J. Basic. Appl. Sci. Res., 2(3)2405-2410, 2012

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

Using Computational Fluid Dynamics to Study Flow Patterns of Egypt Windcatcher Named MALQAFS

Ali Hooshmand Aini[1], Hossein Masoomi[2], Faezeh Nejati[2]

[1]Department of Civil Engineering, Roudbar Branch, Islamic Azad University, Roudbar, Iran
[2]Department of Civil Engineering, South Tehran Branch, Islamic Azad University, Tehran, Iran

ABSTRACT

Windcatcher structures have been utilized in some Middle East states and Egypt due to torrid and humid climates as air conditioners and cooling systems many centuries ago. There are different climate conditions, so, windcatcher structures have been developed based on altitude and windflaw direction in central cities and south of Iran as air conditioners and cooling systems. Various windcatcher has been developed in Egypt too. This is to present history of windcatcher and concerning performances by numeric system; then a usual pattern of windcatcher in Egypt named Malqaf is introduced. Therefore, firstly, Gambit software and then fluent software have been utilized to develop numeral and meshing models for the study of windcatcher and airflow direction. Thus, k-ε is selected as turbulent model. Obtained analysis results include flow pattern, distribution of velocity counters, kinetic energy and turbulent counters.
KEYWORDS: Malqaf, CFD, Flow Pattern, Fluent, k-ε.

1. 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 windcatcher 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 windcatcher 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 windcatcher to ventilate homes, halls, and reservoirs. Windcatcher 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. Windcatcher were used in various residential, religious and service delivery buildings. Some remnants or relics of windcatcher 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(Qobadian. Vahid, 2009).

2. Performance procedure of windcatcher in summer

Windcatchers ' performance procedure is the same as modern water coolers. Wind enters into erforated areas of windcatcher , 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.

Windcatcher 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. (Vosouqi Fard. Hamidreza;Adlparvar. Mohammadreza,2005).

Windcatchers 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 water reservoir is destroyed, so, all water reservoirs are equipped with louver or windcatcher to direct windflaw to the inside and outside of the structure to cool the inside area of water reservoir (Mahdiabadi;Baghery Mojdeh,2003).

Windcatcher is usually directed towards the most effective airflaw 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. Clay brick, brick, clay and wood.

***Corresponding Author:** Ali Hooshmand Aini, Department of Civil Engineering, Roudbar Branch, Islamic Azad University, Roudbar, Iran.
E-Mail: A.Hooshmand@iauroudbar.ac.ir

3. History of windcatcher

Wind catcher is a masterpiece of Iranian engineering, its' designer and inventor is unknown. Fully conversant architects and builders of the engineering master pice, namely, windcatcher have utilized basics of aerodynamic, termodynamic, heat transfer, material resistance and effective thermal standards to create it. There is not comprehensive and precise information, but definitly, ancient Iranians invented windcatcher because they knew how to consruct windcatchers and how to direct airflow into concerning structures to refresh inside air.

There are many different names of windcatcher on Iranian dictionary, including, Badahanj, Badahang, Badkhan, Badkhaneh, Badkhor, Badras, Badghard, and Badang. Some Iranian poets named windcatcher differently. Abuabdollah Jafar Ibne Mohammad Roodaki Samarqandi , the mealymouthed poet named windcatcher 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 sayed:

"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 has refered to the history of windcatchers, then he said:

"windcatcher is not a new phenomenon but a historical invention utilized with different names in antient Iran, including Vatghar, Badhanj, Khishood, Khishkhan.

Some European and American tourists who have traveled to Iran have reported performance procedures and structure of windcatchers. e.g, Macopolo has written on his itinerary that:

"It is treably hot in Iran, there are many towns and cities,Hormoz is a city inhabited with Iranian citizens who speak in Arabic,they have constructed windcatchers on their houses to ventilate them and direct windflaw into the houses to make them cool and refresh the inside air."

Figure 9 is concerning to Boushehr, Bukinkham has painted and published it on his itinerary in 1802(Farshad. Mahdi,1997).

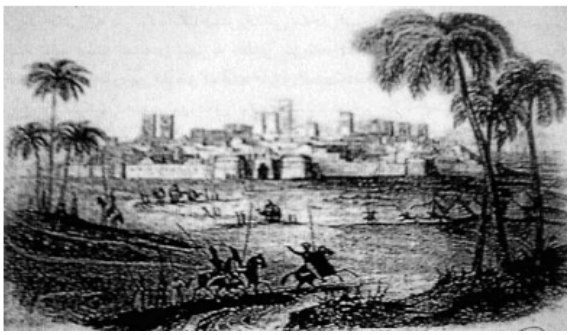

Figure1. Painted and published image of Boushehr on Buckingham's' itinerary

Yazd, the historical city is well-known for its wind catcher, there are majority of windcatcher compared with other central cities of Iran. (Taraghinejad. Amir,2011), 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)(Qasenm Vatar . Mohammad et al, 2006).

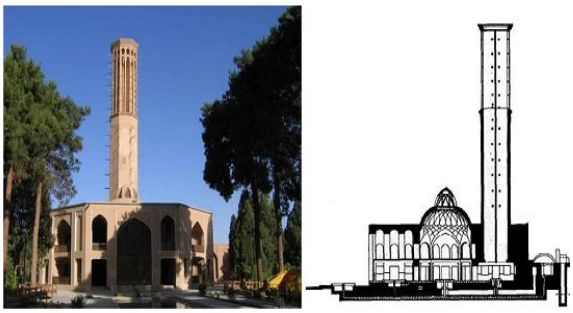

Figure 2. windcatcher of Dolatabad garden the highest wind catcher of the world (Taraghinejad. Amir,2011)

Development of modern architecture, especially utilization of mecahnical installations has gradually defamed remarkable usage of natural climate conditions in newly constructed buildings, but the involved profesional architects and ordinary people have continually focused more on climate to save environment.

Friendly Environmental technology has remarkably facilitated recycling and resumption of industrial vaste 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.

Exesive use of nonrenewable focil energies is the most important deficiency in modern architecture because of cheap materials , ineffective transportation system, unfit practical designs of heating and cooling systems are due to ignorance of climate conditions(Askarinejad, Amin, 2003). 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 neceaaarily utilize modern technology based on regional climate conditions(Khodabakhshi, Shohreh; Mofidi. Seyed Majid, 2001).

Currently, 40% of energy is used in constructed residential buildings, it is remarkably utilized in cooling and heating systems, not only fossil fuels are vasted irregularly, but also they pollute the environment (Kalantar. Vali, 2009).

Environment is drastically being polluted now because of excessive usage of fossil and electrical fuels. Thus, Uthomatic ventilation by windcatchers 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 Americal 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(Vosoughifar, Hamidreza. Adl parvar. Mohammadreza, 2005).

4. Windcatchers of Egypt (Malqaf)

Figure 3 is showing an egyptian Malqaf including a high pillar at the top of the building and perforated structure or entrance section of the windcatcher is directed toward north winds covered with an almost 30 degree plate to direct air into the pillar(figure 4). Roof of egyption Malqaf is an even rectangular. There are differently constructed residential buildings in Qahereh equiped with Malqaf(figure 5).

In a large housing in Qahereh the Malqaf is founded at the top of terrace. The high pillar links the maqaf to the lover story. There are many constructed Malqaf pertaining to 19th century, the ventilators or namely, perforated enetrance area are directly linked to the lower story through a roof window, Malqaf of Qahereh is the singular superior windcatcher developed by the well-known egyptian architect named Moheboldin Shafiolmovakel in 1350 AH or lunar hijirah(Bahadori Nejad. Mahdi, Dehghani. Alireza, 2008).

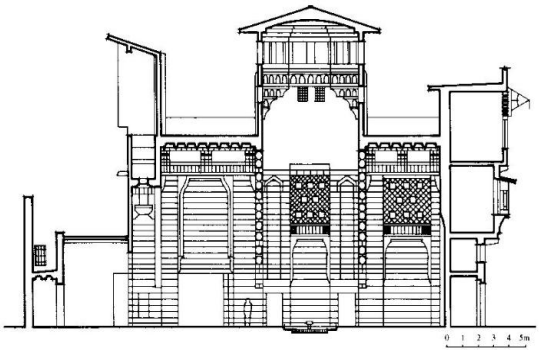

Figure 3. The singular Egyptian Malqaf developed by Qaouf Mohebodin Ashafi almavaghi, the main Malqaf of Alsouhami residential unit in Cairo(Bahadori Nejad. Mahdi, Dehghani. Alireza, 2008).

Figure 4. A- Internal view and B- External view of the Malqaf (Bahadori Nejad. Mahdi, Dehghani. Alireza, 2008).

5. Numeral 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 (Soltani. Majd, rahimi Asl.Rouhollah, 2007).

Gambit software was utilized to recognize and calculate airflow behavior passing through the wind catcher based on available maps (figure.6). 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(Shojaeifard. Mohammadhasan, Nourpoor. Hashtroudi,2007).

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.

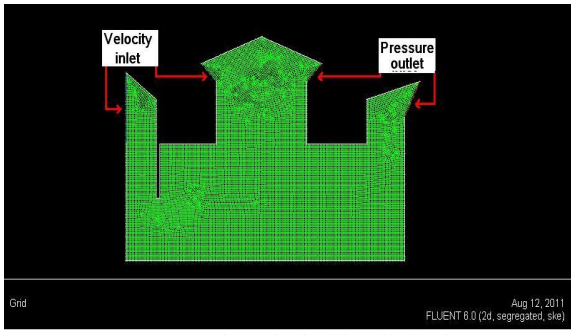

Figure 6. Enforced windflaw limitations

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

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

$$\frac{\partial}{\partial t}(\rho\varepsilon)+\frac{\partial}{\partial x_i}(\rho\varepsilon u_i)=\frac{\partial}{\partial x_i}\quad\alpha+\frac{\alpha_t}{\sigma_k}\quad\frac{\partial \varepsilon}{\partial x_j} \qquad (2)$$

$$+C_{1s}\frac{\varepsilon}{k}(G_k+C_{3s}G_b)\quad C_{2s}\rho\frac{\varepsilon^2}{k}$$

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

K is mass unit of concerning turbulent of kinetic energy
ω = turbulent viscosity
There are five constant and controllable equations including following values:

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

Gk = produce turbulent kinetic energy for medium velocity gradient.
Gb = produced turbulent kinetic energy for buoyancy force.
Obtained results of airflow have shown based on 7 -11 figures. As shown in figure.7, maximum velocity is viewed at the floor of structure. According to figure 8, maximum velocity vectors directed toward x are also viewed at the concerning instance floor. Maximum values of velocity are directed toward Y are divided into two internal and external sections of Malqaf (figure.9). Pattern of windflaw is shown by figure 11.

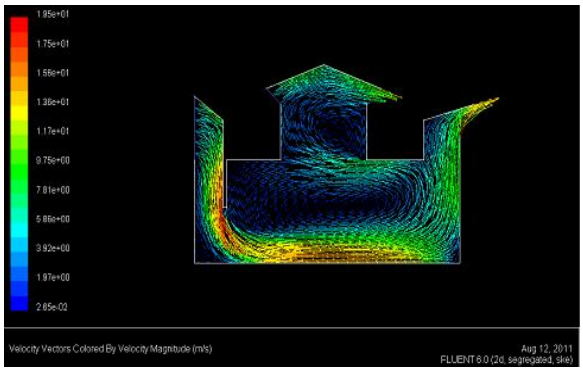

Figure 7. view of velocity vectors of Malqaf

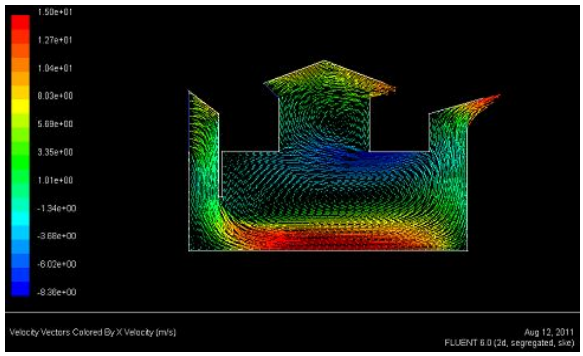

Figure 8. X directed velocity vectors of Malqaf

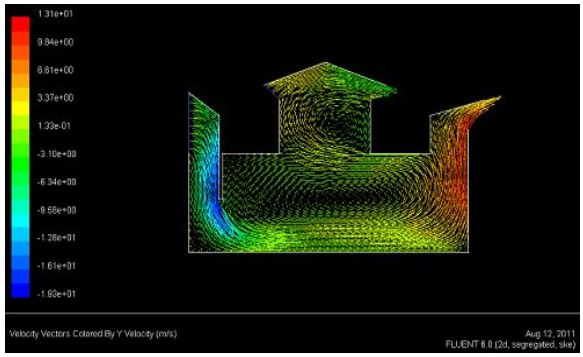

Figure 9. Y directed velocity vectors of Malqaf

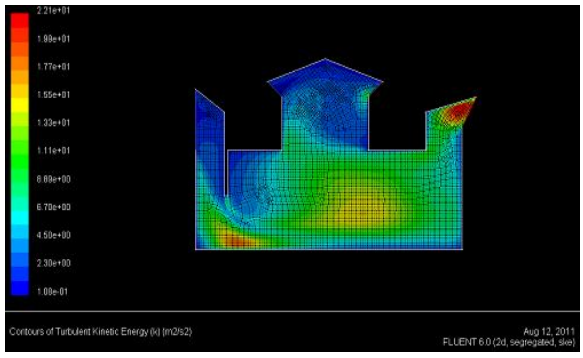

Figure 10. Counters of Kinetic turbulent energy vectors of Malqaf

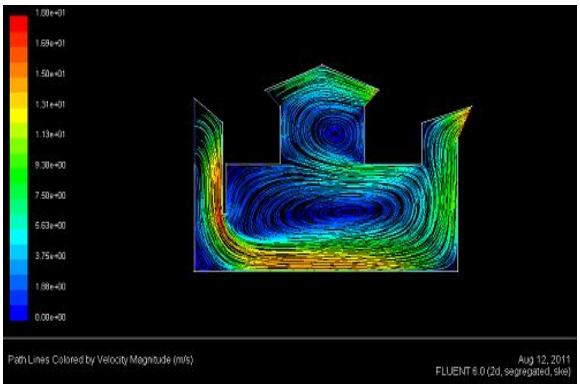

Figure 11. Airflow lines of Malqaf

6. Conclusion

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, windcatcher 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.

7. REFERENCES

Qobadian. Vahid.(2009). *Climate study of traditional buildings in Iran*, Publications of Tehran university.

Vosouqi Fard. Hamidreza, Adlparvar. Mohammadreza.(2005). *New ideas to enhance utilization of traditional winwards in Kerman*. Civil development symposium, architecture and urban development in Kerman.

M. Mahdiabadi,Seyed Mostafa. Baghery Mojdeh.(2003). *Water supply technology in desert: water reservoir and subterranean canal*, 10th conference of civil engineering students.

Farshad. Mahdi. (1997). *History of engineering in Iran*, Balkh publications.

Taraghinejad. Amir.(2011).*Neglected historical wind catchers of Yazd*, Jame Jam Newspaper, 15.

Qasenm Vatar . Mohammad et al. (2006).*Dolatabad garden of yazd ,the highest wind catcher of the world damaged by earquake and intense windflaw*, first international meeting of seicmic reinforcement.

Askarinejad, Amin. (2003). *Compatible architecture to climate conditions*, 10th conference of civil engineering students.

Khodabakhshi, Shohreh; Mofidi. Seyed Majid.(2001). *Concerning steady construction to the traditional Iranian architecture*. Third national conference of energy in Iran.

Kalantar. Vali.(2009). *Thrifty heating and cooling energy consumption in construction through replacement of renewable energies* , 7th national conference of energy.

Vosoughifar, Hamidreza. Adl parvar. Mohammadreza.(2005). *Reduction of energy consumption by airconditioning through new windcatchers* , civil engineering and urban development in Kerman.

Bahadori Nejad. Mahdi, Dehghani. Alireza. (2008). *Wind catcher , the engineering masterpiece of Iran*, 1st edition, published by univesity book publication.

Soltani. Majd, rahimi Asl.Rouhollah.(2007). *Calculated fluid dynamics by using fluent software*, 4th edition, Tarrah Publication.

Shojaeifard. Mohammadhasan, Nourpoor. Hashtroudi.(2007).*Basics of calculated fluid dynamics*; published by science and technology university of Iran.

Shamloo. Hamid. (2009). Turbulant *models and their Application in hydrolic system*,pulished by technical university of Khajeh Nasiroldin Tousi.