Design with Nature: Windcatcher as a Paradigm of Natural Ventilation Device in Buildings

Dr. Abdel-moniem El-Shorbagy
Architecture Department, College of Engineering Effat University, Saudi Arabia
aelshorbagy@effatuniversity.edu.sa

***Abstract*— The traditional architecture of Central Asia and the Middle East is the product of land, the local climate, and people's culture. The human needs and the environment represented the most essential factors to be considered in their designs. The traditional and vernacular architecture of this region introduced many realistic solutions and devices to the local environmental problems such as the Wind-catcher, which became a common architectural feature in buildings. The wind-catcher is based on a traditional Persian architectural device, which was used to create natural ventilation in buildings. Since the energy crisis of the 1970s, the ecological or sustainable architecture movement dominated architect's thoughts of realising buildings that are environmentally relevant to their regions. In recent decades, there has been an increasing awareness of these traditional environmental devices and their potential for possible future buildings. However, traditional and vernacular architecture, which considered the human needs and the environment, provided many realistic solutions to the more recent modern environmental problems. This paper demonstrates the value of wind-catchers and provides insight into the application of natural ventilation systems as an alternative to the inappropriate modern cooling system in hot-climate regions. It also aims to examine the theoretical status of wind-catchers and to identify its specific nature, its use and its function in the context of architectural practice and discourse, in the past, present and future.**

***Index Term*— Wind-catchers, Natural cooling, Sustainability, Technology**

I. INTRODUCTION

Beyond the evident typology in Muslim-Arab architecture and the guiding architectural principles, their buildings were shaped by a conceptual framework, which developed an understanding of conscious responses to environmental, urban and societal conditions of existence. Traditional buildings are the true expression of the architecture that provides comfortable living conditions in all different climates. In hot arid regions, in specific, the forms of these traditional buildings have been shaped according to the available natural sources of energy, which help reduce humidity and create natural ventilation. There are number of architectural elements which help provide cooling in internal spaces, including an inner courtyard, local materials and wind-catchers.

Throughout history, a wind catcher was introduced as an architectural device, which achieves thermal comfort inside buildings. It is believed that it is a traditional Persian architectural device, which was used for many centuries, but there is evidence that the idea of the wind-catcher dates back to the early Pharaonic periods. Examples can be found in the Eighteenth Dynasty houses of Tal Al-Amarna. The Pharaonic house of Neb-Amun (fig. 1), which was depicted from a painting on his tomb of the Nineteenth Dynasty (1300 BC.) shows a wind-catcher with two openings, one facing windward to capture the cool air and the other facing leeward in order to evacuate the hot air by suction [1].

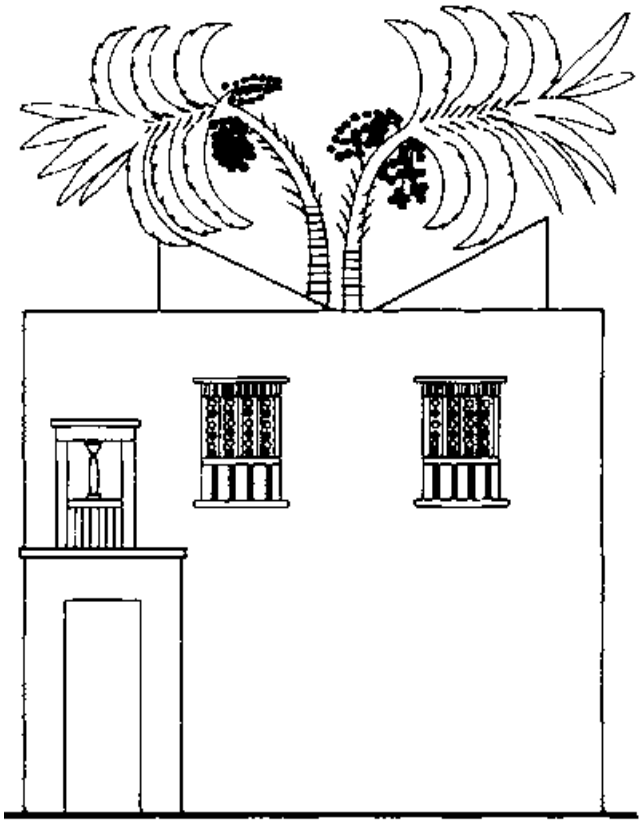

Fig. 1. Malqaf of the Pharaonic, house of Neb-Amun, (c.1300 B.C.), [1]

Other widespread and successful examples can also be traced in the architecture of the Middle East, Pakistan, and India, which exhibit the impact of the traditional Persian architecture on these regions (fig. 2).

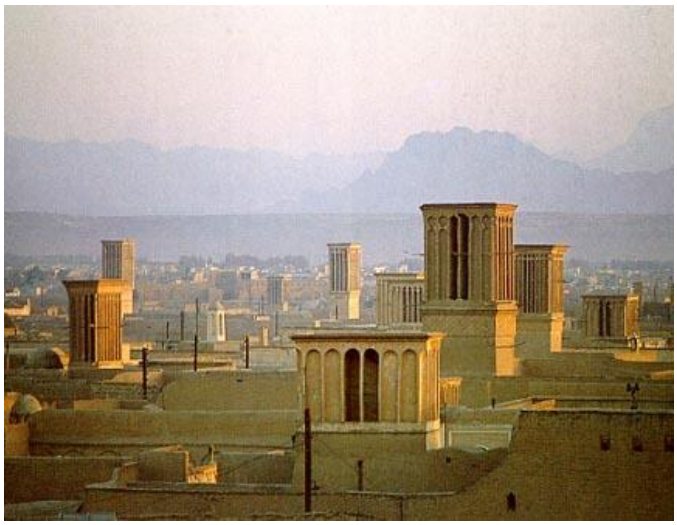

Fig. 2. Wind catchers in Yazd City [12]

There are many different types of wind-catchers, whose forms and functions are based on the climatic conditions of their regions. The most common ones are the unidirectional (*malqaf*, windcatcher), and the multi-directional (*Badgir, windscoop*).

II. Unidirectional Windcatcher (*Malqaf*)

In the early Islamic-Arab houses the courtyard represented an intermediary space between the entrance and the guest area. Meeting casual male visitors always took place in the *takhtabush* , a room with a side open to the courtyard. On the other hand, important male visitors would enter indirectly from the courtyard to another large reception hall with a lofty central space, which was flanked by two spaces at a slightly higher level [2]. In the Mamluk period in the twelfth century, a change in the style of the house took place that involved the covering of the courtyard, and the introduction of the qa'a*h* as the main reception hall in the house. The *qa'ah* consisted of the *dorqa'ah* (a central part of the *qa'ah* with a high ceiling covered by the *shokhshekhah* (wooden lantern on the top)) and two *iwans* (sitting areas) at a higher level on both the north and south sides. The lantern is provided with openings to allow the hot air to escape. Its shape could be square, octagonal, or hexagonal. It was also flat on the top, in order to help the upper layer of air to be heated up through exposure to the sun [3]. With the covered courtyard, a new system of ventilation was invented to achieve thermal comfort inside the *qa'ah*. This was the *malqaf* (a wind catch), which is a shaft rising high above the building with an opening facing the prevailing wind and constructed on the north *qa'ah*. It traps the cool air and channels it down into the interior of the building (fig. 3). The size of a *malqaf* is determined by the external air temperature. If the air temperature is high, a smaller size is required and if it is low, a larger size is preferred [1].

Fig. 3. The Malqaf of the Main Palast Zisa, Sicily, Qa-a of the Suheimi House [13]

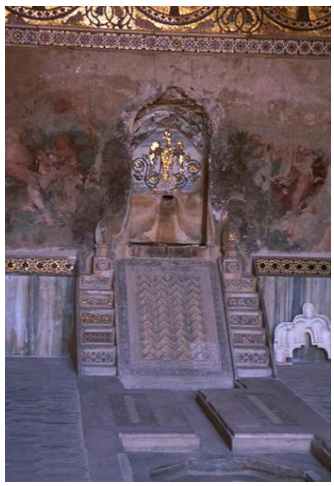

Fig. 4. Salsabil, La Italy [14]

To increase the humidity of the air coming from the *malqaf*, the *salsabil* was also introduced (fig. 4). It is a marble plate, decorated with wavy patterns and provided with a source of water. The *salsabil* was put against the wall of the opposite side of the *iwan* and placed at an angle to allow the water to trickle over the surface. However, this new system of ventilation combined the *malqaf*, the *salsabil* and the lantern in one design to assure a good circulation of cool air in the *qa'ah*. A good example is the fourteenth century Muhib Ad-Din Ash-Shaf'i Al-Muwaqqi house in Cairo (figure 5) which best illustrated this combination [1].

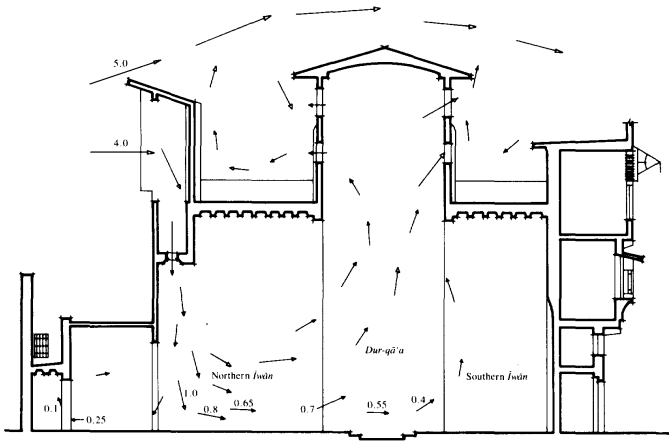

Fig. 5. Air movement:The *qa'ah* of Muhib Ad-Din, Cairo (c. 1350), [1]

III. Badgir (Multi-directional windcatcher)

In Persia (Iran) and the Gulf area, the windcatcher is called *badgir*. It is a multi-directional windcatcher, which have four openings at the top to catch the breezes from any direction. Air circulation coming from the *badgir* can be adjusted by opening or closing one or more of the scoops. Placing a clay porous pot, help humidify and cool the air coming from the *badgir (*fig. 6). The plan of the *badgir* may take different shapes, but the square plan is the most common used one. The *badgir* is

divided by two partitions placed diagonally across each other (fig. 7) down the length of the *badgir's* shaft [4].

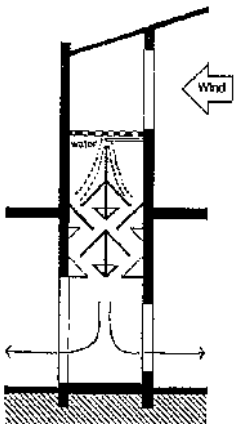

Fig. 6. Evaporative cooler [4] [4]

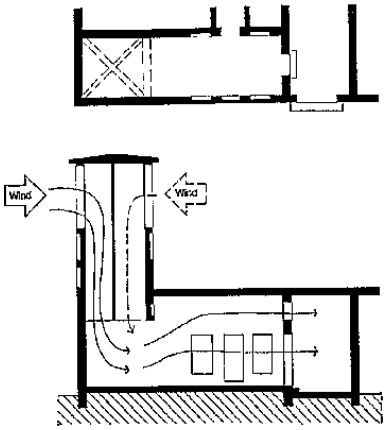

Fig. 7. Multi-directional windcatcher

The *badgir* can also be used in pairs or four at a time to cool underground water tanks (fig. 8). In addition to its role as a ventilation device, the *badgir* is usually used as a decorative element in buildings as shown in (fig. 9).

Fig. 8. City of Yazd, Iran [15] [16]

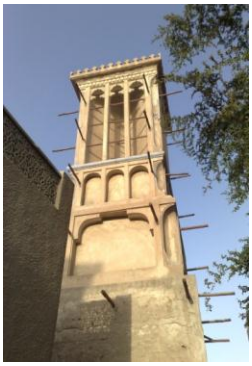

Fig. 9. Bastikia, Dubai

IV. The Tradition Today

Modern architecture has been concerned with the provision of housing, public buildings and services to a large number of populations. Thus, it introduced new forms of building completely different from that of the traditional buildings. These new forms were imported to the Islamic-Arab world from the West together with Western technologies. Architects in the Islamic-Arab world have been deeply distressed by these changes and have searched for forms which can link the contemporary Islamic buildings with the values of traditional architecture.

The common response to vernacular elements such as the windcatcher from architects in the Developing World differed from that of Western architects. Architects in the Islamic-Arab world regarded the traditional architecture as prototypes for the contemporary Islamic architecture, which epitomize their national and regional features. On the other hand, the response of Western architects to Islamic-Arab architecture varied. While some architects admired the new possibilities of employing the windcatcher as it was built in the past, others were inspired by the philosophy and the environmental and humanistic approach behind it.

A. Windcatcher in Islamic-Arab World

The revival of traditional forms' approach, materials and method of construction was to come, first, through the early work of the late Egyptian architect Hassan Fathy in early 20th century. Through his designs and his writings, Fathy influenced a younger generation of architects in Egypt and worldwide. Fathy's ideas and philosophy opened opportunities and became a source of inspiration for architects to recognize and appreciate their traditional architecture. Fathy derived low-technology from the use of vernacular forms which have environmental functions such as the courtyard and the windcatcher in traditional Arabic architecture. There are many examples, which exhibit the use of the windcatcher such as the Abdel-Rahman Nassif House (1974), in Jeddah, Saudi Arabia [1]. The design incorporates a revival of a complete climatic system including *malqaf*, *qa'ah* (reception area), *dur-qã'a* (central part of *Qa'ah*), and wooden lantern, (fig. 10).

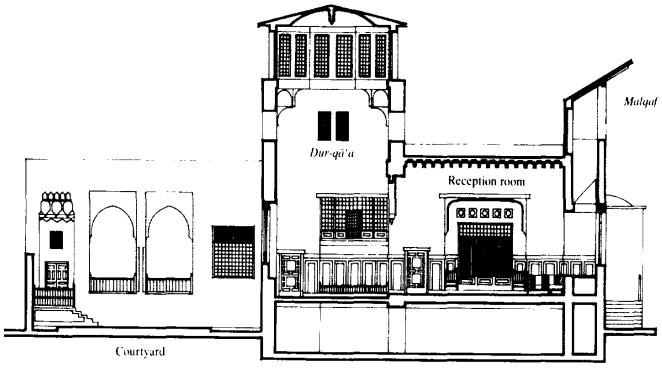

Fig. 10. Nassif house, Jeddah, 1974 [1]

Another expressive example is the University of Qatar which represented a new interpretation to the form of the windcatcher (fig. 11). The building featured number of windcatchers in different levels to catch the prevailing wind. The form of the windcatchers expressed the spirit of its modern time, as well as retained its original function as a generating airflow device in the building. The windcatchers included four open sides covered with perforated geometrical patterns.

Fig. 11. University of Qatar, Doha [17]

B. Windcatcher in Western World

In 1960s, there were an increasing interest in traditional architecture and away from the ideas that were promoted by the first generation of modern architects. This period witnessed a strong rejection of the tenents of the International Style, whose buildings were regarded as unresponsive to the environment as well as less demanding of creativity. Architects regarded the characteristics of modern architecture, such as wide windows and glass-and-concrete structures made no sense in extreme heat, especially in societies with time-honoured environmentally responsive architectural elements such as windcatchers. The appropriateness of glass-curtain-walled, air-conditioned office blocks is now being questioned worldwide, because they require an enormous amount of energy to maintain internal environmental comfort and because they detach their users from the external environment.

There has been an increasing awareness of the application of natural ventilation and passive cooling approach in western countries, specifically the wind-catcher. Experimental studies have been conducted to investigate the performance of wind-catcher, which depends greatly on the wind direction and speed. The results proved that passive air movement inside the building improves the air quality and reduces the internal temperatures. The idea of windcatcher attracted the attention of western architects, who revived the traditional Arab windcatcher as a shape and function and employed it in their modern wooden buildings without the addition of any modern mechanical devices as shown in the Visitor Centre at Zion National Park, US (fig. 12). This centre represents a successful example of the adoption of energy-saving technologies, such as the windcatcher, which yields a significant, measurable energy savings in the building [5].

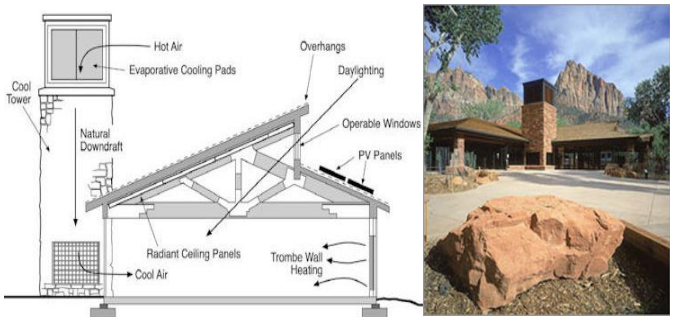

Fig. 12. The Visitor Center at Zion National Park, US [5]

Other western architects integrated the principles of windcatchers with modern technology as helpful devices to improve the quality and efficiency of the provided fresh air. An advanced cool tower design was developed to combine the traditional windcatcher and modern devices (fig. 13). It is made out of light aluminum and provided with a large upwind swivel scoop to create a larger air flow. The exhaust vents also swivel with a venturi system to keep the exhaust openings oriented away from the wind. With this system the wind can blow from any direction and the cool tower will continue to function. The system is also provided wit a water tank and a small pump to circulate and evaporate water to cool the incoming air. A removable door to close off the top of the tower in case of a wind storm can be added [6].

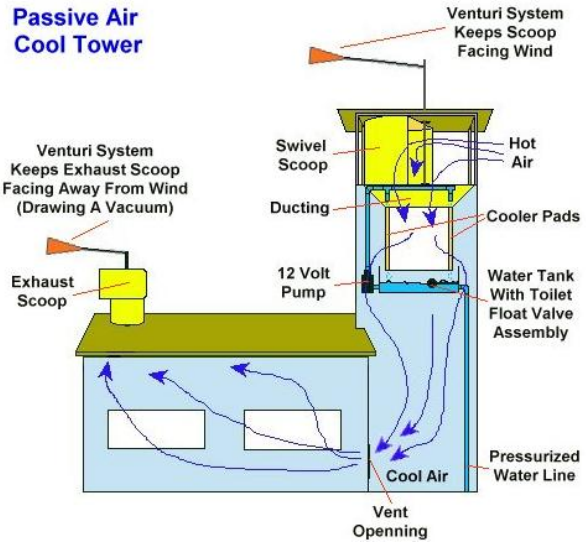

Fig. 13. Passive Air Cool-Tower [6]

There is another modern version of the historical wind catchers, which is called Monodraught. Its main aim is to provide natural ventilation and light to any space in a building (figs. 14,15). Monodraught are fully automatic and programmable and can control ventilation with a fully adjustable ceiling ventilator, dampers, as well as different types of sensors. Windcatcher Sensors may include air temperature, CO^2, wind movement, noise and humidity depending upon the specific requirements of the space. For example, temperature sensors are normally set to start opening at 16°C during the summer months and open 20 per cent for every one degree centigrade in internal room temperature. Another sensor is responsible of distributing fresh air throughout a building when the carbon dioxide levels become too high and ensure the hot air is removed. The unit closes completely in winter, but opening enough to admit enough fresh. Monodraught can take many different forms (fig. 16) that suit the architecture of a building [6]

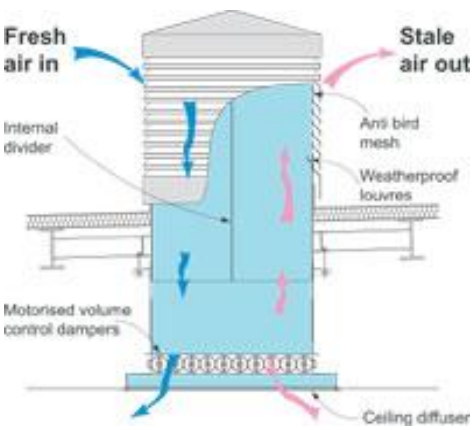

Fig. 14. Air circulation in ventilation a monodraught [18]

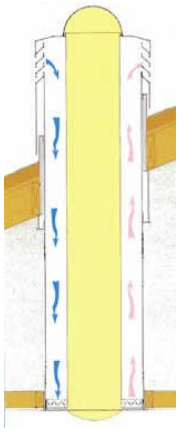

Fig. 15. Air and lighting [19]

Fig. 16. Different forms of Monodraught windcatcher [6]

The Kensington Oval cricket ground (fig. 17), in Barbados by Arup Associates [7], and the Saint-Etienne Métropole's Zénith *Rhône-Alpes* (fig. 18), by Foster and Partner architectural firme [8] represents a new contemporary interpretation for the Islamic-Arab windcatcher. Both applied the same design concept of capturing the prevailing wind and disperse it around the building.

Fig. 17. Kensington cricket ground, ARP Associates [7]

Fig. 18. Métropole's Zénith, Foster and Partner [8].

V. The Future of Tradition

The value of the architecture of the past as well as the architects' aspiration of realizing architecture that is environmentally relevant to its region can provide an inspiration for future innovative approaches. The following are two examples of futuristic buildings, which represent its energy-conscious future. The *Burj al-Taqa* (Energy Tower) in Dubai, designed by Eckhard Gerber, exhibits a futuristic design for a windcatcher to provide a fresh and cool air (fig. 19). It is a unique windcatcher with about 60 meters diameter wind-tower on its roof, and represent a new interpretation to the principles of the ancient Persian windcatcher [9]. The windcatcher Tower is another expressive example of the architecture of the future (fig. 20). It is a schematic design presented in a skyscraper architectural competition in 2008, by Tassilo Hager, Germany. It used the same concept of the traditional windcatcher by employing the buildings' envelope to catch the wind and funnel it to the whole building [10].

Fig. 19. *Burj al-Taqa*, Dubai, 2008 by Eckhard Gerber [9]

Fig. 20. The windcatcher Tower, by Tassilo Hager [10]

The Shower Tower, Australia represents one of the realised projects in the 21st architecture, which would move the history into the future. The design concept of the energy systems behind the heating/cooling and fresh air system is innovative and extensive. As shown in (fig. 21), the shower towers ventilate the retail space below the office levels. Outside air is drawn in from high levels (eight metres or more above street level) and induce into the space. As this air falls within the shower tower, it is cooled through the evaporation of water [11].

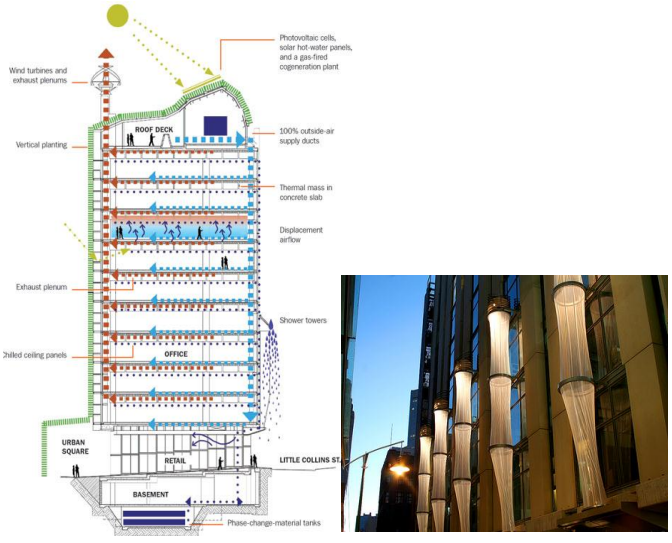

Fig. 21. The Shower Tower, Australia [11]

VI. CONCLUSION

The preceding discussion raised the awareness of the importance of the traditional wind-catcher and helped opens possibilities for improving the performance and widening the applicability of wind catchers. This will bring new opportunities for using this old heritage passive cooling system in today world. The newly interest for wind catchers have a lot to learn from the heritage, but purely traditional solutions seems rather hard to apply and to be accepted by contemporary architects. Combining traditional knowledge and advanced technology is therefore necessary. The lack of real world model development is one of the factors that currently inhibit the wide application of the windcatcher technology. The existence of such built examples in different parts of the world provides a starting point for the research necessary to develop practical guidelines for the design of windcatchers for all types of buildings. There is no doubt that if the leading architects of contemporary architecture realized buildings with windcatchers, it would have attracted the attention of a much wider public and this valued architectural device would have found a new dimension in the 21st century architecture.

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Author

Dr. Abdel-Moniem El-Shorbagy is Assistant Professor of Architecture and Design in the Architecture Department at Effat University. In 2001, he received his Ph.D. in Art History from the University of Canterbury in New Zealand. He also received a M.A. in Architecture from the same university in 1997 and a postgraduate qualification from Lincoln University, in New Zealand, in 1996. Currently, he teaches courses in Architecture, Design, Structure, and Islamic architecture at Effat University.