J. Basic. Appl. Sci. Res., 3(2s)647-652, 2013

ISSN 2090-4304
Journal of Basic and Applied
Scientific Research
www.textroad.com

Using Computational Fluid Dynamic to Study Flow Pattern in One Way Low Wind Catchers

Ali Hooshmand Aini[1], Hossein Massomi[2*], Faezeh Nejati[3], S.M.Alibakhshi[4]

[1] Department of Civil Engineering, Roudbar Branch, Islamic Azad University, Roudbar, Iran,
[2]M.Sc, Institute of Higher Education Ayandegan, Iran
[*3] Ph.D Student in Engineering Research Center of Natural Crises and Passive Defense Shakhes Pajouh
[4]Ph.D Student in water engineering (irrigation drainage), Faculty of Natural Resources,
University of Ferdosi

Received: June 10 2013
Accepted: July 10 2013

ABSTRACT

In Iran the manufacture of building is depends on climate and weather condition and it has a direct communication with tradition architectural. Wind catcher structures have been utilized due to torrid and humid climates as air conditioners and cooling systems many centuries ago. There are different climate conditions, so, wind catcher structures have been developed based on altitude and windflaw direction in central cities and south of Iran as air conditioners and cooling systems. This is to present history of wind catcher and concerning performances by numeric system. Therefore, firstly, Gambit software and then fluent software have been utilized to develop numeral and meshing models for the study of wind catcher and airflow direction. Thus, k-ε is selected as turbulent model. Obtained analysis results include model of windflaw and wind catcher, distribution of velocity counters, kinetic energy and turbulent counters
KEYWORDS: *One Way Low Wind catchers, Computational Fluid Dynamic, Flow pattern, k-ε*

INTRODUCTION

Difference of atmospheric pressure is named wind. It is an important element of temperature change, humidity and displacement of tiny suspended particles, thus, the developed natural air-conditioning and cooling through windflaw on wind catcher structures satisfy our natural welfare conditions; windflaw is also a remarkable disturbance of human welfare. It may reduce consumption of fossil fuels too. Wind has historically been a considerable element for the development of residential buildings.

First human beings tried to save themselves by utilizing natural phenomena; they lived in caves, in shelters made of trees or stone structures. Gradually, they constructed permanent residential homes; accordingly, different world civilizations developed their specific architecture styles based on their special regional civilizations. They utilized sun, wind and water to establish more comfortable houses.

1 year, and 4 years BC, Aristotle and Vitruvius the Russian architect had their views on methods of wind catcher foundations in architecture and civil development. Buildings were constructed based on environmental and climate conditions. Generally, sun, wind, moist, hot and cold climate as well as geographical conditions had their direct effects on traditional architecture of Iran. Thus, Iranian architects utilized wind catcher to ventilate homes, halls, and reservoirs. Wind catcher has been made differently in central cities and south of Iran, their structure is based on altitude and direction of windflaw. They are unique civil respiratory or ventilation systems. Wind catcher was used in various residential, religious and service delivery buildings. Some remnants or relics of wind catcher are seen in tropical areas such as Bandar Abbas, Bandar Lengeh, Qeshm , Boushehr or central torrid areas of Iran, cities like Kerman, Naein, Yazd, Kashan, Semnan,Isfahan, even, some districts of Tehran. [1]

Performance Procedure of wind catcher in summer

An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.Wind catchers ' performance procedure is the same as modern water coolers. Wind enters into perforated areas of wind catcher, it is totally directed on pool and then evaporation process is started. Evaporated water absorbs heat and produces a cold air .the cold air is then directed into the rooms as a cooling element.

Wind catcher is also a chimney, when there is not windflaw, hot air ascending upward and it is directed to outside. Although the intensity of airflow is lower than that when there is windflaw.[2] Wind catchers were also used to ventilate water reservoirs because such structures should necessarily be ventilated or else it is impossible to cool inside air and there is hot and humid while interior surface of the

[*]**Corresponding Author:** , Hossein Massomi, Ph.D Student in Engineering Research Center Of Natural Crises and Passive Defense Shakhes Pajouh[2] Civil_1363 @yahoo.com

water reservoir is destroyed, so, all water reservoirs are equipped with louver or wind catcher to direct windflaw to the inside and outside of the structure to cool the inside area of water reservoir.[3]

Wind catcher is usually directed towards the most effective airflow entrance zone to direct cool air into the interior space of buildings or other concerning structures, while rear of wind catcher structure is directed towards windflaw or Qibleh, there is windflaw with dust.

History of wind catcher

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified. Wind catcher is a masterpiece of Iranian engineering, its' designer and inventor is unknown. Fully conversant architects and builders of the engineering masterpiece, namely, wind catcher have utilized basics of aerodynamic , thermodynamic , heat transfer , material resistance and effective thermal standards to create it. There is not comprehensive and precise information, but definitely, ancient Iranians invented wind catcher because they knew how to construct wind catchers and how to direct airflow into concerning structures to refresh inside air.

There are many different names of wind catcher on Iranian dictionary, including, Badahanj, Badahang, Badkhan, Badkhaneh, Badkhor, Badras, Badghard, and Badang. Some Iranian poets named wind catcher differently. Abuabdollah Jafar Ibne Mohammad Roodaki Samarqandi, the mealymouthed poet named wind catcher Badghard in a couplet:Too many equipped buildings with wind catchers there were happy pledged people Many historical remnants and books have mentioned wind and its remarkable role in human welfare, Zoroaster, the holy prophet of Iran who according to historians lived 660 years BC said: "We worship land and heaven, graceful heavenly creature, wind; we also worship summit of Alborz Mountain, soil and all useful heavenly creatures."Contemporary well-known and the most reputable Iranian architect have referred to the history of wind catchers, then he said: "Wind catcher is not a new phenomenon but a historical invention utilized with different names in ancient Iran, including Vatghar, Badhanj, Khishood, Khishkhan.Some European and American tourists who have traveled to Iran have reported performance procedures and structure of wind catchers. e.g, Marcopolo has written on his itinerary that: "there are many towns and cities, Hormoz is a city inhabited with Iranian citizens who speak in Arabic, they have constructed wind catchers on their houses to ventilate them and direct windflaw into the houses to make them cool and refresh the inside air." Figure 1 is concerning to Boushehr , Bukinkham has painted and published it on his itinerary in 1802 that is shown 9 wind catcher in the city.[4]

Figure 1. *Painted and published image of Boushehr on Buckingham's' itinerary*

Yazd, the historical city is well-known for its wind catcher, there are majority of wind catcher compared with other central cities of Iran. [5], the highest wind catcher is wind catcher of Dolatabad garden. The mentioned garden is a unique large remnant of Zand dynasty. Mohammad Taghi Khan Bafghi, named the great khan established the garden in Yazd in 1160 solar hegira (Figure.2). [6]

Figure 2. *Wind catcher of Dolatabad garden the highest wind catcher of the world [5]*

Development of modern architecture, especially utilization of mechanical installations has gradually defamed remarkable usage of natural climate conditions in newly constructed buildings, but the involved professional architects and ordinary people have continually focused more on climate to save environment. Friendly Environmental technology has remarkably facilitated recycling and resumption of industrial waste materials to utilize pure and clean solar, wind, and water energy. Designers of traditional architecture have also tried to focus more on climate and environmental conditions to establish residential buildings and other concerning structures.

Extensive use of nonrenewable fossil energies is the most important deficiency in modern architecture because of cheap materials , ineffective transportation system , unfit practical designers of heating and cooling systems are due to ignorance of climate conditions.[7] thus, qualified and experienced experts have effectively tried to utilize native construction materials based on modern technologies , they try to use renewable solar, wind, and water energies in cooling and heating systems to develop modern air conditioning units, architects and professionals of energy systems should nearly utilize modern technology based on regional climate conditions.[8]Currently, 40% of energy is used in constructed residential buildings, it is remarkably utilized in cooling and heating systems, not only fossil fuels are wasted irregularly, but also they polluted the environment.[9] Environment is drastically being polluted now because of excessive usage of fossil and electrical fuels. Thus, Automatic ventilation by wind catchers facilitate remarkable energy saving. Residential constructions should utilize the lowest proportion of energy both in heating and cooling systems.Currently advanced technology has remarkably reduced constructional energy consumption by heating and cooling systems. According to a study of American HED plan of housing and industry, it has resulted in 160 Milliard USD saved energy. The plan is to be enforced to automatically reduce consumable energy in high cost industries. Thus, the involved authorities decided to automatically utilize Iranian wind catcher systems.[10]

Low wind catchers of east, north-east, south-east of iran

In route of Heydarie to Gonabad, north of Ghaenat piedmont and south of Bakherz Mountain in Khorasan and in the most villages, we had seen the short wind catcher. One of the village is name Mahne that we seen in figure 3a.with different weather condition we seen this kind of wind catcher up to zabol. In the Mahne village, the compatible wind puff in the low height and it goes into room by wind catcher. Every house have lot of room and this room arrange in the different part of the house in the courtyard as you seen in the figure 3b.wich rooms that be use most of the time equipped by wind catcher. In winter for interception of the wind they close the entrance of the wind. The dust wind puff in the behind of wind catcher. Because of different condition and different texture in village, the some kind of wind catcher that makes upper than the roof makes most welfare and better climate for citizens.[11]

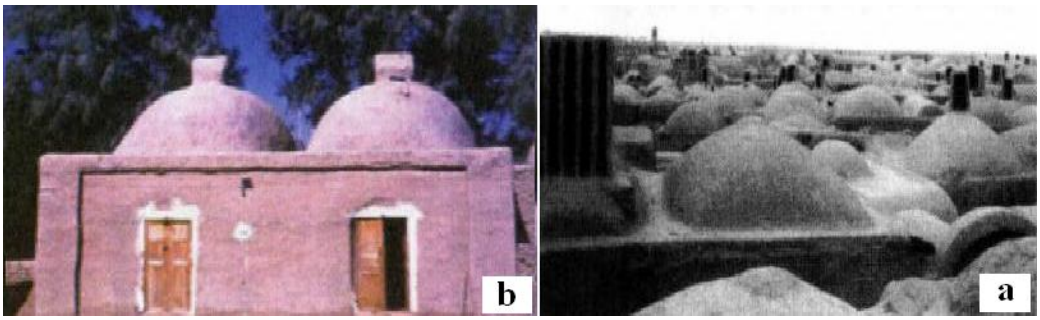

Figure 3. *a- the view of one way low wind catcher in the Mahne village*
b-the view of one way low wind catcher in Zabol[11]

Numerical simulation of wind catcher

There are three methods to solve concerning problems of fluid mechanics; they include tentative, analytical and numeral methods. In engineering calculations, different sciences have remarkably advanced in 10 recent decades. Majority of researchers are using numeral systems because of high cost tentative systems or ineffective analytical systems to solve concerning problems. [12]

Gambit software was utilized to recognize and calculate airflow behavior passing through the wind catcher based on available maps (figure.4). According to figure.6, air entrance velocity and output pressure have been used to solve the problems. Then the calculated results are entered into fluent software. Fluent is the most advanced and complex numeral programming software to model air flow and

thermal transfer. The software is based on limited volume that is a very powerful and effective calculation method in fluid mechanics. [13]

k-ε is chosen as a turbulent model, it is a relatively complete and general but a very expensive model. It is to describe turbulent as well as medium entering turbulent properties to reduce effective disturbance. There are two air transfer equations named PED or partial differential equation, they are applied to solve k, turbulent kinetic energy and reduction rate of turbulent kinetic energy.

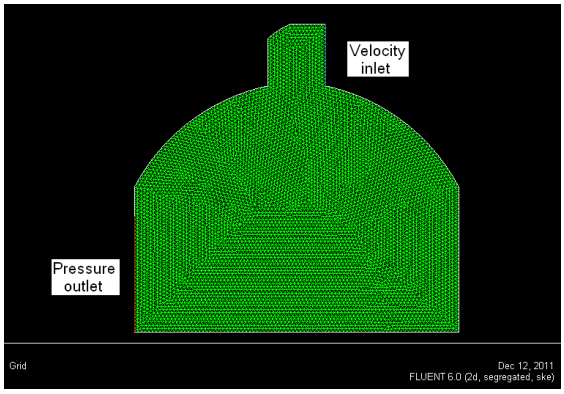

Figure 4. *Geometry, Meshing and Boundary condition in Model*

k-ε standard model, air transfer equation (1) and (2) for ε, k is applied by the fluent software: [14] [15]

$$\frac{\partial}{\partial t}(\rho k)+\frac{\partial}{\partial x_i}(\rho k u_i)=\frac{\partial}{\partial x_i}\left[\left(\alpha+\frac{\alpha_t}{\sigma_k}\right)\frac{\partial}{\partial x_j}\right]+G_k+G_b \tag{1}$$

$$\frac{\partial}{\partial t}(\rho \varepsilon)+\frac{\partial}{\partial x_i}(\rho \varepsilon u_i)=\frac{\partial}{\partial x_i}\left[\left(\alpha+\frac{\alpha_t}{\sigma_k}\right)\frac{\partial \varepsilon}{\partial x_j}\right]+C_{1s}\frac{\varepsilon}{k}(G_k+C_{3s}G_b)-C_{2s}\rho\frac{\varepsilon^2}{k} \tag{2}$$

$$k=\frac{1}{2}(\overline{u'^2}+\overline{v'^2}+\overline{w'^2}) \tag{3}$$

k=Mass unit of concerning turbulent of kinetic energy, ω =Turbulent viscosity, Gk=Produce turbulent kinetic energy for medium velocity gradient, Gb=Produced turbulent kinetic energy for buoyancy force. There are five constant and controllable equations including following values:

$$\sigma_k = 1.0 \qquad C_\alpha = 0.09 \qquad C_{1\varepsilon} = 1.44 \qquad C_{2\varepsilon} = 1.92 \qquad \sigma_\varepsilon = 1.30$$

For discussion of wind flow in the short wind catcher the inlet velocity is 5 meter per second, Obtained results of airflow have shown based on 5 -8 figures.

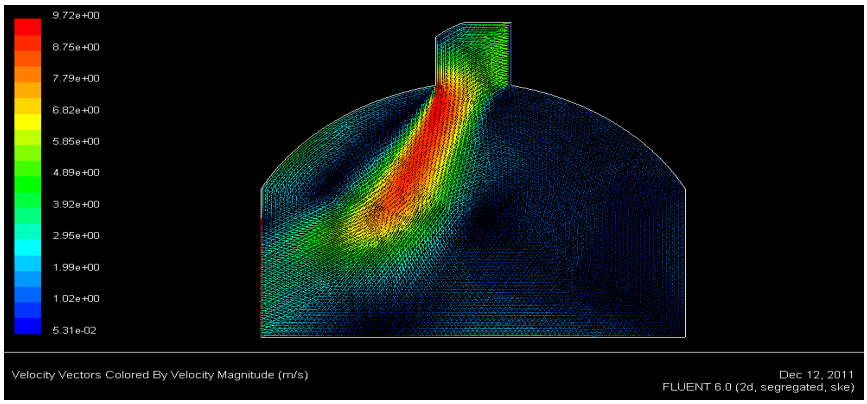

Figure 5. *.Velocity vectors in one way low wind catcher*

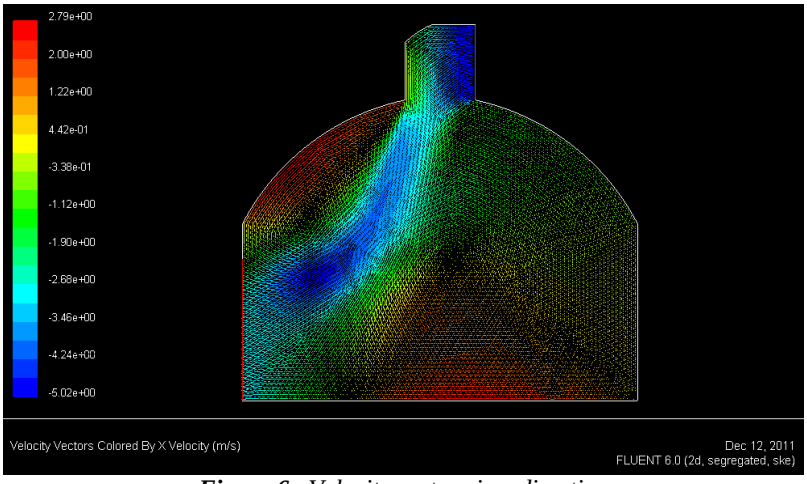

Figure 6. *.Velocity vectors in x direction*

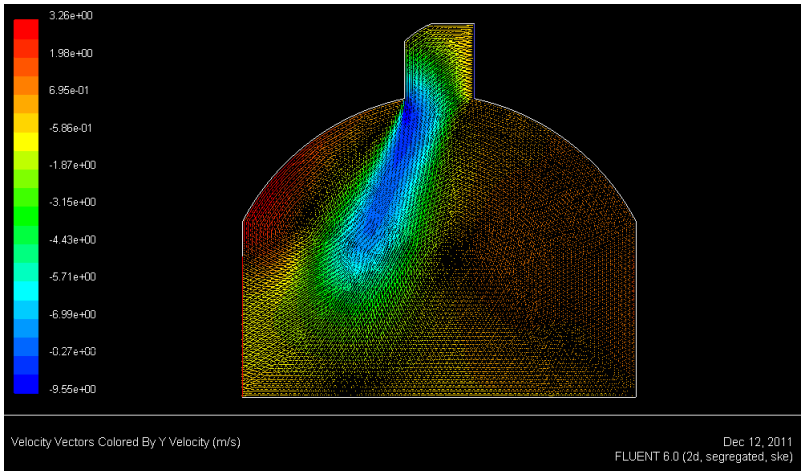

Figure 7. *Velocity vectors in x direction*

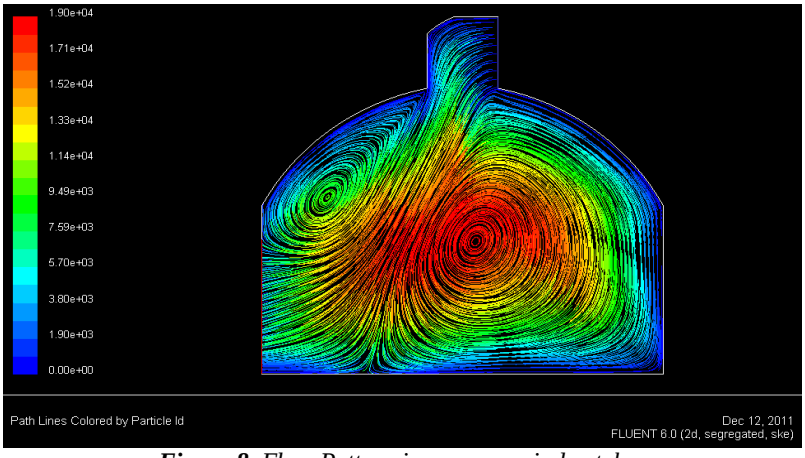

Figure 8. *Flow Pattern in one way wind catcher*

CONCLUSION

According to outcomes and figures in this research we can conclude that:

1- The maximum velocity vector in x direction is happen at the part of somewhere that we have much horizontal flow, the maximum value in positive X direction is happen in the bottom of

building and in negative direction it's happen in existence of wind catcher. The minimum of velocity vector in X direction is happen at the part of somewhere that we have much vertical flow.

2- The maximum velocity in Y direction is happen at the entrance of wind catcher of the room.
3- By showing at the figures 5-7,the wind flow by the 5 meter per second velocity, at the some point of structure, the velocity in X and Y direction in order are 9.7183, -5.0239, -9.5544.
4- by showing the result at the figure 4,the wind flow by the 5 meter per second velocity, at the some point of structure the quantity of velocity and the velocity in order are 1.943,1.91,that is shown the best application of theses wind catchers.
5- Obtaining the results of airflow that is shown on figure 5, we can conclude that the functions of these systems are proper enough for ventilating the weather of the room.

Fluent software has a good potency to develop numeral and meshing models for the study of wind catcher and airflow. This software helps to calculate parameters of flow in an acceptable range. An outlook of run out fossil reserved energies of the world in next 10 decades, globalization and global competition of states of the world have resulted in optimization of energy consumption, it has been a strategic global policy of economists and statements to necessarily utilize newly produced energies instead of fossil fuels. Concerning authorities intend to utilize newly produced energies for heating and cooling of residential buildings, while Iranian architects and engineers intend to effectively reduce cooling cost of residential buildings in torrid areas of Iran.

Thus, optimized energy consumption and reduced energy cost is to utilize natural resources to enhance thermal efficiency of the buildings.

Nowadays, wind catcher is used as a complement of thermal as well as ventilation system of building. It may facilitate natural ventilation of residential building, thus, mechanical systems may be utilized when usage of wind catcher and natural ventilation system is ineffective.

REFERENCES

[1] Qobadian. Vahid; Climate Study of Traditional Buildings in Iran, Publications of Tehran University, 2009.

[2] Vosouqi Fard. Hamidreza; Adlparvar. Mohammadreza. New Ideas to Enhance Utilization of Traditional Windward in Kerman. Civil development symposium, architecture and urban development in Kerman, 2005.

[3] Mortezav. Mahdiabadi;Seyed Mostafa. Baghery Mojdeh. Water supply technology in desert: water reservoir and subterranean canal, 10th conference of civil engineering students, 2003.

[4] Farshad. Mahdi; history of engineering in Iran, Balkh publications, 1376.

[5] Taraghinejad. Amir; neglected historical wind catchers of Yazd, Jame Jam Newspaper, 15, May, 2011.

[6] Qasenm Vatar . Mohammad et al. Dolatabad garden of yazd ,the highest wind catcher of the world damaged by earquake and intense windflaw, first international meeting of seismic reinforcement, 2006.

[7] Askarinejad, Amin; compatible architecture to climate conditions, 10th conference of civil engineering students.

[8] Khodabakhshi, Shohreh; Mofidi. Seyed Majid, concerning steady construction to the traditional Iranian architecture. Third national conference of energy in Iran, 2001.

[9] Kalantar. Vali; thrifty heating and cooling energy consumption in construction through replacement of renewable energies , 7th national conference of energy, 2009.

[10] Vosoughifar, Hamidreza. Adl parvar. Mohammadreza. Reduction of energy consumption by air conditioning through new wind catchers , civil engineering and urban development in Kerman, 2005.

[11] Bahadori Nejad. Mahdi, Dehghani. Alireza; wind catcher, the engineering masterpiece of Iran, 1st edition, published by university book publication, 2008.

[12] Mahmoudi, M; Analysis on Iranian Wind Catcher and its effect on Natural Ventilation as a Solution Toward Sustainable Architecture (Case Study:Yazd), World Academy of Science, Engineering and Technology 2009, p.p 574-579.

[13] Soltani. Majd; rahimi Asl.Rouhollah; Calculated fluid dynamics by using fluent software, 4th edition, Tarrah Publication, 2007.

[14] Shojaeifard. Mohammadhasan; Nourpoor. Hashtroudi; basics of calculated fluid dynamics; published by science and technology university of Iran, 2007.

[15] Shamloo.Hamid; turbulent models and their application in hydraulic system, published by technical university of Khajeh Nasiroldin Tousi, 2009.