is some meters high.

### 6.2 Stalk

That part of the wind-catcher which is located between shelf and the room is called the "stalk"; the higher is the wind-catcher the higher is its stalk too. The higher of the stalk in Yazd wind-catchers according to the climatic reasons and the height of the wind-catcher is for taking suitable wind which blows in heights, the beauty of this part is mostly dependent on the brick working decoration.

### 6.3 Catgut and chain

The catgut and chain is located between the stalk and the shelf. This element would be made and the shelf, this element would be made in different shapes.

### 6.4 Shelf

The head of the wind-catcher is the shelf which includes the blades, the channel of air passing. The common types of geometric figure of the shelf include: a lengthened, vertical rectangle, horizontal and a square.

Shelves are usually front open or front closed. And this feature would be changed according to the wind blast, on the other hand two shelves would be usually considered for each ways of air channel towards the room.

## 7. DIRECTING

Locating of a wind-catcher sides in regard to the geographical four cardinal points is determined for the climatic function of the wind-catcher and using of wind force, and also for the prevailing wind blast, so directing of wind-catchers in

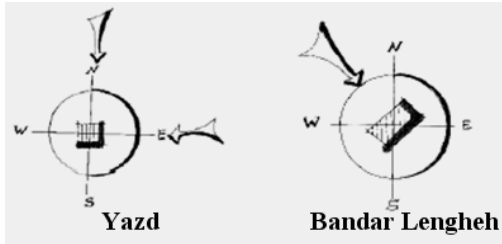


Figure 5: Wind direction in *Bandar Lenghe*.

Yazd is different from the Bandar Lenghe's ones, and this difference is related to some affective factors specially the wind (Fig. 5).

## 8. MATERIALS AND TEXTURE

The materials forming the wind-catcher structure have determining effect in harmony with the climate. (The way of using materials in making a wind-catcher is expensive to harmonize with climate, and its more usage is provided in the process of climatic function.)

In Yazd the wind-catcher façade color is plastered with cob color, which has covered wind-catchers and thus, its bright color greatly helps the reflection of sun radiation from wind-catcher surface and its non-absorption by that surface. At the same time presence of straws inside the mud increases coarseness of façade texture, which in turn hinders the abortion of sun radiation.

In Bandar Lenghe wind-catchers, on the other hand, the mortar plaster and plaster of lime and ashes time mortar, which is white in color, hinders sun radiation absorption and increases its reflex. Also the reflexive surface improves reflection of sunbeams.

## 9. MAIN MATERIAL OF WIND-CATCHER STRUCTURES

In Yazd: mud-brick or brick together with plaster of clay and straw- because the heat passage time of mud brick is desired.

In Bandar Lenghe: plaster and plaster of lime—it prevents humidity penetration into walls of wind catcher.

## 10. STRUCTURE

Using wood hanks in a horizontal state inside

the mud-bricks plays the role of brace in Yazd wind-catcher and also increases its resistance against lateral imposed forces in high heights. The reason would be that wind-catcher skeleton ascends to a height more than of building itself and wind soaking holes also decreases its resistance against lateral forces (Fig. 6).

These hanks tie the structure to each other and wood bars ends are put out of structure to create trellis or ladder for constructing the upper of wind-catcher or for doing later repairs. The minor and major blades inside the Yazd wind-catchers are considered as stabilizing factors.

In hot and humid regions like Bandar Lenghe, the Chandal wood is used in the structure of wind-catchers' wooden hanks.

The wood is resistant against humidity, rotteness and termite.

## 11. SHAPE AND SYMMETRY OF WIND-CATCHER PLAN

Wind-catchers are seen in diversity of forms in the plan:

- Rectangular, square, and octagonal plans in Yazd (for diversity of plans: economical competence of people and proficient architects, etc.) the ratio of length to width: 2 to 1.
- Square plan in Bandar Lenghe and ratio of length to width: 1 to 1.

## 12. SECTION

Since the function of wind-catcher is to get desired wind and transfer it to internal space, its dimensions would act as a canal to pass the air through and the ratio of length to height and width to length would be of much importance. Yazd wind-catchers are divided into two spaces:

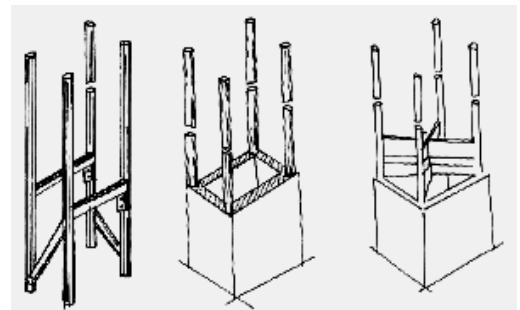


Figure 6: Wooden hanks in Yazd wind-catchers.

1. Cellar of underground, 2. summer sitting hall in ground floor but; there is not underground in Bandar Lenghe because of high altitude of water, which in turn results from sea neighborhood.

One of the advantages of wind-catchers is creating temperature balance in the building during day and night. This springs from the fact that the high special heat capacity of water reads to creation of suitable flywheel for ventilation during day night. Though, during the day, which the weather is hot the cold one comes inside the building and in contrast during the night as an exchange outside cold weather the mild weather is inside spaces.

### 13. CONCLUSIONS

Iran's traditional architecture is caused by the climate and conditions in which it has been grown and developed, so climate as the most effective factor has been affecting in architectural element structure, specially the wind-catcher, which has climatic function. The wind-catcher is the most intelligent arrangement that proceeds of exploitation from the wind natural energy, and at last it makes possible the coldness comfortability in hot regions.

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