Architecture
Image Studies
AIS Scientific Journal

Vol.6 , Issue 1, Territories, 2025
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Adobe wind towers in Iran and examples of wind towers in Anatolia, in Şanlıurfa

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ABSTRACT

Adobe is one of the oldest building material dating back to the beginning of civilization. It is said that the first use of adobe was around 8-10 thousand BC. Early human beings discovered the origin of adobe. When they saw the soil that was cooked and hardened from the clay next to their hearths, they understood that they could use this tool in building materials. Today, mudbrick is used in all historical buildings, including temples and mosques, on the facades of buildings and in the flooring of structures. Another application of adobe in historical buildings, which one can see as an architectural heritage today, is wind towers.

Wind towers are traditional structures used in Iranian architecture in hot, humid, hot and dry climates, and they are tools that refresh and cool indoor air using renewable wind energy. These structures consist of two parts, external and internal. The exterior consists of a closed roof made of adobe and brick on the roof of the building, with most of it a vertical duct at right angles. Wind- towers are usually designed according to the needs of the house/building, so the larger the inlet, the greater the incoming air volume.

Wind towers have holes at the top that allows directly the wind inward. The interior of the building consists of a single opening and is divided into two or eight parts with inclined separator wings according to the openings made of mud brick and brick in other types.

Keywords: Adobe wind towers, wind catchers, Iranian architecture, Şanlıurfa badgel

1 INTRODUCTION

‘’Wind tower’’ has been used in Iran since ancient times and is one of the special masterpieces of Iranian architecture and one of the signs of science and intelligence for its predecessors to live in arid and desert regions. In the cities of Yazd, Kashan, Jahrom Tabas and even along the Persian Gulf coast, especially in Qeshm and along the Arvand River, he used ventilation systems similar to windbreakers, the principles that govern his work.

In this paper, the historical course of the windbreak from past to present, its features and advantages, and finally, the use of windbreaks in buildings today will be presented in both symbolic and functional forms.

The research method in this article is descriptive-analytical; the studies will be based on library, and research. Wind towers, one of the components of Iranian local buildings in hot climates, provide air conditioning by using renewable wind energy as a cooling system. The wind tower is one of Iran’s architectural masterpieces, estimated to have been used in Iran several thousand

years ago.The wind tower is one of the architectural elements built with a climatic approach in the domestic architecture of hot, dry, hot and humid areas (Fig 1).It is connected to the mechanical energy of the engine, etc. As a device that circulates the air without the need, it cools buildings in the desert in summer months, and accordingly, it controls the wind flowing from outside and directs it into the house.

Fig 1 Badgir -windtowers at the roof (Mehr News Agency, 2009)

Wind towers are usually designed according to the needs of the house and of course how much the entrance the larger the volume, the larger the incoming air volume. Direction of most wind curtains towards the prevailing winds. It is not ineffective in high altitude work and the wind speed dispersion from zero to high velocities, curved to a constant value at altitude changes dispersion, and on the other hand, due to the presence of more dust around decreases as it increases. In this way, as the air altitude increases, it has more speed and less dust. The function of wind towers in areas where moisture is needed in addition to wind flow has been in the form of modern water coolers. It enters through its pores and is directed to the water pool. In new wind towers, in the conventional wind deflector column, the more efficient and cooler air-forming wet curtains are used. Using wind towers in Iran dates back to pre-Islamic times. Wind towers have been built at various points since ancient times, but archaeological excavations no scientific conclusion has yet been reached yet. There is no information about the upper parts of any structure other than the foundations or little information is obtained. Some date the use of wind towers in other countries to the centuries BC.It is very difficult to find the first plan of wind towers in architectural remains. The first signs of d from the XIX th century and other samples were destroyed (Abouei,R. 1998,Satavand,. Owlia, 1997).

2 HISTORY OF WIND TOWERS IN TURKEY

Examples of wind towers in Anatolia, which are common in the Middle East. It is located in Şanlıurfa.The wind towers in Şanlıurfa are called *badgel* in the local language**: *Badge.***

The name is quite famous, with the word ‘’badgir’’ used for wind towers in Iran.Apart from ‘’Badgelin’’, in Şanlıurfa, to describe this building component, in the local language. The name ‘’badia’’ is also used. In traditional Şanlıurfa houses, the visible part of the wind receivers is on a flat roof. This part, whose arched body is covered with a half dome, is actually the wind tower forms the upper part (Fig 2). This part seen from the outside is called the wind tower. The inwardly concave arc-shaped face of the tower indicates the direction of the wind. The received wind is the air duct, which is one of the parts of the wind tower that is not visible from the outside. It flows from the north, northwest or west through the outlet is under this air duct, which is located just above the ledge on the rear wall of the porch (Fig 3). When viewed from above, these air outlets, the updraft duct and the head of the wind tower is visible. It is produced for ventilation and cooling of the cavity in traditional houses of wind towers, the wind direction is the north. It flows into the iwan (*eyvan*) through the opening just above the middle niche.

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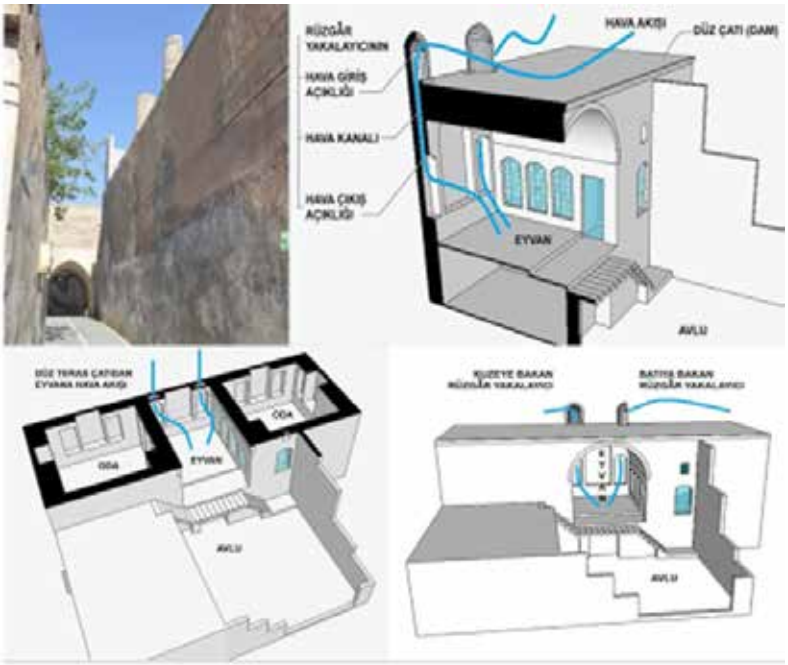

Fig 2 .Wind towers in Şanlıurfa, Turkey (Bekleyen. Melikoğlu , 2019)

Fig 3 Haci Hafızlar Mansion is one of the traditional wind break in Şanlıurfa (Bekleyen. Melikoğlu, 2019)

Fig 4.A sample of badgelin in a Şanlıurfa house(Bekleyen. Melikoğlu ,2019)

Fig.5 Another sample of badgelin in a Şanlıurfa house (Bekleyen. Melikoğlu ,2019)

HISTORY OF WIND TOWERS IN IRAN

Most wind towers in Iran, especially four-way wind towers, have a channel.It is divided into four vertical channels by its separator and one of the channels always takes the breeze and the other three axes act as wind chimneys, helping the outflow of moist air.According to the effect of the chimney, as the temperature increases, the density of the air increases and as a result the air rises.Wind towers are based on three types, Ardakani, Kermani and Yazdi.Ardakani wind tower is mostly seen in Ardakan region and the direction of wind towers.They do not have openings from the west, east and south. The construction of this type of wind tower is relatively simple compared to other types of wind towers. It is economical. Therefore, it is possible to build a wind tower for each room, but Kermani wind towers are simple and small and are dedicated to the house of lower middle-class families. Any building can make these wind towers and main materials of these elements mostly clay and mud. Because such wind towers are bidirectional, twin wind towers.

They are built as twins in the direction of known winds. The operation of the Ardakani wind towers is a little more accurate and ideal because wind pressure in one direction allows rapid evacuation of hot and polluted air on the other side (**Hedayat, Belmans, Ayatollahi, Wouters &Descamps,2017)**

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Fig 6 A historic badgir in Iran

4. TYPES AND PLANS OF WIND TOWERS:

4.1. First type:

Wind towers fall into several categories in terms of their external shape. The smallest piece made on a partition, such as the heater whole in the roof, to prevent simple type of windbreaker, in this method the wind tower only creates cool winds and pleasant breezes, and they are closing the other fronts.

In some cases, one-way wind towers are built behind strong and destructive winds (strong winds and storms) and these wind towers perform the function of ventilation and air evacuation.

It is smaller and simpler in shape than other types. This diagonal path (the upper part of the roof) is connected to a vertical duct in the wall and has an outlet like a heater inside the building. The window is placed on one side.

Fig 7 One sided wind towers /(www.semanticscholar.org/paper/The-wind-catcher-)

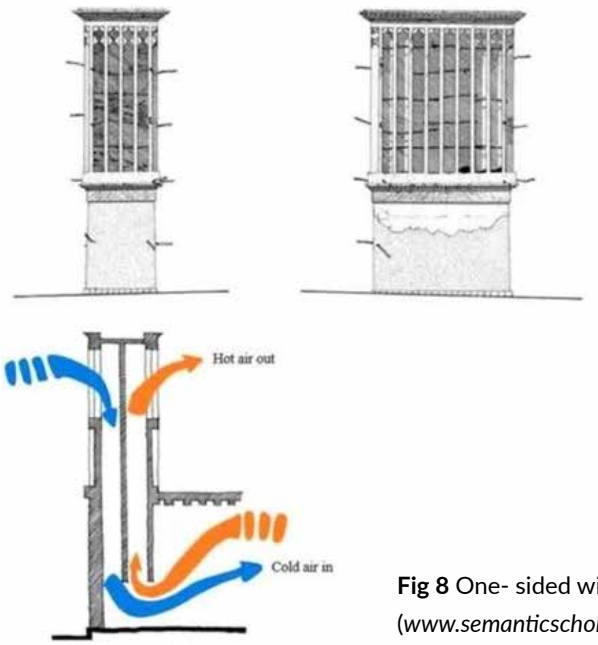

Fig 8 One- sided wind towers
(*www.semanticscholar.org/paper/The-wind-catcher)*

Fig 9 One-sided wind towers (*www.semanticscholar.org/paper/The-wind-catcher)*

4.2 Second type:

The second type has three wings and two types, three interconnected wings, and three separate wings. In this example, one, two or three facades can be used separately, but such wind towers use is rare. Another example: Badgir mansion, the jewel of the Golestan Palace complex:

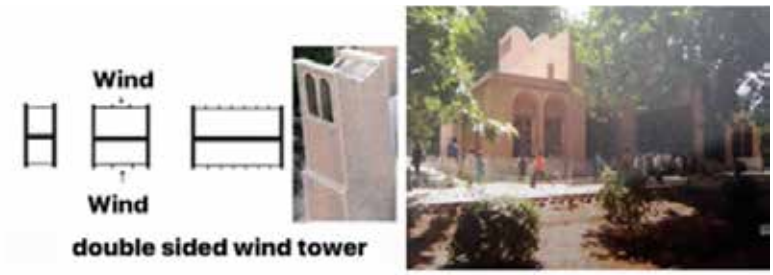

Fig 10 Two-sided wind towers

It was built on the south side of the Gulistan Garden, during the reign of Naseroddin Shah.

It is a building belonging to the period of Fath Ali Shah, which became modern with the conquests.

Air conditioning and the presence of wind towers to transfer it to the pool house and main hall (Fig 10).

Under the hall and the mansion, you can breathe the air of the pool house, the hall and the rooms.

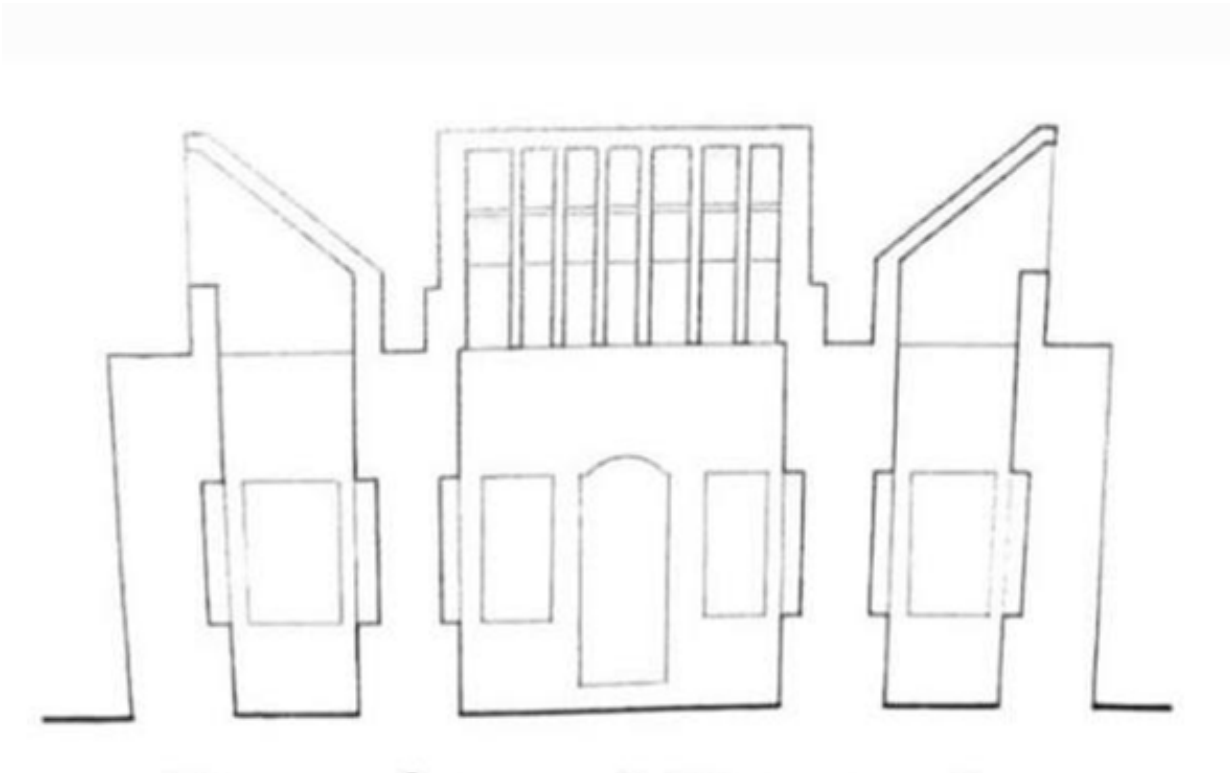

Fig 11 Three sided wind towers

4.3 Third Type:

A four-way wind tower made completer and more detailed than other types and generally It is divided into several parts by brick or wood or plaster wings inside the channels. In addition, in some instances, the cold humidity of dry and dusty air and relatively large and beautiful, where it is separated from the water by absorbing the dust and a pool was built. For instance: The wind tower of Dolatabad mansion in Yazd is the highest wind tower with a height of 18 meters is the tower.

4.4 Forth type:

This example can be seen in Yazd, Kerman and Bushehr. In the city of Yazd and some parts of central Iran polyhedral wind towers, (often octagonal and sometimes even circular) varieties can be seen. The main wings in the square plan are the cross wings, the H wings and the Cross wings.

4.5 Fifth type:

Chopoghi wind towers, the outer volume of the manufacturer's wind towers, instead of a cubic outer space the sixth type of wind, which he used to form several bent (knee-shaped) pipes.

It is a deflector, but the channels and internal parts are in Sircan as in multi-sided examples.

The facade of wind towers has its own characteristics, and finally thin, adobe brick.

4.6 Sixth type:

This wind tower is a very rare example found in Kashan with protection in the lower part of the courtyard.

Wind tower of the Abbasian estate (Abbasids) in Kashan: this wind tower is lower than courtyard level.

5.Wind tower structure:

Local architects designed brickwork from the roof to the floor facing a small room dedicated to the wind tower. For example, it gives a special effect to the facade of the wind tower and enhances the building of the wind towers. Strengthens, because sometimes the wind towers in Ardakan, Meybod, and their surroundings. It is built facing the street.

Wind towers (arc):

The width between the two wings is called the "arc". The width between leaves 5, 7 and 11 arcs respectively. The number of springs in this region is not even. Every windrower's depth is one to two and a half meters. Sometimes the power of the wind tower can be up to half a meter.

To increase the wind, wood is placed between the walls of the towers. The roof of the two columns "capillary" form is closed. In this way, two bricks are tangible upwards. The roof of the wind tower allows fresh air to be drawn in or hot and polluted air to the outside. Then, with half a straw, they cover the roof of the wind tower with a diameter of three centimetres. Sometimes

Figs 10, 11 Octagonal or circular wind towers

the space between two columns levelled with bricks and straw, then two or three rows of bricks to the sides of the roof is placed. So, laying the bricks this way, in addition to the strength of the wind tower.. Sometimes the roofing material is thatched. Later A row of bricks is placed on it. And the distance between the bricks is closed with plaster and soil. Material in houses with more facilities, plasterwork is done on the arc walls of the wind tower. The arc number of the wind tower is directly related to the size of the wind tower. On the other hand, the number of springs on both sides of the wind tower, the strength of the wind on the same side, and the total relates to the weather of each region.

In some houses, sometimes for the winter, when the wind tower is not needed, the spring of the wind tower is in some parts, razors are made of brick or clay. On the other hand, a valve is installed at the bottom of the wind tower, and they turn it off when needed. This job is done every year in late autumn and on the eve of winter. Since the households are resting in the room under the wind tower during the summer months. the birds especially pigeons nesting in wind towers and dropping their droppings down possible. Therefore, to prevent this, the spring part of the wind towers is made of wire mesh or wood.

6. Working performance of wind towers:

Wind towers are effective at generating natural cooling in two ways.

Air movement

- Evaporative cooling (Evaporation)

In a general category, wind towers create air movement and perform performance in two ways can be displayed.

- Directing the wind towards the building (when the wind blows).
- Diverting the indoor air to the outside (when the wind blows

At the top level of the wind towers, it is usually perpendicular to the direction of the prevailing wind. Thus, when the wind towers are placed in the wind direction, the air vents exposed to positive pressure and vice versa, negative pressure at the rear air vents occurs and ventilation only occurs when the wind speed is greater than 2.5 meters per second.

At night, the formation of air flow inside the wind towers and the wind temperature of the mass of wind towers, due to the thermal radiation of their surface drops to the temperature of the sky and the so-called wind tower is cooled; Wind tower interior surfaces by exchanging heat with the air, the air is slightly cooled and then the wind tower or enters the building below. The only way for the wind tower body to lose heat is the continuous

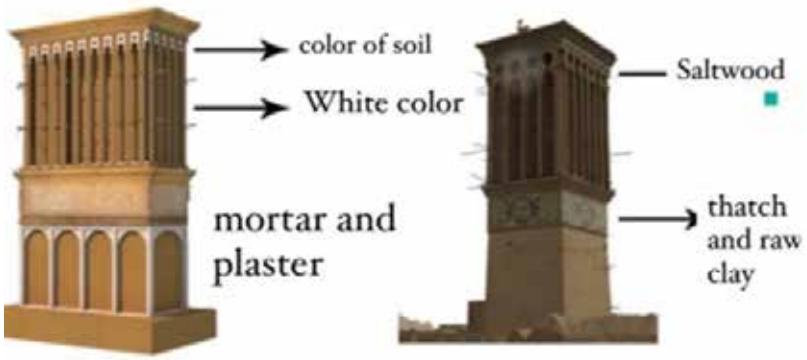

Fig 12 Typical wind towers

evaporation of the ambient air with the walls, floor and ceiling. In this case, the wind is warmer than the ambient air because the warmer wind vaporizes the water droplets in its hull and blows the windshield body at the same rate. Natural ventilation of wind towers where wind speed is not critical.

It is based on the “chimney feature” phenomenon, in which case all wind towers work as a chimney
When there is no wind the air inside the tower heats up and the chimney acts as a heating pipe, allowing warmer air from the tower outlets.
This causes cooler air to come out. Bottom to the tower withdrawn and alternately replaced by courtyard air. This can happen at any time of the day, but mostly at night and maybe in calm weather.

7 How wind towers are built

Water was found in the space under the wind towers in four ways:
1. Placing water jugs under the wind tower,
2. Establishing a pool in the middle of the wind tower room,
3. Connecting the wind tower to the living area by a moist horizontal channel. There is a rare example of the evaporator function of wind towers, in which a horizontal.
There is a wind tower a little far from the residential area that reaches from the canal. The flowers and plants in the gardens are kept constantly wet by watering and infiltration. Located under the gardens and under the courtyard; and out of the wind tower the air was cooled by evaporation from this wet underground duct and then enters the field (Ahmadkhani, 2017).

. Construction method:
The construction of wind towers refers to these two methods and how to build them. There are two construction methods available:
Channel construction: These spaces, in a section of one meter wide and two meters long, It was built in square and rectangular dimensions depending on the multi-door room and the cellar.
This section usually has two channels:
1. Sub channels
2. Upper channels
The hole for the lower duct to reach the basement or pool house, and the upper ducts in the room.
The hole is one-third to one-fourth above the crypt, and in some cases toward the ground. Today, a net is installed at the top (entrance) of the wind tower channel. The middle channel from the ceiling level to the wind tower can be implemented in various ways.

3. Connect the wind tower with groundwater flow through a vertical channel.

8 Materials used in wind towers:

- The importance of the body components of wind towers as an element with a climatic function is obvious. Reed clay or adobe brick was used in the construction of the wind towers. It is very convenient, since the earth element has an uncompressed and soft volume and water
Holes form, which prevents heat and cold from reaching the molecules. Dirt, layer
and turns into clay. The building materials of wind towers are generally raw clay, brick, mud, plaster and salty wood.
- Salty wood, a tree with a high coefficient of strength and resistant to termite attack type. The colour of the facade of the wind towers, with the colour of the straw. In addition, the presence of straw in the mud, contributes to the texture of the facade, which prevents the absorption of rays. Clay in hot and humid areas and the brick is clearly visible; this is probably due to the use of environmentally friendly materials was due.

9 Advantages of conventional wind deflectors and disadvantages:

The most important advantage of traditional wind towers is that they are passive systems, that is, they work.

They do not need any energy other than wind energy.
The main disadvantages of traditional wind towers can be summarized as follows:

1. It is possible for dust and insects to enter the building from the wind towers.
2. Some of the air entering from the wind towers exit through the other openings of the building. When the wind towers have a single opening to the wind, the air is the same enters a large volume building at once.
3. The amount of cold air that can be stored in wind towers is generally limited (Wind towers due to the low heat capacity of energy-saving materials) and in the building may not provide the necessary cooling for hot summer days.

A. The cooling feature is not fully utilized by absorbing latent heat and evaporating air.

B. Wind deflectors are not used in areas where the wind speed is very low Application of Wind towers in modern architecture

11 CONCLUSIONS

Application of Wind towers in modern architecture:

Wind towers may not be used as a ventilation system. However, in the current situation, required cool buildings, using the general principles governing how they work. Important measures can be taken to reduce energy consumption.

With the emergence of modern architecture and especially the use of mechanical installations, The role of climate elements in buildings has gradually decreased, but climate and environmental protection are constantly since the second half of the last century. Conversion and use of clean energies such as sun, wind and water has become very important.

Since this period in the field of architecture, the importance given to the environment and the climate compatible with the climate buildings and architectural design studies started.

Reliable and effective tool for the use of wind energy in the world of building industrialization.

As a result, products called wind tower were launched. in the design of these products. In addition to benefiting from the experience and structure of traditional wind towers,

The disadvantages of using the traditional form are eliminated and the main idea is modern. and used in developing architecture.

Based on the natural effects of wind and the movement of hot and cold air, modern wind- towers that are not part and use vertical vents, brings fresh air into the room and removes used air. The operation of this system is warm and light.

By moving the air upwards, the traditional wind towers follow simple rules, which causes a pressure drop in the chamber, hence suction, and in general, the current use of wind towers according to their history can be divided into two categories.

Symbolic use:

In this approach, the formal and visual features of the wind towers are included in the concept and design idea. For example, the famous and prominent Iranian in the design of the Museum of Contemporary Art architect Kamran Diba, in the general volume of the museum, visual and stylistic of the wind towers.

Functional use:

This feature is also reflected in the buildings of the Persian Gulf countries. For example, one of the buildings built in the Jumeirah neighbourhood next to the Burj Al Arab in Dubai.

Today, in addition to the ventilation and cooling system of the building, wind towers are available. Natural ventilation at certain times of the year with the help of wind towers comfort conditions can be provided and only the wind can no longer meet the needs of the residents.

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