

Wind Catchers and Sustainable Architecture in the Arab World

Dr. Ayman Al Suliman (Corresponding author)
Department of Architecture, Alzaytoonah University of Jordan, 11733, Amman, Jordan
E-mail: a.suliman57@gmail.com

Abstract

Ventilation is considered as one of the most important aspects in a successful architectural design. Distinguished designers dedicate a considerable part of the design process to develop this important aspect in their building design.

The research presents a comparative analysis of the mechanical ventilation system that is in one of my suggested projects in Aleppo (Syria), and the wind catcher system and the soil cooling properties.

The design concept is based on suction of outdoor air through vertical wind catchers positioned on top of the buildings adjacently to staircases and directed to the North West. The imported air is directed into underground horizontal ducts where heat exchange takes place between the hot air in the ducts and the cooler soil, thus cooling the air and increasing the humidity level which ultimately results in colder air in the ducts. The hot air is then repelled into the courtyard or the outdoor. The research concludes the advantages and disadvantages of both systems from environmental, economical, urban and social perspectives.

Keywords : Wind catchers, natural ventilation.

1 .Introduction

1.1. Natural ventilation (*Wind catchers*)

Human comfort is determined by many factors such as health, activity, gender and time of the year. Some scientists have defined it to be around 24 Celsius. A human being needs a suitable climatic conditions, and illumination comfort and noise control that should be realized naturally and architecturally and complimented with mechanical and industrial means, which achieves maximum comfort and financial feasibility in the initial and operational costs of a building.

1.2 . *Wind Catchers: A historical Glimpse*

Wind catchers usage for residential cooling and ventilation is considered an invention required by human and architectural needs in the pre-mechanical air-conditioning era. It ameliorates the impact of the harsh hot climate in the Arab region. There is no defined first implementation of the concept. It has been common in the Abbasids era, since all hospitals back then were equipped with wind catchers. Catchers also existed in houses.

The wind catcher is a natural solution for the climatic problems in hot climates. It functions based on the principle of cold air suction from higher elevations into buildings or through underground ducts for heat exchange with the cooler soil. Fig (1).

Al-Saleh Talae' mosque's wind catcher is considered the oldest and most preserved catcher followed by the Kamaliya Catcher and the Papurs Jashnkeer catcher.

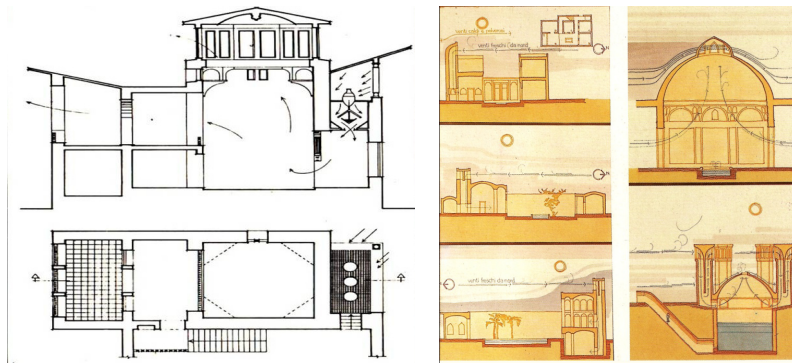


Figure. 1. An illustrative function of Wind Catcher.

1.3 Wind Catcher Definition

It is a tower with air inlets on the building's facade for cold outdoor air suction into the interior building spaces. The air movement results in negative air pressure, which assists in air supply to the interiors. The presence of the wind catcher along with the mashrabiya (a decorative window wooden grill) ensures a continuous air supply.

Although it varies in design, form and height its main purpose is consistent; catching cold air from the higher elevation of the atmosphere and direct it through vertical passages into the interior spaces. It is insulated from the exterior with a thick external wall, which is a necessity to lower the internal building temperature. It is also a living necessity for the inhabitants to accommodate the hot weather which is the characteristic of the climate in the Arab region.

Some wind catchers are furnished with a net or grill that filters air from pollutants and dirt.

Other catchers have been also furnished with coal that acts as an absorber for foul odors from air.

As for hot dry climates, water evaporation can be deployed to lower air temperature that flows through air passages. In this case a water-filled pottery is placed in the passage. As air passes by it, water evaporates and air temperature decreases as humidity level increases. This ultimately assists in making the indoor climate more pleasant. In order to maximize the benefit from wind catchers, wind speed and direction must be analyzed.

1.4 Benefits and qualities of wind catchers

Wind catchers provide natural ventilation of air that is free from pollutants and dirt as its air source is the elevated strata of the atmosphere, which flows into the interior spaces, regardless of the buildings orientation and its relation to the wind direction.

Contrary to the case of window ventilation, ventilation through catchers does not lead to higher noise levels in the interior space.

The size of the cross-section of the wind catcher tower is determined by the surrounding temperature. It is reversely proportional to the temperature: as the air temperature at the catcher inlet is higher than the maximum comfortable internal air temperature, the cross-section must be smaller in size. This is given the condition that the air must be cooled down as it passes through it via wet fabrics or damped coal boards placed between steel grills. The airflow can also be directed over a water feature such as a fountain to increase its humidity.

1.5 The difference between a catcher and badger

The one-direction wind catcher has been modified into abâdgir; which is a wind catcher that receives air

from four directions and can be controlled to let in air in one direction. Fig (2).

Both types of catchers have been frequently used in Iraq, Syria, Egypt and Iran. Whereas the typical wind catcher has been highlighted in hot dry climates, the badger has been frequently used in hot humid climates. This difference in usage is due to the fact that a wind catcher is potentially a tower, Iwan or a horizontal/vertical architectural composition that forces air into the interior spaces from a single direction. It takes one of the following three forms:

A square or rectangular wind tower that allows air in from a single side that faces the favored prevailing wind. The air is caught at the top of the tower and is forced to descend into the interiors due to wind pushing force.

A recessed composition placed on the building's facade that catches air and forces it through inlets in the frame of the catcher.

A composition in the massing of the building that forces the air to descend into the courtyard, where part of the building's ceiling that faces the prevailing wind is lowered while keeping the remaining parts of the ceiling at a higher level.



Figure. 2. badger located in one of the mosques in Iran has been replaced in the minaret of the mosque.

The badger, is an architectural element that catches cold air from higher elevations, where wind speed is higher and reaches double the wind speed at the ground level. It can reach from 8-50 meters in height and catches wind from four sides. Openings can be controlled to be opened and closed according to the needs.

This tower is placed in one of the larger rooms of a house, where it is built at the back of a rectangular room on one-third of its area. It replaces hot air with colder moist air in the spaces, where the heavier cold air descends to the ground and pushes the lighter hot air towards the ceiling. This element is common in the coastal gulf cities. Fig (3).

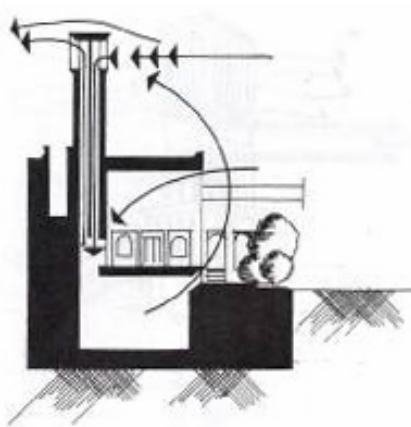


Figure. 3. Wind Catcher. Multidirectional antenna in Iran. And the treatment of modern architectural badger in Dubai, United Arab Emirates.

2. Geothermal Heat energy

It is a type of embedded energy in the outer layers of the Earth's core. It contains energy that is equivalent to the human race's needs for 30 million years, which means it is an underground sun. The geothermal heat energy will become the spine of the renewable energy economy in the world, as it can be said that its amount is infinite. The temperature of the first 30-70 cm of the earth's crust varies according to the external air temperature, as is the case with the deeper 10-20 m which is affected by the season's temperature. This influence diminishes in deeper layers of the following 15-20 m. The Earth's core temperature is affected by many factors such as the soil's type, rocks, air humidity and the geographic location. From a theoretical point of view, the first three km of the Earth's crust stores energy equivalent to the human race's needs for 100000 years.

2.1 Historical glimpse

Human comfort is determined by many factors such as health, activity, gender and time of the year. The animals were the first to exploit the geothermal heat energy, since they dig underground tunnels for their hibernation. Doing so, these animals make use of the temperature in the deeper layers, which is around 10-12 Celsius. Fig (5).

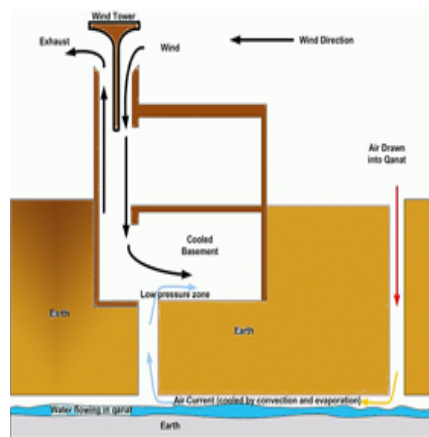


Figure 4. Taking advantage of the underground energy.

Ancient Romans used to heat their houses using hot water springs. As such, the people of New Zealand cooked their food on hot water spring.

Iceland's capital Reykjavik is considered the world's cleanest city since it uses the geothermal heat for heating purposes.

In addition, hot air current systems, used for residential heating purposes make use of the geothermal heat energy at depth of 1-2 m when a horizontal piping system is used. As for the vertical Piping system, the excavation is 100 m deep into the ground.

3. Suggested Residential project, Aleppo

The project design incorporates the implementation of principles of traditional environmental architecture and its various elements such as the wind catchers, window screens (mashrabiya) and the courtyards.

The building consists of a ground floor and four repetitive floors that contain a number of apartments. These apartments are made up of multiple rooms that are consistent to the traditional architectural functions in the city of Aleppo.

3.1 Study of the natural ventilation system in the building

The design concept is based on external air suction through vertical wind catchers placed adjacent to the staircase on the roof. It is oriented towards the west and is opened from the four directions. The openings can be manually controlled according to the needs of the inhabitants. It can be also controlled mechanically.

It directs air into underground ducts at a depth of three meters, where the cooler soil temperature induces the heat exchange process with the hot air in the ducts. The humidity level in the air increases as it passes by the underground water storage tank, which is a Civil defense requirement.

These tunnels terminate at vertical ducts that provide the cooler air into the interior spaces. At the same time the hot air in the interiors is removed through suction fans that are incorporated in the walls, and the air is repelled into the courtyard.

The piping system of the wind catcher did not affect the design of the structural system of the building.

Though the concrete amount used for the structural system is not affected by the wind catcher system, the overall cost of the foundation work is increased by 15% due to the need for extra excavation work and accordingly a shoring system is needed to support the excavation against collapse.

3.2 Using light-weight concrete blocks in construction

Light-weight concrete blocks are manufactured from sand, cement, lime, water and a small amount of aluminum powder

Properties of Light-weight blocks:

- 1- The light weight of the blocks contributes marginally to the dead loads of the building, which is conceived positively when the reinforced concrete needed in the building's structural skeleton is considered. The amount of the steel and concrete can be reduced by an amount of 15%.
- 2- The u-value of these blocks is relatively high, which results ultimately in the reduction of the heating and cooling loads in addition to its sound insulating properties.
- 3- It is easily managed as a building material for construction purposes. It can be easily cut into the needed sizes using typical cutting tools which results in a lower loss in the raw materials
- 4- It can absorb excessive moisture amount and give it back in dry air periods.
- 5- Compression resistance
- 6- Fire resistance; it stands three hours and a half from time of ignition.

3.3 Methodology of implementation of the design concept in the project

Vertical wind catcher is built on the building's roof behind the staircase and elevator cubicle to keep it in shade. The wind catcher opening is oriented towards the North West, which is the prevailing wind direction. A steel grill is placed on the outside of the opening for protection against the entry of insects and birds.

The vertical wind catcher is supplemented with a suction fan that ensures air movement into the system even when the wind speed doesn't serve the system well. The air is sucked and directed into lengthy passages below the courtyards and at the cellar's level. It is topped with a mud layer that is 3 meters thick. They are poly-ethylene pipes or clay pipes which diameters do not exceed 24 inches to ensure a quality heat exchange process between the hot air in the pipes and the cooler soil. Fig (6).

Vertical ducts are built inside the building that terminates at horizontal openings that are supplemented with an aluminum grill that can be controlled to be opened or closed. Another grill allows the cooler air from the catcher into the bedrooms and other spaces via passages. The walls are to be built using balinablocks which are light-weight blocks that don't require plastering since its surface is smooth. It allows air movement and absorbs excessive moisture in air and has excellent thermal insulation properties.

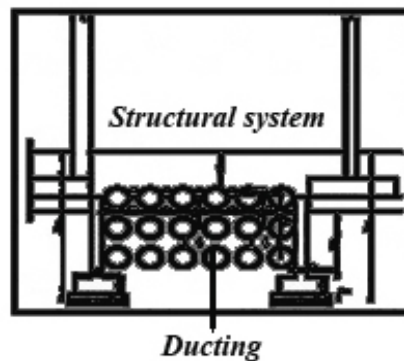


Figure. 5. Section explaining the foundations upon ventilation tunnels.

4. Conclusion

4.1 Qualities of Natural ventilation system

- 1- Increase of cooling and natural ventilation versus the reduction of loads on the typical mechanical air-conditioning system
- 2- Increase of the life-time expectancy of the cooling system as it is directly related to the building's life-time
- 3- Easiness of maintenance in addition to savings in operational costs in comparison to typical mechanical systems.
- 4- The system is environmentally friendly as it does not include Freon gas which is harmful to the environment. In addition, it lowers energy consumption.
- 5- Higher thermal comfort levels due to higher oxygen levels in the air with the guarantee of continuous ridding of CO₂, which ultimately results in higher productivity levels of the inhabitants.
- 6- Providing continuous natural ventilation to the building with ability to control and shut down the system in winter.
- 7- Choosing the natural ventilation system allows us overcome the main downsides of the mechanical system which does not renew the circulating air in the space. This is considered unhealthy especially for people with Asthma or respiratory problems.
- 8- Avoiding the occurrence of short circuits that may result in fire, which is common with mechanical ventilation systems.
- 9- System maintenance is minimal compared to mechanical ventilation systems.

4.2 Summary

- 1- Using natural underground ventilation system results in 60% savings in energy consumption.
- 2- This natural ventilation system provides filtered air free from pollutants and dust and allows for the renewal of the circulating air continuously, in addition to the removal of foul odors.
- 3- Using sound insulating light-weight block maintains privacy and reduces noise levels.
- 4- Using sun breakers on the building's facades allows for a better thermal insulation level which results in a better living environment for the inhabitants.
- 5- This natural ventilation system is characterized with a natural perspiration property, due to the air passage through multiple filters before reaching the inhabitants. The building blocks are also characterized with the ability to absorb excessive moisture from air and giving it off when air is drier. Fig (7).

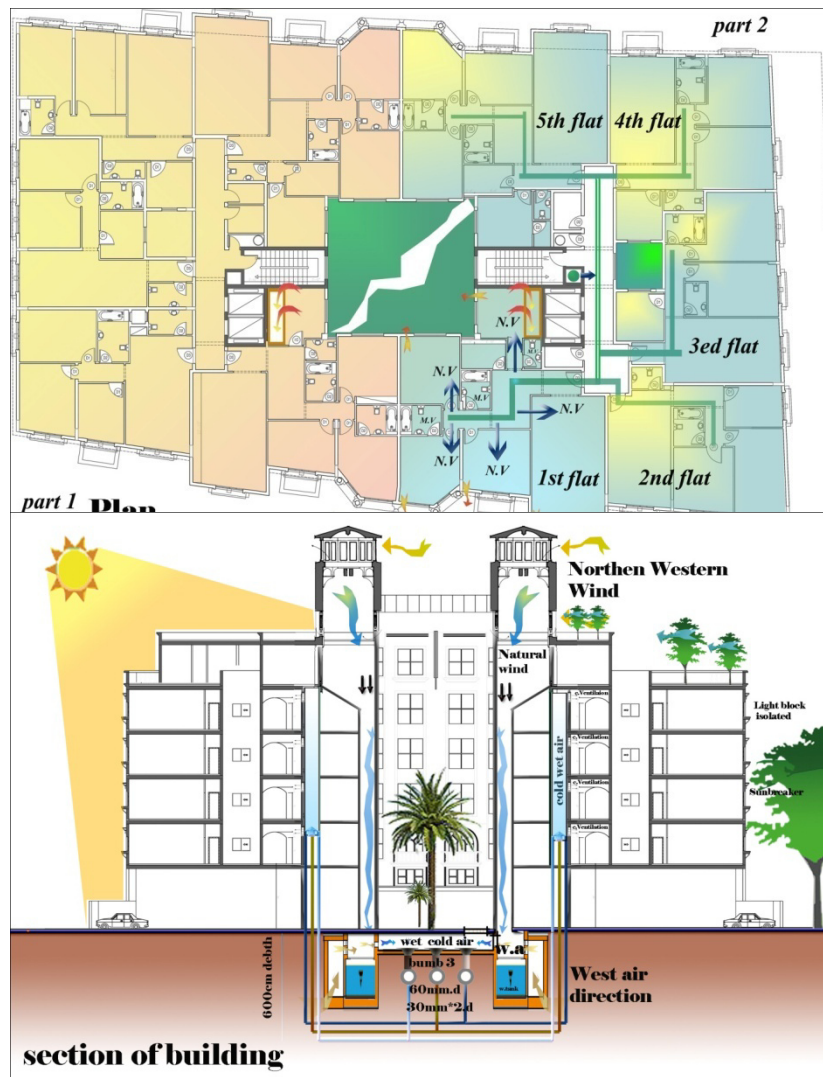


Figure 6. The final proposal.

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