Combination of Wind Catcher and Chimney for More Energy Efficient Architectural Buildings

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Abstract  Energy, plays a crucial role in our everyday life. As energy supplies are limited, energy conservation is unquestionably one of the great importance to all of us. Although improving energy efficiency can be achieved in many ways, but energy saving in buildings plays one of the main roles in saving energy. Using natural ventilation systems can be effective to achieve this goal. This article tries to propose a pattern in which the combination of two common natural ventilation systems, Wind catcher and Chimney, will be use for optimum ventilation efficiency so that the energy efficiency will be increased.

Keywords: energy efficiency, natural ventilation, wind catcher, chimney, evaporative cooling, Persiana


1. Introduction

New technology is the fastest-growing and has a lot to do with energy efficiency. [1,2] Nowadays, this energy efficiency is employed in various fields such as engineering, applied sciences and construction industries. [3,4] Development of new materials helps other disciplines and has made a meaningful contribution to other fields especially energy efficiency in building construction. [5,6] Energy efficiency is going to find a more meaningful role in contemporary architecture. [7,8] Building construction industry is in need of energy efficiency to meet new customers' demands. The impacts of energy efficiency on architecture have been considered as the matter of significance in the current decades [9,10]. Improving energy efficiency can deliver a range of benefits to the economy and society. However energy efficiency programs are often evaluated only on the basis of the energy savings they deliver [11]. The International Energy Agency (IEA) estimates that residential, commercial and public buildings account for 30 percent to 40 percent of the world’s energy consumption [12].

2. Research Method

The simulation research method is one of the well-known methods in quantitative researches. It also used in qualitative researches along with the modeling technique.

3. Literature Review

Regarding to the literature review one of the passive design methods is using and combining a wind catcher and a solar chimney as a mechanical eco concept which is a simple idea to increase natural ventilation in surrounding spaces. In past usually one of these items used in architectural designs to help natural ventilation but with this combination we can achieve to a more efficient ventilation system which mentioned in natural ventilation systems. Meir [13] explains that the air trap operates with the change of air temperature and the difference of weight of inside and outside the trap. The difference of weight of the air impels a suction process which causes the air to flow either to the bottom or to the top. It can be concluded that increasing the chimney width from 0.1 to 0.3 m with fixed air entrance size, increases the ventilation rate up to 25%. In addition, they found that the chimney width has more important effect on air flow pattern than the chimney inlet size. Mathur et al. [14] compared the natural ventilation rate from four different types of solar chimney experimentally and reported that when the absorber is inclined at 45°, the ventilation rate increases. In addition, by making the absorber more sloped, the ventilation rate will increase to 15.94% due to the increase of effective height of chimney.

4. Mechanism Analysis

A Wind catcher could come in various designs: uni-directional, bi-directional, and multi-directional. The construction of a wind catcher depends on the direction of airflow at that specific location: if the wind tends to blow from only one side, it is built with only one downwind opening and if there are two main directions for airflow it may have more than one downwind opening. The orientation of wind tower generally means the positions of the wind tower flank based on the four main geographical
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directions. [15] It is determined in view of function, use of wind power and the desired direction in which the wind blows.

Figure 1. Uni-directional wind catcher

![Uni-directional wind catcher](image)

The construction materials used for wind towers depend on climate. The choice of materials is made to ensure that the wind tower operates effectively as a passive cooling system. Wind towers in hot dry are built either of mud brick or more commonly of baked brick covered with mud plaster. Mud brick — adobe — passes heat at long time, because soil has got uncompressed volume and mud makes from water and soil [15].

Figure 2. Bi-directional wind catcher

![Bi-directional wind catcher](image)

A solar chimney is look like a tall and thin wind catcher in sky line of cities. They are vertical shafts which help the natural ventilation in buildings. In average a solar chimney is twice taller than a wind catcher. Its mechanism is based on second law of thermodynamics: heat transfer always occurs from a hot body to a cold one. In other words, heat always flows to region of lower temperature, never to regions of higher temperature without external work beings performed on the system. A solar chimney usually place where it can absorb the most sun shine and appears in dark colors to raise the absorption range. The solar energy absorbed by chimney causes the air larger between two parallel planes of chimney to be heated so that the air of space in which the chimney entrance is located is sucked in. Therefore, the breeze inside the space lets the fresh air enter the space through openings [16].

Figure 5. Orientation of a solar chimney based on the sun shine direction

![Orientation of a solar chimney based on the sun shine direction](image)

5. Proposing Pattern

Kashan is a city in and the capital of Kashan County, in the province of Isfahan, Iran. It lies in a desert at the eastern foot of the Central Iranian Range. Kashan is an ancient city and contains many houses which already use wind catcher as a natural ventilation system. This proposing pattern tries to presents an optimum combination between using a wind catcher and a chimney in one of these houses which is named as Alaghband house.

In order to find out the best place and orientation of the wind catcher and chimney, some base climate information of Kashan such as the direction of the main wind blow, the temperature and the solar path will be needed. Selected information illustrated below.

Figure 7. Wind speed by direction – Iran and stereographic Sun path Diagram – Iran – Kashan – 36N

![Wind speed by direction – Iran and stereographic Sun path Diagram – Iran – Kashan – 36N](image)
For optimum result, after hot weather entered through the wind catcher, it becomes cooler because of passing over a shallow water pool and moisturized. Then it enters interior spaces of the building and makes there cooler. After it becomes warmer it goes up through grating, placed at the top of the wall between wind catcher and chimney, which works as evaporative cooling Persiana [Figure 9].

This passing will cool down the weather again and will help to keep the temperature of interior spaces pleasant. After this cool weather absorbed interior spaces heat and becomes warmer, it goes up and being led out of the building through the chimney which is hot because of the sun.

In order to provide interior spaces privacy and functions, the height of gratings are chose to be 2.10 meter above ground level.

This proposing pattern will work as a passive natural ventilation and will help to make the interior temperature much more comfortable. The proposing place of the chimney for this house, based on two main parameters: 1. The local climate information 2. The architectural plan of the house. This pattern is illustrated below in Figure 11.

6. Summary

In fact this proposing pattern is a combination of two common natural ventilation systems: 1-The wind catcher
2. The chimney. It will increase the efficiency of the ventilation system and in addition the energy efficiency. In past usually one of these items used in designs as a natural ventilation item but with this combination we can achieve to a more efficient ventilation system. Actually the two main parameters — Wind catcher and Chimney — are supplement each other in this method to achieve to the optimum result in ventilation.

7. Future Perspective

This pattern will be inefficient in some seasons or months. It needs to be model and analysis with Energy Plus software in order to have numerical information and charts about this pattern efficiency.

References


