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RESEARCH ARTICLE

AN ANALYSIS OF THE WINDCATCHER TYPOLOGY AND FINDING THE BEST PERFORMANCE (CASE STUDY OF TADAYON, TAHERI AND KALANTAR HISTORICAL HOUSES IN SEMNAN, IRAN)

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ABSTRACT

As the name implies, windcatcher is a part of the building's framework of the hot and dry or wet and dry climates of Iran, in which by directing the windflaw and enjoying the clean energy of the nature has a particular rule in coordinating the residential space to a comfort temperature for human being. In this study Semnan has been selected as a case study of warm and dry area. The method of study is descriptive- analytical and the reason for choosing the samples is their proximity to each other and their differences in the size and other key features of the wind catchers. Typology has been done by analyzing the common features and patterns of the wind catchers, for this reason the through research on the windcatchers of the Yazd houses written by dr. Mahnaz Mahmoudi has been used. Also, in the study architectural proportions of the wind catchers has been examine and finally the differences between all these windcatchers and finding the best form from the thermal function perspective has been reported. The results of this study would be applied for the development of this element in in today's modern architecture.

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INTRODUCTION

If we consider climate variability of the Iran plateau as four climates, most of the half of this vast land is at the hot and dry and wet and dry climates which creates special characteristics of architectural designing in reducing the temperature by relying on wind energy. These areas consist of the north of Persian Gulf and Oman Sea and the central and eastern part of Iran. Exploiting this climate situation and accessing the behavioral knowledge of temperature, humidity and windflaw exchange in this plateau leads to the creation of the windcatchers as the most prominent and common structural elements of air refrigeration with a historical background. Windcatcher is a significant architectural composition in the buildings to provide natural ventilation which facilitate airflow in the building without applying electrical energy. By blowing the wind, the air enters the windcatcher pillar through the windcatcher spout and then enters the building after heat exchange with the windcatcher walls. The windcatchers are divided into four categories based on wind direction:

Research Methodology

The research methodology used in this study is qualitative and the data collection method is library and field.

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Location of Houses in Semnan Plan site

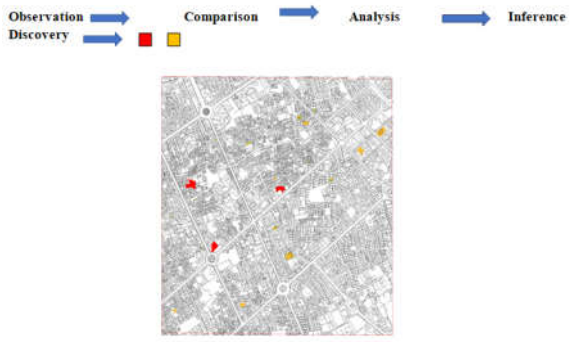
House under study
House with windcatcher in Semnan
Map 1: Semnan windcatcherHouses (Source: Semnan Province Cultural Heritage)

Topology of the windcatchers

Typology A (Based on Location)

Windcatchers in the house's plan is in direct and indirect connection with yard and hall. Windcatcher always are located at the summer hall and the reason is back to the past traditional constructions and the location of the summer hall at the south part of the house. Since in the summer cooling was the basic principle, the summer hall was constructed at the north part of the house in order for the winter hall to enjoy the sunshine. Based on the financial ability of the owner traditional houses has had one to three yards, but having one yard was an inseparable part of the old houses. Hall is a space at the center of the house and is safe from direct sunlight hence it does not get warm during the day. This space is either in direct connection with windcatcher or this connection would create by the other spaces.

- Position the windcatcher behind the hall and in the symmetry axis of the hall and the yard

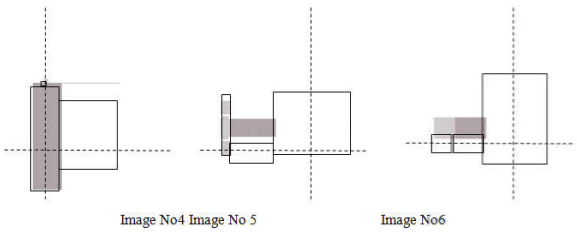


- Positioning the windcatcher on the back of the hall and on the symmetry axis of the hall (lack of hall and windcatcher symmetry in the yard)
- Positioning the windcatcher at the back of the hall (long hall)

Image 1. Kalantar House planImage 2. Tadayon House planImage 3. Taheri House plan

(Source: Semnan Province Cultural Heritage)
(Source: Semnan Province Cultural Heritage)
(Source: Semnan Province Cultural Heritage)

Location of windcatcher in plan is as follow:



The connection of hall and the yard windcatchers- (Source: Author)

In fact, in all these 3 houses the windcatcher is in direct connection with hall and has been located at the back of the hall and near to the yard. As it can be seen the windcatcher has been located at the summer hall at the south part of the house.

Typology B (Based onthe Shape and Type of Windcatcher): As the windcatcher is an architectural element with climatic function, it has also examined from engineering perspective. Therefor to categorize the windcatchers examining them from various perspectives has a significant role. According to the number of wind-receiving sides, two of the sample houses are four-sided and one of them is two-sided.

In Tadayon House the windcatcher is triploid and two- sided, which means in fact three windcatchers has been put together in which the central one is higher than two others. In Kalantar House there is a four-sided win catcher in which the wind entrance is wider than the other windcatchers. In Taheri House there is a short four-sided windcatcher with smaller duct than the others.

Typology of P (Based on Windcatcher Plan): The shape of the windcatcher plan plays an important role in the formation of the windcatcher and its appearance in the urban landscape. Generally, in Iran, a windcatchers are seen with circular, hexagonal and rectangular plans. The blades are made of clay and brick, which divide the windcatcher channel into several smaller channels. These blades start from 1.5 to 2 meters high and extend to the ceiling. The blades are subdivided into two main and sub-groups, the main one is extending to the center of the tower and dividing the windcatcher channel into smaller channels. The main blades can be seen with the diagonal forms, +, H, I. Depending on the general shape of the windcatcher plan and the shape of these windcatchers, they can be divided into two types.

The sub-blades sometimes do not extend to the center of the tower and sometimes go up to the main blade. The sub-blades are called bases. The sub-blades have some benefits such as:

- they give the windcatcher a special look, in such a way that blends architecture and structure.
- They give strength to the windcatchers building.
- Provides homeowners security to prevent burglars from entering.

Splitting the windcatcher channel into smaller channels using the primary and secondary blades results in a higher Bernoulli * air velocity in fluid mechanics.

Typology (Based on Vertical Cross Section and Duct): The windcatcher can be defined as a traditional structure for static and spontaneous indoor cooling. It works in two ways: 1. Air displacement, 2. Evaporative cooling. The TadayonHouse's windcatcher works by evaporative cooling, where evaporative cooling is carried out using a water pond. Dimensions of the pond below the windcatcher are 1 m at 1.5 m with a depth of 0.5 m. The Kalantar House's windcatcher operates on air displacement, which is the pressure difference between the inlet and outlet points that causes the air to flow into the interior. Taheri's windcatcher also works with evaporative cooling, with the use of a water jar.

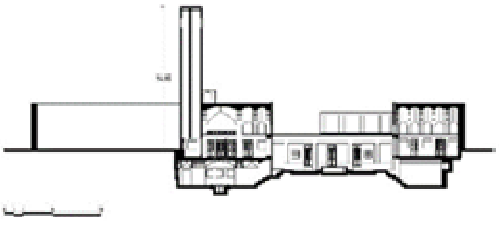


Image 7, Windcatcher section of the TadayonHouse

Image 8, Windcatcher section of the Kalantar House

(Source: Semnan Province Cultural Heritage)

Image 9, Windcatcher section of the Taheri House

Due to the cross-section differences, these three windcatchers can be classified into three different categories:

- TadayonHouse windcatcher: Two side ducts reach the basement and the middle duct only reaches the first floor of the fresh air. In the basement of this house is a dock.
- The Kalantar House windcatcher only brings fresh air to the ground floor.
- Taheri House windcatcher: It only brings fresh air to the first floor.

Factors Affecting Windcatcher Performance

Windcatcher Height: The height of the windcatcher affects the intensity of the windcatcher's ventilation, so that more intense winds pass through the top of the windcatcher and, as a result, the higher the negative pressure, the higher the windcatcher's height, the greater the distance from the air inlet to the outlet. The higher the pressure difference, the greater is its efficiency. Thus, among the three houses, the Kalantar House creates more pressure difference on the windcatcher surface due to the higher altitude, but it is not only the windcatcher height which is effective in this process, and as the air passes through the narrower cross section, the velocity increases, and as the altitude increases, the ratio of the total area of the channel to the cross-section decreases and the wind moves more rapidly. According to this effect, the Taheri windcatcher has a narrower cross section than the others, in fact each of these windcatchers has privileges to adjust the ambient temperature.

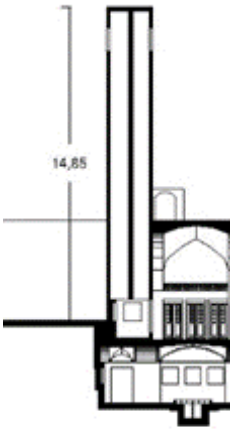


Image10

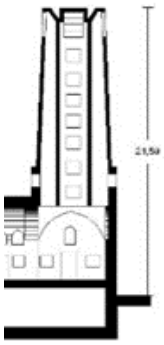
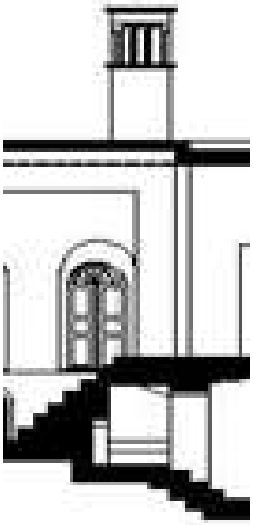


Image 11



Source: Author

Image 12.

The Pavilion Effect: In all buildings with ponds, a geometry such as a curved roof or ceiling will help to rotate the indoor air flow. This further decrease will further reduce the temperature and coolness of the indoor air. There is a pool with a roof and we have a roof top.

The Geometry Effect andThickness of Wet Surface Effect: The wet surface area is proportional to the amount of evaporation, which means that the greater the wet surface area, the better the performance of the wind-driven evaporative cooling system. If cooling and evaporation occurs at the top of the windcatcher, the air will become cold and heavy upon entering the channel. It then descends faster due to gravitational force. In these houses, since the house has only a dock and no wet surface it is larger than the Taheri house which has a water jar, so the area of the wet surface in this house is greater and consequently better system performance.

The Geometry Effect and Cross Section of Windcatcher
Two factors influencing the performance of the evaporators or the performance of the windcatcher are the mass input to the building as well as the wet system. The higher the evaporation, however, the better the efficiency. The amount of evaporation also requires more air volume. What is important in this investigation is how the geometry of the cross section of windcatcher should be; that is the maximum volume of the air which is available must navigate at a proper and constant speed.

Table 1. Types of the Windcatchers (Source: Author)

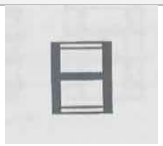
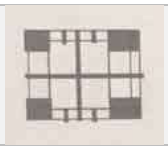
Windcatcher's Plan	Windcatcher's Image	Windcatcher's Name	Windcatcher
		**One-sided**	**Model 1**
		**Two- sided**	**Model 2**
		**Four- sided**	**Model 3**
		**Multi-sided**	**Model 4**

Table 2. Case Study (Author's)

Type	Image	Windcatcher
Two- sided		Tadayon House
Four-sided		Kalantar House
Four-sided		Taheri House

Table 3. Windcatcher Plans (Reference: Author)

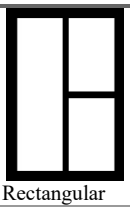
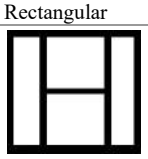
Main Blade Type	Hall Dimensions	a*b Dimensions	Plan	Windcatcher
T Blade	3.15*3.30	2.42*1.54	 Rectangular	TadayonHouse
H Blade	5.62*3.33	3.82*3.33	 Rectangular	Kalantar House
X Blade	3.21*9.63	0.8*0.8	 Square	Taheri House

Table 4. Evaluation of Three Windcatchers Performance. (Source:Author)

Appearance Factors Influencing Windcatcher Performance	TadayonHouse	KalantarHouse	Taheri's House
Geometry of the Plan	Rectangle	Rectangle	Square
Blade Type	T Blade	H Blade	XBlade
Geometry of Cross Section	Four-sides	Two-sides	Four-sided
Other Influencing Factors of Windcatcher Performance			
Height			
The Pavilion	Has	Doesn't Have	Doesn't Have
Wind Effect	Constant	Constant	Constant
Thickness Effect and Wet Surface Geometry	More Wet Surface	No Wet Surface	Less Wet Surface
Rate of Air Mass Flow Effect	Constant	Constant	Constant

Considering the cross-sectional area of the windcatcher and the size and dimensions must be conformed with the size and dimensions of the hall and the space which the temperature degree should be adjusted. Each of these windcatchers meet the thermal requirements of thathouse.

The Rate of Air Mass Flow Effect : In a windcatcher, the air mass flow rate varies throughout the day. The maximum impact of the mass flow rate happens when the evaporation rate increases. The air mass rate is proportional to the velocity of air entering the windcatcher. Given that the houses are in the same neighborhood, the factor is common to all three houses and their air velocity is the same.

Wind Speed Effect : The wind speed is proportional to the air mass flow rate. Increasing the air velocity or the air flow rate requires less time for optimum evaporation, which reduces evaporation efficiency .It must be noted that the evaporation efficiency is proportional to the volume of air at a constant speed. That is, the higher level of the cross section of the windcatcher, the greater the volume of air entering the building at a suitable speed and the evaporation efficiency will improve.

RESULTS

According to the studies done on the windcatchers of these houses, several factors can be mentioned due to the proximity to one neighborhood and climate for evaluating their differences:

- The design of the entire house and the hall have been designed in a way that has influenced the architecture of the windcatcher, for example the square form of the Kalantar's House has created the windcatcher square in line with the symmetry of the yard and influenced its architecture. Or in the TadayonHouse, the rectangular and elongated form of the hall, created three symmetrical three-section windcatchers. However, other factors are involved.
- The cultural habits of the people living in these houses, are another factor in the appearance of the windcatcher. As we can see in cities like Yazd or the south of the country, nowindcatchercan be observed in the exact same way and the homeowner pays to build such a windcatcher due to his affordance or his personal opinion at that time.
- The architect's creativity createsthese many forms, as we can see in the windcatcher of both the Kalantar House and the TadayonHouse has proper condition for thermal system,but the appearance of each one, creates the aesthetic effects for each house.
- Windcatcher function and how it creates thermal comfort is a factor in forming the windcatcher shape.
- The recognition part of the architectural sections was carried out with the typology and parameters affecting the performance of the windcatcher was compared and analyzed separately, and the researchers came to the conclusion that each of the windcatcher had some sort of proper response to each part of the houseand even in the summer climate. Also, in according withthe size of the hall and the dimensions of the windcatcher plan and the type of windcatcher blades, the thermal performance of each windcatcher has a proper condition.

However, in spite of the similarity of factors such as climate, wind, mass flow rate, location in the plan, the windcatchers have different height and cross sections, and the shape of the plan blade also varies. but the H blade plan worked best for the thermal system and the Kalantar House has an H blade plan.

PS:

Bernoulli Effect- Khanacademy has detailed explanations about Bernoulli's work .https://www.khanacademy.org/science/physics/fluids/fluid-dynamics/a/what-is-bernoullis-equation Wind Tower- Solaripedia have done researches aboutwindcatcher and their effects in relation tothe area of the surrounding space. for furtherstudy: http://www.solaripedia.com/13/205/2085/wind_tower_convection_illustration.htm

REFERENCES

Abui, R., Mozafar, F., & Zaker Ameli, L. (2012). The emergence of windcatcher in Yazd plain- Arkan. Maremmat Journal, historical and cultural texture work

Bahadori Nejad, M. (2012). Windcatcher; Iran's Masterpiece of Engineering. Yazda Publication

Mahmoudi, M.P. (2009). Windcatcher;Symbol of Iranian Architecture. Yazda Publication.

Mahmoudi, M., & Mofidi, M. (No date). The Impact of Yazd and Bandar Lengeh Climate onWindcatchers. Proceedings of the Third Conference on Building Fuel Conservation.

Mahmoudi, M., & Mofidi, M. (2008) An Analysis of the Typology of Yazd Windcatcher Architecture and Finding the Best Practical Species. Journal of Fine Arts.

Mahdizadeh Seraj, F., Japlaghi, A., & Sanayeiyan, H. (2014, December). The Impact of Pre-input of Thermal Behavior of Main Space in Warm and Dry Climate of Iran (Study of Old Houses of Yazd). Iranian Architecture and Urban Planning Journal.

Ziae, M.,&Fakhar, A. 2012. Air Conditioning in Iran DESERT.International Conference, Mukogawa Women's Univ., Nishinomiya, Japan.

El-Shorbagy, A.M. 2010a. Traditional Islamic-Arab house: Vocabulary and syntax. *International*
Journal of Civil & Environmental Engineering IJCEE-IJENS 10(4):15–20.
Hughes, B.R., and M.C. Ming. 2011. A study of wind and buoyancy driven flows through commercialwind towers. *Energy and Buildings* 43:1784–91.
Montazeri, H. 2011. Experimental and numerical study on natural ventilation performance of variousmulti-opening wind-catchers. *Building and Environment* 46(2):370–8.
Zaimi, F. 2010. The way of saving energy in the traditional houses of Iran's arid zone regions. *EWBUKNational Research Conference*, London, UK.

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