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Air Duct a Symbol of Sustainable Architecture in Hot and Dry Climate

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Abstract: Today, when science and technology is expanded, the human society sees increasing growth of gap in climate and architecture close relation. In case relation between climate and architecture is expanded using the strategies only based on technology and without considering climate and environmental conditions of the region. Considering that major area of Iran is eco deserts, therefore, it is necessary to study and find strategies for establishing this link and meet needs of the region. Valuable Iranian architecture works are part of the best architectural strategies for design in desert climate among which we can name an element called air duct as one of the considerable and multifunctional phenomena. Air ducts are important element of desert climate especially in ventilation of the internal space of buildings and cooling the basements, cisterns and creating air flow in addition to texture identification and aesthetics. In this writing, necessity and importance of air ducts, function and design of air ducts and its types are studied. Then, horizon and future perspective for using the air ducts in desert climate are studied and analyzed. This research studies climatic problems of the desert region in recent and future decades to provide the proposed strategies in order to utilize the air duct element.

Key words*:* vernacular architecture, climate, sustainable architecture, wind catcher, desert areas

INTRODUCTION

One of the considerable phenomena of the buildings in the past years of Iran is wind catcher which is found especially in cities and villages in margins of the windy desert, plain and heaths on top of the buildings and some persons regard it more decoratively important than its advantage of ventilation but the fact is that it plays very effective and valuable role in ventilation of internal space of the buildings and cooling of basements and cisterns. Wind catchers are regarded as respiratory system of the city. Wind catchers are the towers which direct natural airflow to different buildings considering their special structure. In houses, wind catchers are usually made in southern side of the yard i.e. in summer part of the house. Wind catchers are connected to hall, pool and basement, allow air to flow inside the building, compensate for shortage of the ground humidity while contacting humid elements such as pool, small garden, trees, wall of the basement and fords and provide a pleasant place for living at hot and exhausting summer days for the residents.

Necessity and Importance of Wind Catchers:

Wind catcher is a suitable ventilation means for houses at center of desert so that it creates pleasant airflow in rooms, hall and basement. For this reason, they make wind catcher at any place in the direction which absorbs the most suitable airflow of the region, for example, they make direction of wind catcher toward the north to bring air of north inside the house. In this case, they make back of the wind catcher in direction of Kiblah Wind along with dust.

Main function of wind catcher is summarized in two parts:

1- It directs pleasant air to the lower part so that once air blows toward the wind catcher springs; wind is pulled downward with higher speed toward special condition of the wind catcher springs.

2- Another direction of wind catcher sends hot and polluted air outside, that is, it performs suction action.

In addition, they embed shelf or closet at center of wall in direction of some wind catchers which find a way to cellar and they put a wooden door on that to control wind that is they close door of closet at winter to stop connection of inside and outside space of the room. These closets at room function as modern fridges so that they put meat, yogurt, cheese and leftovers in closer and close its door to protect them against hot air of the inside space and access of the domestic animals. In Aghda Village, these wall closets are called *Gambijeh* (Abu Zia, Z., 1985). In addition, wind catcher is used to cool the food in better way in addition to ventilation and what was mentioned. For this purpose, they fasten a wooden pulley on the wood in the middle of wind catcher shelf and pass a string through the pulley which enters lower part of the wind catcher and they form another end of string into four strings which are fastened to four corners of the fretted board with approximate length and width of 70 cm which is called *Chavosh.* Then, they fasten another end of string to nail of the wall of hall and put yoghurt, meat, cheese and leftovers on the fretted board. In order to put the board upward and expose it to

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airflow, they open end of the string on the nail and pull them downward to pull another end upward with pulley which is connected to the fretted board. In this case, the fretted board goes up and is exposed to cold air and prevents perishing food. Another advantage is that the food is kept away from the domestic animals (Christian Bromberger, 1991).

The presence of wind catcher has direct relationship with climate of each region so that the colder the air, the lower the number of wind catchers, for example, wind catcher is meaningless to the inhabitants in mountainous Tarzjan village and Dehbala which are cold while one can say that almost all houses have wind catchers in Meibod district which is hot and dry.

Function and Some Points about Design of Wind Catchers:

There are two main functions for wind catchers which are studied in detail based on their importance:

Function Based on Traction Principle of Windward Opening and Leeward Openings Suction:

The late Pir Nia explains mechanism of the wind catcher in book "Familiarity with Islamic Architecture of Iran ": In wind catcher, wind blow is used to drag pleasant air inside the building and reaction of its force i.e. suction is used for driving hot and polluted air away . Perhaps, it is not necessary to explain that because wind collides with barrier or wall of the internal blades of wind catcher, it is forced to come down but it is necessary to note that other fissures of the wind catcher which are leeward send polluted and hot air to the wind and act as fan and suction device (Behjati Ardakani, M., 2003). This function of wind catcher is performed considering this principle that when the wind collides with a body , positive pressure is applied in this side considering more air compaction in the side which is against the wind. In this side, positive pressure is applied and we will have negative pressure in another side. Therefore, in case of opening on both sides, we will see wind movement from positive pressure to negative pressure. In wind catchers, windward opening pulls air inside and brings it in inside the patio and air inside the patio is pulled outside considering negative pressure in leeward opening (Tavasoli, M., 2003). Sometimes, they provide necessary humidity by passing wind of the wind catcher through water and cold storage and considering surface evaporation. Regions such as Egypt and India, this action is done by putting jug full of water against wind direction.

Action Based on Temperature Difference:

But it seems that what is less considered by the specialists in this field. Function of the wind catcher is based on temperature difference. In fact, when wind doesn't blow noticeably, wind catcher functions based on this principle. At day, considering exposure of southern side of the wind catcher to sun, air in the southern side of the wind catcher is heated and comes up. This air is compensated with air inside the patio which is pulled upward and a kind of partial vacuum is created inside the patio which pulls cold air inside the yard inside itself. In this regard, air of the northern opening is pulled downward (Kasmaei, M., 1993). At night, the outside air is cooled and moves downward. This air is heated due to heat reserved in walls and comes up and this cycle continues until temperature of walls and outside air becomes equal but night ended usually before reaching this condition and wind catcher acts again as explained above.

Structure and Function of Wind Catcher:

Wind factor is used in wind catcher such that they construct narrow and long tower-like buildings with four sides or eight sides on roof of the building and keep the upper part of the mentioned building open in four directions. The upper part of four or eight openings is closed to the sky but its lower part is open to the building or cistern (Abu Zia, Z., 1985) while inside of the tower-like building is divided by oblique brick blades into four parts so that the wind enters inside the opening of the direction from which the wind blows in the upper space of the mentioned building and wind traction continues downward and wind enters inside the building from the outdoor space and air comes out on another side and this causes wind to blow and causes air to move inside the building.

Types of Wind Catcher:

Wind catchers can be classified and studied in terms of some factors:

Bar Cut Shape:

Body of the wind catchers is made in the form of square, rectangle and octagon. Quadrangle and octagon body is mostly suitable for the regions in which mild and varied breezes blow wind is caught by different sides. Rectangular bodies are also suitable for the areas which are blowing directions of wind in hot season on the one hand and from northeast to southwest. For this reason, they make the bar in the form of rectangle in such areas so that the opening which directly takes the wind has more surface contact.

Number and Types of Opening:

Wind catchers are divided into two general classes of one-opening and four-opening ones. One –opening wind catchers are divided into three types: A- in the areas which whirlwind and storm blow, the make wind catchers with one opening and the opening usually faces mountain and mostly fasces northeast and they make their roof as raised roof for resistance against wind, B- in coasts of Persian Gulf, wind catchers have one opening and are like trunk. The opening is behind the sea and humid wind arising out of sea flows inside the building and it makes the inside air light. In Bandar Abbas, they tried to raise cold air of well by digging water well below these suction wind catchers and tolerate the inside space, C- there are double wind catchers on houses and cisterns of some cities such as Tehran and Kashan. Their number sometimes reaches six dependent on size of cisterns. Openings of these wind catchers face different directions and wind is drawn to cistern from any side wind blows and inside air is sent outside and air flows from the wind catcher or other wind catchers. Therefore, one or two bars act as wind catcher and other bar or bars act as fan. Architects call these wind catchers "*bedeh va bestan*" (Kasmaei, M., 1993). Four-opening wind catchers are found more in central cities and sides of desert which add to beauty and appearance of public space of city architecture far from their main function which is cooling of the building. In Minab and Qeshm, there are some four-opening and eight –portion wind catchers and divisions inside the bar act as wind catcher and fan concurrently and make air flow from inside the building to cisterns. Although double wind catchers are very strong, one to six wind catchers with four openings are made on the large buildings (an example is six- wind catcher cistern in Yazd)(Razjooyan, M., 1988).

Number of Stories:

Wind catcher is one of the Iranian wind catchers. This wind catcher is huge and is made in the areas which wind flows variably. In order to utilize wind of the area which blows high or low, they make two wind catchers on each other and the lower wind catcher with larger surface and the upper wind catcher with smaller surface (an example is found in Yazd and Abarghoo).

Building Inside the Bar:

In order to direct pleasant wind inside and drive hot and polluted air outside, they divide inside of the bar with oblique brick blade. Wind is pulled downward after entrance from one of the openings due to collision with wall and blades located in its route. Due to wind entrance, polluted and hot air goes upward and outside through other channels of wind catcher which are leeward.

Blade and Valve of Wind Catcher:

In opening of wind catchers, vertical blades are located in parallel so that they have forms and decorated them beautifully. Main and technical function of these blades is to set wind pressure. Upper end of the wind catcher bar is located on the roof or side of the wall body and a fretted wall covered with tile or wood has been installed in front of the opening not to damage beauty inside the building. Sometimes, they embed a thing like window in this place which can be opened and closed. In alcove ceiling of the large buildings which have two-story wind catchers, they put quadrangle valve below each one of the wind catcher channels which can be opened and closed (Christian Bromberger, 1991).

Determining Height of the Wind Catcher Bar:

It is technically important to determine height of the wind catcher bar and location of its openings. Wind architects climb up the two-sided ladders and determine desirable height of wind , height of the bar and location of openings and its height so that one can utilize the best and the highest efficiency through collision of wind with their earlobes.

External Shape: It is Different in Forms Which Has Been Studied:

One-Sided Wind Catchers:

The simplest type of wind catcher has one side and is made very small on top of a chamber such as hole of stove behind the roof. In this method, they make wind catcher only in direction of cold winds and desirable breezes in order to prevent damage of whirlwinds and heavy storms and close other fronts. In some cases, they make one-sided wind catchers behind the severe and bothering winds and in fact, this wind catcher performs function of air ventilation and discharge. It is smaller in size and more primary in form than other types are. This oblique route (which is found on the roof) is located as stove in one side of the room after connection to the vertical channel inside the wall and external window inside the building. It does ventilation. This example is found more in Sistan region and a part of Bam County (Aghaei, S., 1993).

Two-Sided Wind Catchers:

Two-sided type which has two sides facing each other and with long and narrow windows is made without support and is found in internal side of the building as one or more holes in shelf. This example is found in Sirjan and seldom in Kerman.

Three -Sided Wind Catcher:

The third type of wind catcher has three sides and two types: three connected sides and three separated sides (Ashkam Darideh). In this example, one can use one or two or three fronts. Of course, this kind of wind catcher is rarely used.

Four-Sided Wind Catchers:

The fourth type is four-sided wind catchers which have been made more completely than other types and are divided into some parts inside its channels with brick or wooden or plaster blades. In some examples, they have made large and beautiful pool below the wind catcher channel in which dried and dusty air has become separated after collision with water by absorbing cold humidity and dust and room air (pool room) in very pleasant warm summer days. In the regions which pool room is not made on the ground floor, they caused water of qanat to flow and manifested it and the wind catcher channel continues on this water flow. These spaces (cellars) have been gathering place of the household in the afternoons of summer. This example is found in Yazd, Kerman and Bushehr.

Multi-Sided Wind Catcher:

In Yazd County and some central parts of Iran, multi-sided wind catchers (usually octagonal and even rounded) are common as the fifth type of wind catchers. The reason for construction of these wind catchers is the presence of pleasant winds which blow on each side and blades of channel can catch wind from each side and direct it inside the route.

Pipe-Like Wind Catcher:

Pipe-like wind catcher is the sixth type of wind catchers in which the constructor has used some folded pipe (elbow-shaped) instead of external cubic space for external volume of wind catcher but channels and internal parts are like multisided samples. This type of wind catcher is found only in Sirjan. (Abu Zia, Z., 1985).

Future Vision:

With entrance of modern architecture and especially use of mechanical installations, role of climate faded gradually in the buildings but since the second half of the past century which climate and environmental protection were continually considered, use of technology which is consistent with natural environment, recycle of industrial wastes and use of clean energies such as sun, wind and water became very important. In architecture, environment was considered and attempt was made to design climatic and architectural buildings harmonic with Climate. Today, one can use wind catcher as complement of the ventilation and cooling system. One can provide comfort with natural ventilation during the year using the wind catcher and one should utilize mechanical installations when the wind can no longer respond to need of the residents. Hassan Fathi, Egyptian architect who made effort to combine traditional architecture and modern technology used a water pump inside the wind catcher channel of his buildings which reduced warmth and dust rate by creating a fountain at hot and dusty days (Kasmaei, M., 1993). In addition to the mentioned cases, other designs were available in other countries with reliance on natural ventilation. For example, in Blue Water shopping center of England, fresh air is provided through a tail of conical wind catchers with height of 2 m. These wind catchers were mounted on the roof to send colder air downward and distribute it in internal space. They are located in 15 m far from each other and on central axis of the complex and send fresh air to the building after receiving external airflow. China Armory Tower includes a set of uniform blocks mounted on each other with administrative, retailing, hotel and residential uses. In summer season, a wind catcher directs fresh air to lower part of the middle corridor. Then, this air is taken out of walls. In winter season, this wind catcher pulls air from body of the building and channel of solar absorbents toward itself and takes it out of building. Another considerable example is Lister in England. Energy consumption rate in Queens Building of Montfort University is half of the energy consumed in an ordinary building which is similar to this building in which air conditioning system has been used. High wind catchers prevent air turbulence and have been designed for transferring internal air to outside of the building.

Conclusion:

Today, one can use wind catcher as one of the best complementary elements of the ventilation and cooling system. Wind catcher can provide comfort inside the building through natural ventilation during the year and one should utilize mechanical installations when the wind can no longer respond to need of the residents. Some examples of this complementary system can be observed in some renovated houses of Safayieh district of Yazd

and residential buildings of Railway Personnel of this city. Unfortunately, new wind catchers are decorative in renovated houses of the cities and if the wind catcher is only symbolic and has no function, this valuable relic will be omitted from the old and new view of cities of Iran. Therefore, one can study the following cases as a basic and important matter for execution of climatic strategies with prophases of using element of wind catcher in architecture.

*****Recognizing climate and environmental patterns of the region

*Familiarity with traditional climatic –architectural strategies common in texture

*Familiarity with and proficiency in use of modern technology in climatic textures

*Designing functional strategies based on reconnection of climate and architecture based on traditional responsive strategies using modern technology

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