International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:3, No:6, 2009

# Analysis on Iranian Wind Catcher and Its Effect on Natural Ventilation as a Solution towards Sustainable Architecture (Case Study: Yazd)

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***Abstract*****—**wind catchers have been served as a cooling system, used to provide acceptable ventilation by means of renewable energy of wind. In the present study, the city of Yazd in arid climate is selected as case study.

From the architecture point of view, learning about wind catchers in this study is done by means of field surveys. Research method for selection of the case is based on random form, and analytical method. Wind catcher typology and knowledge of relationship governing the wind catcher's architecture were those measures that are taken for the first time. 53 wind catchers were analyzed. The typology of the wind-catchers is done by the physical analyzing, patterns and common concepts as incorporated in them.

How the architecture of wind catcher can influence their operations by analyzing thermal behavior are the archetypes of selected wind catchers. Calculating fluids dynamics science, fluent software and numerical analysis are used in this study as the most accurate analytical approach. The results obtained from these analyses show the formal specifications of wind catchers with optimum operation in Yazd. The knowledge obtained from the optimum model could be used for design and construction of wind catchers with more improved operation

***Keywords*****—**Fluent Software**,** Iranian architecture, wind catcher

## I. Introduction

A WIND CATCHER, as its name denotes, is considered a part of a building form as is customarily constructed in any hot and dry or humid area of Iran. It plays an effective role in modifying heat and adjusting a temperature of interior living spaces in regard to thermal comfort as it uses the convection created by a wind flow and natural pure energy as exists in nature.

This paper is created to understand and identify, on the whole, how a form of these characteristics can influence the operations or functions of wind catchers by investigating them and recognizing their forms. The city of Yazd, as one unique hot and dry city of Iran with the most number of wind catchers and known as wind catcher city, has been selected for study in this enterprise.

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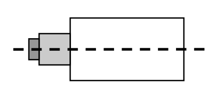
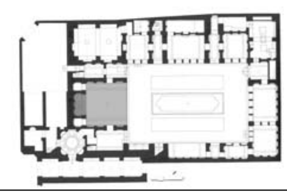
Understanding a typological study of different wind catchers as incorporated in a plan and categorizing them according to their particularities and features serve as a first step in identifying them. Then, fluent software has been used as CFD[1] to analyze the thermal property and behavior of each of them. This would allow finding a plan provided the best results of a decreased temperature of air.

## II. Typology of Yazd Wind Catchers Based on What Set up in a Plan

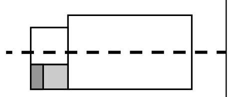
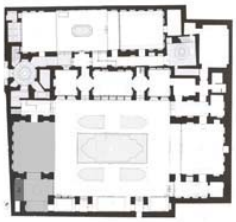
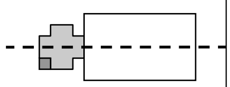
The ways in which wind catchers were set up on top of a house differed from different plans from one plan to another. However, it probably contributes to the cooling operation of a wind catcher. The main sections of an Iranian house, as concern our discussion in this paper, is yard or courtyard, hall or saloon and wind catcher.

A hall is directly and closely connected with a wind catcher but from time to time this link is provided through a medium of an alternative space. Based on their positions on sites on top of roofs in different houses and their interactions with original spaces of aestivation ward and courtyard, the wind catchers can be divided in to three types [1]:

TABLE I
THREE KINDS OF TYPOLOGY OF TYPE A

| type | model | plan |
|---|---|---|
| 1 |  |  |

[1] computational fluid dynamic

| | | |
|---|---|---|
| 2 |  |  |
| 3 |  |  |

1) A wind catcher positioned behind the hall its axis of symmetry. In this type of wind catcher, the axis of symmetry, hall and courtyard extend together.
2) A wind catcher positioned on a corner of a yard: this type requires that wind catcher connected to the hall through the medium of an aquarium space but not directly related to it.
3) A wind catcher positioned on one of northern corner of a hall (Table I).

## III. Typologies of Wind Catchers in Plan

Varied plans of wind catchers in Yazd are nowhere to seen at least throughout the middle cast area. This indicates how much genius and creativity the architects in the city of Yazd have.

Generally speaking, in Iran wind catchers have been recognized in varied forms and plans such as circle, Octagon, polygon, square and oblong. No triangular form of it has been yet recognized or located nowhere in the Middle East area. Wind catcher with a circular plan or form is the very rare. Such type of wind catcher doesn't exist in Yazd. There is only one sample of it Yazd suburb.

Not in view of their internally- arranged blades form. Such blades as are commonly used in wind catchers are elements that are made up of adobe and brick which decompose a wind catcher's duct in to some smaller ducts. These partitions form a plane grid of vents ending to a heavy masonry roof on top of the tower [2].

These blades can be divided in to two categories: Main blades and side blades. Main blades take their rise from a floor at ground reaching 1.5m -2.2m high, continue to the ceiling of a wind catcher and contribute to development of smaller ducts.

Main blades play operational roles more often and influence operation of wind catcher. In contrast, side blades are inserted within the input gap of a wind catcher and play lesser roles. They resemble exactly the blades of modern cooler. These blades add more aesthetic feature to wind catchers rather than anything else. Main blades can not be in sight on the external view but those of secondary; that is to say side blades substantially affect the outside views of a wind catcher and urban landscape altogether.

Given the geometrical form of plan and the manner in which the blades are arranged in their positions, the wind catchers can be etymologized. This paper deals with typologies of wind catchers with oblong plans as a final purpose of studying how the architecture of wind catchers plans affects thermal or heat treatment the most commonly applied type of which already exists in the city of Yazd and encompasses 88/6% as reported [3].

*Typology of wind catchers with oblong plan*

This is the most commonly applied type of wind catcher and the only one out of 53 types of wind catchers under consideration that has an oblong plan. The varied main blades that make up a wind catcher provide a plan with an oblong shape in different types.

### *A. Wind catcher with X-form blades*

This type of wind catcher exists rarely or in a small number in Yazd. The length of wind catcher of this species is fairly 1/5 times as many as its width. There were only two out of 53 houses under study in Yazd had wind catchers with oblong blade and blade X (fig1).

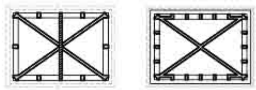


Fig. 1. Wind catchers with X-form blades

### *B. Wind catchers with + shaped blades*

Wind catchers with blades perpendicular to each other and with a + shape is the most dominant shape of a wind catcher in Yazd [4]. The different types of them with their varied symmetries have been seen there. The depth of its canal in linear front is 1/2 of its latitudinal depth. In this latitudinal front the depth of its canal depends largely on its length and number as well as forms of its separating blades. This specie of wind catcher can be separated in to two more subsets (fig2).

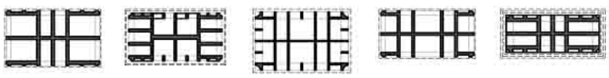


Fig. 2. Wind catchers with +-form blades

*Wind catchers with equal canals*

In these types of wind catchers, the blades are equally spaced and as a result of it some tiny canals are created with equal sizes and spaces (fig3). this type of wind catcher is the most prevalent one in Yazd in view of plan. Plan symmetries (length-width) vary from 1 – 1.4 to 1 - 2.25 (fig4).

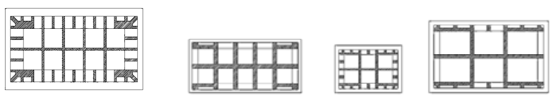


Fig. 3. Wind catchers with +-form blades and equal canals

*Wind catchers with different canals*

Plan extension is more oriented in these species of wind catcher and the symmetries of plan vary from 1-1.58 to 1-2.92 according to field study (fig 5). In species where the canals on the latitudinal form are larger, the width of oblong plan faces the dominant winds. In these patterns, the architect could not lay the wind catcher exposed to northern dominant wind from longitudinal form because of the plan form the house had and as a consequence, having changed the plan form, the architect was able to provide more wind to flow from the latitudinal to that of longitudinal (fig 6).

Fig. 4. 3D model of a Wind catcher with equal canals

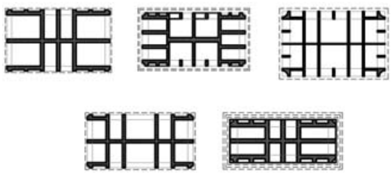


Fig. 5. Wind catchers with +form blades and different canals

Fig. 6. 3D model of a Wind catcher with different canals

*C. Wind catcher with H-form blades*

For these types of wind catchers, the plan is designed that the main blade of a wind catcher that isolates the duct of it is inserted in to the centre of canal and does not extend to the latitudinal walls of wind catcher. The symmetries of plan approach the square (quadrant) and plan is not extended with an oblong. The symmetries of a plan is 1-1.3 or less.

This type of a wind catcher is seldom seen in Yazd. Four of them under study are adapted to this plan configuration. This specie reveals that the cross- section of canal in the latitudinal front is larger than canals that receive wind from the longitudinal from (fig7)

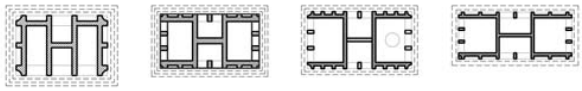


Fig. 7. Wind catchers with H form blades

*D. Wind catcher with a K-shaped blade*

This species of plan design is, indeed, combination of a plan and X blade and + shape. This had been rarely seen in living houses architecture (fig8).

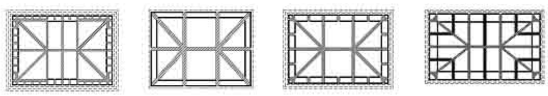


Fig. 8. Wind catcher with K form blades

*E. Wind catcher with I-shape blades*

The main blade is hidden in the latitudinal front of the wind catcher. One closed opening exists on the opposite side of an opened hole to let wind escape, for the wind would have escaped through a hole or gap on the opposite direction. This is the most extended oblong. Shape plan in Yazd the proportional plan of which is 1- 3.75. Only one model out of 53 has been configured and drawn as below (fig9).

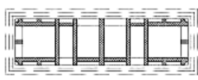


Fig. 9. Wind catcher with I form blades

## IV. Function

A Wind tower is used to convey the wind current to interior spaces of buildings in order to provide living comfort for occupiers. In Iranian architecture a wind tower is a combination of inlet and outlet openings (fig10).

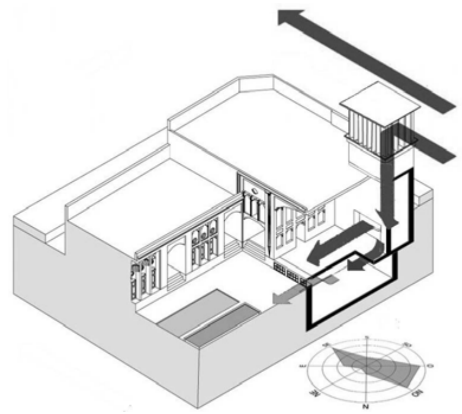


Fig. 10. Function of wind tower with high wind speed (www.cyberarchi.com)

The purpose of using wind catcher is reaching reasonable temperature and relative humidity. Therefore, considering below parameters will improve wind catchers operation:

1. Wet decks; which is used as water basin or jug that is placed below wind catcher canal. Hence, leaving air temperature from wind catcher is reduced as the air flows over this humid system.
2. Geometry; cross section and wind catcher height.

Evaporation efficiency is proportional to air volume in constant speed [5]. Namely, the more cross section of wind catcher, the more air will flow through building with suitable speed and evaporation efficiency will improve. The most important item to achieve this goal is wind catcher geometry.

The more wind catcher height (distance from air entrance to discharge point), the more pressure difference will be and efficiency will improve. On the other hand, according to Bernouli Effect, as the air flows through smaller cross section, the airflow speed will increase [6]. Therefore, increasing height proportional to total area of canal will cause the wind flow speed increase.

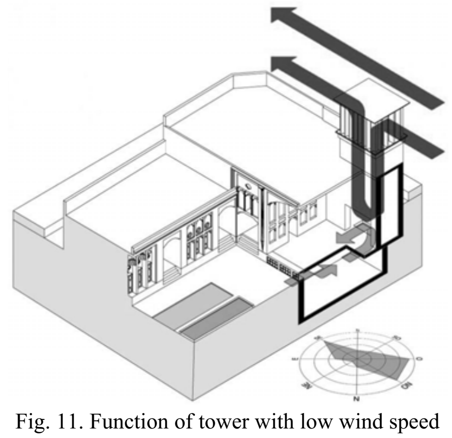


Fig. 11. Function of tower with low wind speed (www.cyberarchi.com)

The tunnel therefore provides cool air for the building while serving as a conduit through which the stuffiness within the building is conveyed through its shaft.

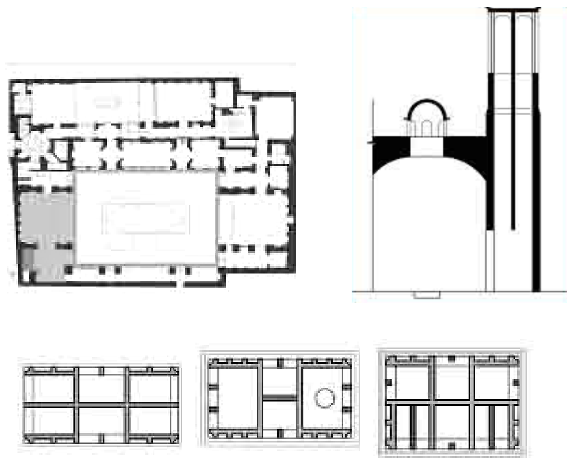
Wind tower is divided by partitions to make disparate shafts. One of the shafts operates all the time to receive the breeze and the other three shafts work as outlet air passages. They convey the stuffiness out of the living space based on the chimney effect. The chimney effect is based on the principle that air density increases with temperature increase. The difference in temperature between the interior and exterior parts of a building and between different regions creates different pressures and result in air currents.

## V. Bases to Select Samples of Wind Catchers for an Analysis of Heat Treatment

given the way in which a wind catcher has been most importantly set in a plan, the house of type 1 which was the only specie fitted under a wind catcher of a pool where an evaporating cooling was occurring was selected and the house belonging to a man called Rasoulian was nominated as a model house that is a valuable historical- architectural house. The wind catcher of this house was investigated in field study during the research.

Given the different types of configurations that the internal blades of wind catchers with oblong plan form, three dominant models of plan with uniformed dimensions but with only differed internal blades were made as computerized models and their heat conduct property was reviewed.

To known how a passing air current behaves in the wind catcher the geometry of a wind catcher's structure was modulated by using available maps in Gambit software. Considering the fact that the existing buildings are dispersed or distributed and a used UBC[2] as well as data concerning the climatic conditions in Yazd area such as temperature, relative humidity and wind speed, a suitable borderline (marginal) conditions were used. Similarly input and output borders were delimited in sufficient number a way from building so that the uniform effects of flow would be maintained.



1 2 3

Fig. 12. Samples for analysis

[2] uniform building code

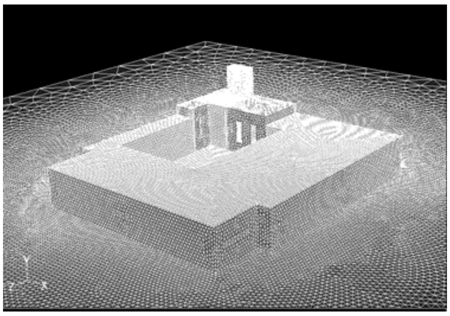


Fig. 13. model of Rasolian house geometry in fluent soft ware

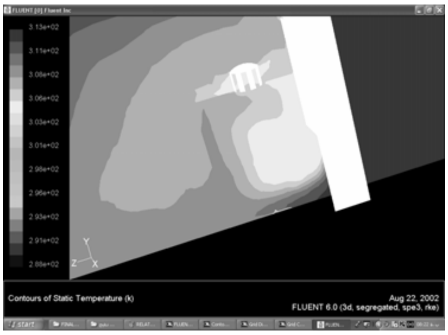



Fig. 14. counter of temperature, model 1

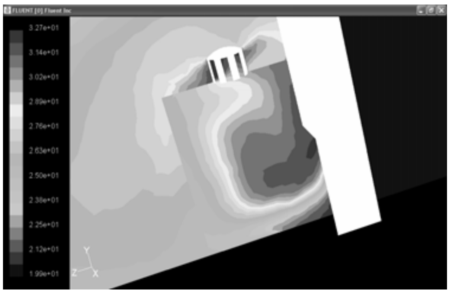


Fig. 15. Counter of relative humidity, model 1

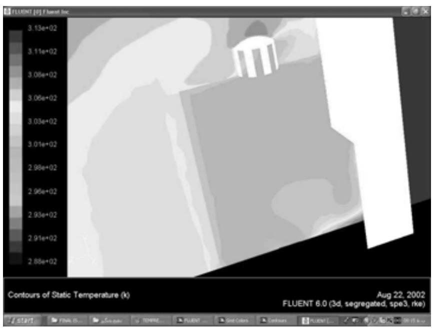



Fig. 16. Counter of temperature, model 2

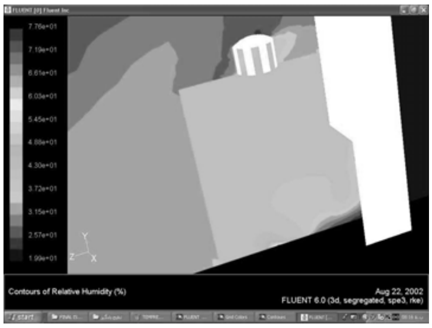



Fig. 17. Counter of relative humidity, model 2

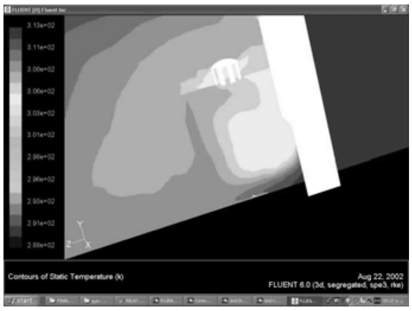



Fig. 18. Counter of temperature, model 3

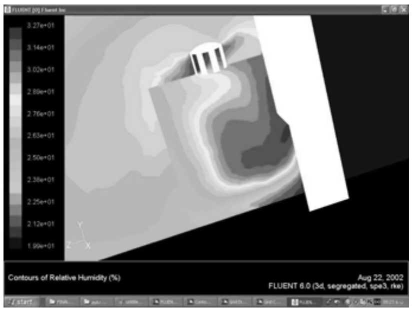



Fig. 19. Counter of relative humidity, model 3

TABLE II
CONCLUSION OF FLUENT ANALYSIS OF MODELS

| Effective parameters for comfort | **Model 1** | **2** | **3** |
|---|---|---|---|
| Fall of temperature from 40 $^{o}{}_{C}$ | 29.3 | 30.8 | 32.2 |
| Rise of humidity from 17% | 36.7% | 34.15 % | 32.9% |

## VI. Conclusion

Three different wind catchers in 3 models as exist in resultant's house were studied and different results were obtained although the plans of houses, the way in which they were set up in houses, uniformed cross section height and inter-faces, it therefore follows that architecture and forms of wind catcher's blades play role in thermal behavior. A wind catcher with + shape will respond the best from among other models.

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